Production and operations Management by Dr. Ranjeet Verma

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PRODUCTION

AND

OPERATIONS MANAGEMENT

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PREFACE

Production and Operations management is an area of business concerned with the production of goods and services, and involves the responsibility of ensuring that business operations are efficient in terms of using as optimum resource as needed, and effective in terms of meeting customer requirements. It is concerned with managing the process that converts the inputs (materials, labor and energy) into the outputs (form of goods and services).

This is an all-inclusive Production and Operations Management book that covers much more in complexity than most college texts. Approaching the subject from a engineering and managerial perspectives, this brand-new text provides clear and concise coverage of the nature, principles, and practice of Production and Operations Management. This book can also act as a reference to various courses since several concepts are discussed in abundant detail which the authors found useful in multi disciplines. The book also offers a pleasant sense of balance with theory and application in the formulation and calculation course.

The text is well organized in five parts comprising of totally 17 chapters and the authors had done a great job in keeping explanations as modest as possible. Relevant diagrammatic presentations and examples are included for better understanding of the contents. This book offers a comprehensive and real-world overview of production and operations, strengthened with an all-embracing assemblage of Questions for discussion, MCQs, Case studies, Illustrative problems and a well-defined Glossary. The authors have taken very much care about the fact that each and every topic is framed in a clear, simple and understandable language.

The Part-1 is comprised of chapters 1,2,3 and 4 are devoted to building a comprehensive understanding on the basics of production and operations management, operations strategy, manufacturing and service operations and the system concept of operations management. The Part-2, contains the chapters 5, 6, 7, and 8 focuses on the key initiatives such as the functions of facility location and layouts, Forecasting process, Product planning and design, and process planning. Chapters 9, 10 and 11 are grouped under Part-3 which focus on the work study procedures, Production planning and control, and scheduling process.

Part-4 has chapters 12, 13, and 14 which deal with Materials management. This unit helps the readers to explore the areas such as purchase management, material handling and inventory management practices and system. The Part-5 contains chapters 15, 16 and 17 which deal with the crucial areas of operations management such as maintenance management and quality management. Also the development of the process of automation in various operations is also discussed in this part which will help the readers to update the latest technologies in production and operations.

Considerable efforts have been made to design a comprehensive textbook which will meet up to the standard requirements of the undergraduate as well as post graduate management and engineering students. We hope this book proves to be student - friendly as well as teacher- friendly. Critical comments and constructive suggestions for improvement of the book are most welcome and will be highly appreciated.

Thank you..

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Our life is so blessed with some of the most amazing people. Thank you all for being part of our journey.

We sincerely dedicate this book to the amazing people around us including our relatives, friends, colleagues, students and all the ardent readers.

We thank our college management for providing us the wonderful opportunity and support to publish this book.

We also extend our heartiest gratitude to **Wellwritten Publishing Co.** for giving us encouragement to publish this book.

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CHAPTER -1

INTRODUCTION TO PRODUCTION AND OPERATIONS MANAGEMENT

INTRODUCTION

Have you ever imagined a car without a brake or the steering wheel? Whilst, what remains of an utmost importance to you is to drive the locomotive from one location to another for whatever purpose you wish, but can only be made possible with each and every part of the car working together and attached. Organizations behave in the same manner. The company has an ultimate goal of delivering goods to a client, but the processes of designing, manufacturing, analysing and then finally being delivered are the driving forces for the company's success.

Production management plays a very important role in achieving organizational excellence. A number of organizations worldwide have achieved and sustained excellence by effective production management. Effective production management involves understanding of the characteristics of various types of production systems, identification of the dynamics of the different phases of the management process, realizing the potential of different analytical tools, learning the nuances of the implementation of these tools, visualizing the impact of various uncertain situations and developing the ability to react under various scenarios to achieve consistently excellent business results.

"Production is the process by which, raw materials and other inputs are converted into finished products." On the other hand, operations refer not only to the production of goods but also to the services and the set of all value-added activities that transform inputs into outputs. Fundamentally, these value-adding creative activities should be aligned with market opportunity for optimal enterprise performance. A set of various activities, which are involved in manufacturing certain products is called as production management.

Operations management is an area of business that is concerned with the management of production of goods and services, and involves the responsibility of ensuring that business operations are efficient and effective. It is also concerned with the management of resources, the distribution of goods and services to customers, and the analysis of queue systems. Operations management focuses on managing the processes to produce and distribute products and services. Overall production activities often include product creation, development, production and distribution whereas related activities include managing purchases, inventory control, quality control, storage, logistics and evaluations. A great deal of focus is on efficiency and effectiveness of the production process. Therefore, operations management often includes substantial measurement and analysis of internal processes. Ultimately, the way in which operations management is carried out in an organization depends very much on the nature of products or services in the organization, for example, retail, manufacturing, wholesale, etc.

The Association for Operations Management (APICS) also defines operations management as "the field of study that focuses on the effective planning, scheduling, use, and control of a manufacturing or service organization through the study of concepts from design engineering, industrial engineering, management information systems, quality management, production management, inventory management, accounting, and other functions as they affect the organization".

Meaning

Production management performs many tasks in relation to the production of goods and services. This involves planning, supervising and controlling the activities involved in the production of goods and services. The main purpose of product management is to produce the right quality at the right time and cheaply. Operations management is the administration of business practices to create the highest level of efficiency possible within an organization. It is concerned with converting materials and labor into goods and services as efficiently as possible to maximize the profit of an organization. Operations management teams attempt to balance costs with revenue to achieve the highest net operating profit possible.

Definitions

The important definitions given by various authors are summarized as follows:

"Production management deals with decision making related to production processes so that the resulting goods or services are produced according to specifications, in the amount and by the schedule demanded and out of minimum cost."

-E.S. Buffa

"Production management is the process of planning and regulating the operations of that part of a business which is responsible for actual transformation of materials into finished products."

-A.W. Field

"It is concerned with the processes which convert the inputs into outputs, various inputs such as men, material, money, method, etc. and the output such as gods and services."

-H.A. Harding

"Production management becomes the process of effectively planning and regulating the operations of that part of an enterprise which is responsible for that actual transformation of materials into finished products."

- E.L. Brech

"Operations management may be defined as a systematic approach to address all the issues pertaining to the transformation process that converts some inputs into output that are useful and could fetch revenue to the organization."

- B. Mahadevan

"Operations Management is the management of systems or processes that create goods and/or provide services."

-William Stevenson

"Operations Management is concerned with the efficient conversion of an organization's resources into the goods and services that it has been set up to provide."

- Barnettt

"Operations management is concerned with creating, operating and controlling a transformation system which takes inputs of a variety of resources and produces outputs of goods and services which are needed by the customer."

- Naylor

GOODS AND SERVICES

'Goods' are the physical objects while 'Services' is an activity of performing work for others. Goods imply the tangible commodity or product, which can be delivered to the customer. It involves the transfer of ownership and possession from seller to the buyer. On the other hand, services allude to the intangible activities which are separately identifiable and provide satisfaction of wants.

Examples of goods

Ball, Automobiles, refrigerators, food products, books, pen, computers, Batteries, etc.

Types of Services

- Government services (Judicial, central, State, Panchayat, etc.)

- Financial Services (Banks, Insurance, stock, investments, etc.)
- Medical and Health Care services (Hospitals, Surgeons, Nurses, etc.)
- Education services (Universities, colleges, schools, etc.)

Table-1.1 Comparison between Goods and Services

Basis for comparison	Goods	Services
Meaning	Goods are the material items that can be seen, touched or felt and are ready for sale to the customers.	Services are amenities, facilities, benefits or help provided by other people.
Nature	Tangible	Intangible
Transfer of ownership	Yes	No
Evaluation	Very simple and easy	Complicated
Return	Goods can be returned.	Services cannot be returned back once they are provided.
Separable	Yes, goods can be separated from the seller.	No, services cannot be separated from the service provider.
Variability	Identical	Diversified
Storage	Goods can be stored for use in future or multiple uses.	Services cannot be stored.
Production and Consumption	There is a time lag between production and consumption of goods.	Production and Consumption of services occurs simultaneously.

CONVERSION PROCESSES

Conversion processes involve the activities related to the transformation of resources into goods or services. These resources include the following:

- Materials, including raw materials inventory
- Labor, namely, the human resources required for operations
- Overhead, including fixed assets, indirect materials, indirect labor, and various other expenses necessary to run the operating facility

Fig 1.1 Conversion Process: Education sector

Inputs	Processing	Outputs
1. Knowledge 2. Text books 3. Lecture notes 4. Handouts 5. Course CD	1. Lecturing 2. Tutoring 3. Assignment 4. Exam	Future operations managers

Teaching Evaluation

Table- 1.2 Converting Inputs to Outputs

Type of Organization	Input	Output
Airline	Pilots, flight attendants, reservations system, ticketing agents, customers, airplanes, maintenance crews, ground facilities	Movement of customers and freight
Grocery store	Merchandise, building, clerks, supervisors, store fixtures, shopping carts, customers	Groceries for customers
High school	Faculty, curriculum, buildings, classrooms, library, auditorium, gymnasium, students, staff, supplies	Graduates, public service
Manufacturer	Machinery, raw materials, plant, workers, managers	Finished products for consumers and other firms
Restaurant	Food, cooking equipment, servers, chefs, dishwashers, host, patrons, furniture, fixtures	Meals for patrons

DIFFERENCE BETWEEN PRODUCTION AND OPERATIONS MANAGEMENT

Table1.3 Difference between Production and Operations Management

Basis	Production Management	Operations Management
Definition	Production Management connotes the administration of the range of activities belonging to the creation of products.	Operations Management refers to the part of management concerned with the production and delivery of goods and services.
Objective	The objective of production management is to produce the best goods or services that are of the right quality, right quantity at the right time.	Its objective of operations management is to utilize resources, to the extent possible so as to satisfy customers' wants.
Occurrence	Production management occurs on outputs after manufacturing rose in the market.	Operations management occurs on input during manufacturing.
Decision Making	Production management decision making is related to the aspects of production.	Operations management decision making is related to the regular business activities.
Capital	Production management requires extra capital to make the capital in the beginning and needless labor because it offers with the unit.	The operation management requires less capital funding because it wants extra work and needs immediate outcomes.
Found In	Production management is found in enterprises where production is undertaken.	Operations management is found in Banks, Hospitals, Companies including production companies, Agencies, etc.

- Production management is defined as the management of a set of activities related to the production of materials or the conversion of raw materials into finished products. Rather, Operational Management is the branch of management that deals with the management of both the production of products and the provision of services to customers.
- Production management is found only in companies where the production of goods is carried out. Unlike, in every company, one can find operational management, that is. Manufacturing concerns, service-oriented companies, banks, hospitals, agents, etc.
- Production management does not require any entry from the shopkeeper, however, because operational management uses more firms from shoppers.
- Production management requires additional capital gear to build production at the outset and requires very little labour as it is supplied with units. In contrast, operational management requires very little capital funding, although everyone wants more work because they need immediate results.
- Operational management is often referred to as the management aspect of issues related to organizational activities and the processes that effectively deal with the team.

Table- 1.4 Types of Operations

OPERATIONS	EXAMPLES
Goods Producing	Farming, mining, construction, manufacturing, power generation
Storage/Transportation	Warehousing, trucking, mail service, moving, taxis, buses, hotels, airlines
Exchange	Retailing, wholesaling, banking, renting, leasing, library, loans
Entertainment	Films, radio and television, concerts, recording
Communication	Newspapers, radio and television, newscasts, telephone, satellites

Table- 1.5 Manufacturing vs. Service

Characteristic	Manufacturing	Service
Output	Tangible	Intangible
Uniformity of output	High	Low
Uniformity of input	High	Low
Labor content	Low	High
Measurement of productivity	Easy	Difficult
Customer contact	Low	High
Opportunity to correct quality problems before delivery	High	Low
Evaluation	Easy	Difficult
Patentable	Usually	Not Usually

IMPORTANCE OF OPERATIONS MANAGEMENT

FOR BUSINESS

Production management has become an important part of business organization nowadays. It is treated as a separate, independent functional area of the management. It's some of the importance are as follows:

1. It is the foundation for organisation to earn profits by production and sales of goods and services in to the market.
2. Production management ensures that the goods or services produced are of the desired quality, required quantity and as per the time schedules.
3. It facilitates optimum inventory level.
4. It ensures that there is proper coordination and necessary control, which are needed for adequate, timely and economic production.
5. It ensures to cope up with the changes in demand in the market and maintaining stability in the production department.
6. It ensures to maintain the efficiency.
7. It helps the organisation in achieving all its objectives. It produces products for satisfying the needs and desires of the customers and thus facilitating increase in the volume of sales.
8. It helps to satisfy the customers, which in turn increases the firm's repo, goodwill and image. A good repo helps the firm to expand and to grow.
9. Production management helps to introduce new products in the market with newer and better quality. Before launching any product in the market, it ensures to conduct Research and Development (R&D) which can help to launch successful product in the market.
10. Production management also provides support to other functional areas in an organisation such as – marketing, finance and personnel.
11. It helps the enterprise to face competition in the market. This is possible because production management produces the product of right quantity, right quality, and right price and at the right time.
12. It facilitates optimum utilisation of the available resources such as manpower, machines, etc., so that the firms can meet the capacity utilisation objective.
13. It helps to minimise the cost of production. It tries to maximise the output and minimize the inputs. This is helpful for the firm to achieve its cost reduction and efficiency objective.

FOR CUSTOMERS AND SOCIETY

1. It conducts continuous research and development (R&D), thus, the producing newer good quality of products. These products are used by the people and they enjoy a higher standard of living.
2. It creates many job opportunities in the country, either directly or indirectly.

a. Direct employment is created in the areas of production.

b. Indirect employment is created in the supporting areas like marketing, finance, customer support, etc.

3. It produces good quality of the products. Because of large scale of production, there are economies of large scale, which brings down the cost of production. This also reduces the consumer price.
4. Other sectors also expand because of production like-

2. Companies making spare parts expand, service sectors such as banking, transport, communication, insurance, B.P.O., etc. expand. This spread effect offers job opportunities and boosts the economy.
5. Production creates form utility. Consumers can get form utility in the shape, size, and designs of the products.
6. Production creates time utility. Consumers get the goods at the time of requirement.
7. It ensures optimum utilisation of resources and effective production of goods and services.
8. It leads to speedy economic growth and well-being of the nation.

Table-1.6 Historical Milestones in Operations Management

Year	Initiator	Event
1875	James Watt	Steam Engine was commercially manufactured
1899	Eli Whitney	Introduced mass production and the concept of standard interchangeable parts.
1900	Frederick.W.Taylor	Scientific Management
1900	Frank & Lillian Gilberth	Time and motion study
1901	Henry.H.Gantt	Scheduling, Gantt chart
1905	Henry Ford	Assembly Line
1905	Alfred P.Sloan	Organizational management
1927	Elton Mayo	Assembly Line
1931	Walter.A Sherwart	Quality Control charts
1935	H.F.Dodge & H.G.Romig	Statistical sampling applied to quality control
1940	P.M.S. Blacket et.al	Operations Research Application
1947	George.B.Dantzig.et.al	Linear programming
1950	A. Charnes, W.W. cooper & H. Raiffa	Non-linear and stochastic processes programming
1970	J.Orlicky &O.Wright	Computer applications to manufacturing – material requirement planning (MRF)
1980	W.E.deming ,Philip Gosly & J.Juran GM &IBM	Quality & productivity, applications from Japan, CAD/CAM, Robotics
1990	Netscape, US Dept of Defence Michael Hammer, James champy	Internet, electronic enterprise Business process Reengineering
2000	Amozon,ebay,yahoo,America online Dr. Daniel Whitney & Prof charles fine, MIT	E-commerce ,Agile Manufacturing High performance work systems.

FUNCTIONS OF OPERATIONS MANAGEMENT

The primary responsibility of the Operations Manager is to ensure that the appropriate processes and practices are implemented throughout the organization. Formulating strategy, enhancing performance, acquiring material and resources, and ensuring compliance are some of the specialized responsibilities of an operations manager. Operations managers are accountable for or involved in making choices about the following at the strategic level (long term):

- Product development (what shall we make?)
- Process and layout decisions (how shall we make it?)
- Site location (where will we make it?)
- Capacity (how much do we need?)

Operations management deals with the difficulties of efficiently arranging material and labor within the restrictions of the firm's strategy and making aggregate planning decisions at the tactical level (intermediate term). The following decisions are made by operations managers:

- Employee levels (how many workers do we need and when do we need them?)
- Inventory levels (when should we have materials delivered and should we use a chase strategy or a level strategy?)
- Capacity (how many shifts do we need? Do we need to work overtime or subcontract some work?)

Operations management is focused with lower-level (daily/weekly/monthly) planning and control at the operational level. The following decisions must be made by operations managers and their subordinates:

- Scheduling (what should we process and when should we process it?)
- Sequencing (in what order should we process the orders?)
- Loading (what order to we put on what machine?)
- Work assignments (to whom do we assign individual machines or processes?)

1. Pre-Planning Activities

Pre-planning is a strategic level planning and it deals with the analysis of data from feedback received from both operations and external environment such as competitors, political, economic, social and cultural environments. It is concerned with the decision making regarding products, processes, machineries, plant location and layouts with respect to availability, scope and capacity. It deals with the outline of production policies based upon forecasted demand.

2. Demand Forecasting

Demand forecasting is very important for the organizations to know about the quantity of output an organization has to plan for in the future period to meet the demands of the customer. ”Estimating the different activities level of the future in the organization is known as Forecasting.” It helps the managers in making continuous decisions regarding employment levels, carrying inventories, purchasing new equipments, developing new products, scheduling production, quality control, plant maintenance etc.

3. Product Design

Product design is defined as the determination and specification of parts of a product and their interrelationships so that they become unified as the whole. It is the process of transferring the customers’ expectations into technical specifications. The components of the products must be designed in such a way that it meets the specification of the whole product. Also the design should contribute to the economy of the production process. The product design is elaborately discussed in the forthcoming chapters in the same part.

4. Process Design

The physical processes for producing goods and services have to be designed to ensure optimum production in the organization. Some decisions have to be taken at top level management regarding the selection of process, choice of technology, process low and layout facilities.

5. Flow Design

Flow design decides the direction of movement of materials, semi-finished goods, and finished goods inside the plant. The flows of materials have to be decided according to the nature of product to be manufactured. It decided the type of manufacturing system. The flow pattern for materials, type of layouts and material handling systems are defined in this process.

6. Production Planning

Production planning is the function of deciding the manufacturing requirements such as raw materials, facilities, manpower, and manufacturing process. Based on the results from demand forecasting and other facilities forecasting of the organization, the planning function establishes the programmes to meet the demands using the various resources.

7. Scheduling

Scheduling is an important tool for manufacturing and it can have a major impact on the productivity of a process. The purpose of scheduling is to maximize the efficiency of the operation by minimizing the production time and costs. The production time and cost is minimised by telling a production facility what to make, when, with which staff, and on which equipment. Effective scheduling can also give a company the competitive advantage in terms of customer service if its competitors are less effective with their scheduling process.

8. Production Control

Production control regulates and stimulates the orderly how of materials in the manufacturing process from the beginning to the end. Control function is exercised over the quantity to be produced, quality expected, time needed, inventory consumed and cost incurred.

MAJOR SUB FUNCTIONS OF PRODUCTION AND OPERATIONS MANAGEMENT

1. Inventory Control

Inventory control deals with the control over raw materials, work-in-progress, finished goods, stores and supplies, tools, jigs fixtures etc. purchasing and store keeping is also an important aspect of inventory control. Proper decisions should be made regarding maintaining proper inventory of raw materials, work-in-progress, finished goods, supplies etc.

2. Quality Control

In engineering and manufacturing, quality control is involved in developing systems to ensure products or services are designed and produced to meet or exceed customer requirements. These systems are often developed in conjunction with other business and engineering disciplines using cross-functional approach.the quality standards are prescribed. In terms of specifications like size, colour, shape, taste etc. the quality control is mainatined by testing the actual production and by assertaining whether they conform to the preset standards.

3. Materials Management

Materials management is concerned with planning, directing and controlling the kind, amount, location, movement and timing of various flows of materials used in and produced by the process. An effective materials management ensures that right kinds of materials are at the right place whenever needed.

4. Purchasing

Purchasing refers to buying of a material or an item from a company or division that supplies materials. Purchasing is a very important function in production management since it deals with the input which is the primary resource for manufacturing process. The purchase procedure varies according to the nature of demand and market conditions from company to company and also from industry to industry.

5. Maintenance management

Maintenance in any activity is designed to keep the resources in good working condition or restore them to operating status. Maintenance can be defined as a productive activity undertaken to bring an equipment, facility or system back to its original level of performance in terms of quality and quantity of output. Maintenance also includes activities to improve the quality over and above the design capability and also augment the capacity through debottlenecking, modification and modernization.

6. Cost Reduction and Control

Cost reduction methods are developed in the organization to improve productivity and attain the competitive advantage in the market. Cost reduction and cost elimination are productivity techniques. The techniques like value engineering, budgetary control, standard costing, cost control of labour and material helps to maintain optimality in cost.

NATURE OF PRODUCTION/OPERATIONS MANAGEMENT

Production/Operations management has the following major nature / features:

1. Production management results in value addition

It results in value addition because raw materials are purchased from right source, at right price, in right form, in right quality, at right time and in right quantity. These all are helpful in producing better quality products which can satisfy the needs and wants of the customers in the best way possible.

2. Production management as decision making system

It is helpful in taking decisions such as production and administration related activities, purchase and warehousing related activities, material handling activities, transportation, etc.

3. As an inter-disciplinary approach

Many disciplines have contributed in the development of production management. Various subjects include economics, sociology, engineering, mathematics, etc.

4. Operation function

By monitoring production process, it is helpful in controlling day-to-day production of goods and services.

5. Part of general management

Production management includes the process of planning, organising, coordinating and controlling all managerial and production activities.

6. Production management is both art and science

It is both science as well as an art. It is an art due to work assignment and co-ordination in activities and is science because of management of machines and other cause and reason based activities.

7. As transformation process

Production management also acts as a transformation process by converting raw materials into finished products using the various techniques.

OBJECTIVES OF OPERATIONS MANAGEMENT

The major objective of the operations management is to achieve the corporate goals of the organization through a strategy that ensures effective performance of the operations function measured in terms of cost, quality, dependability, flexibility and responsiveness in the production of goods / services. The objective of the production management is related to the production of goods and services:

1. Right Quality

The quality of product is developed as per the customer needs. The right quality may not be the best quality. It is determined by the cost of the product and the technical characteristics as per the desired requirements.

2. Right Quantity

The manufacturing department must produce the products in right number i.e. right quantity. If the goods are manufactured in excess of demand the capital will block up in the form of inventory and if the goods are produced in short of demand, it will lead to shortage of goods and services.

3. Right Time

Effectiveness of production department depends upon the timely delivery of the goods and services. So, the production department has to make the optimum use of input resources to achieve its goals and objectives.

4. Right Manufacturing Cost

Manufacturing costs are to be established before the actual production of the product. Thus, all the efforts must be made to produce the products at pre-established cost only, so that variation between actual cost and the pre-established cost can be reduced.

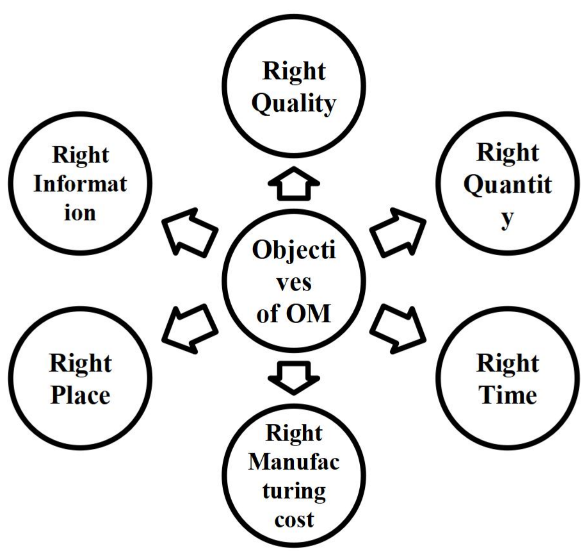
5. Right Place

Delivery and manufacturing locations are considered very important. Manufacturing and delivering the products at the right place or locations are very important and it can be considered a key factor for success.

6. Right Information

Collection and dissemination of information to the right authority is the key to success for any business. Passing the required information from the right source to right receiver completes the fitness of information cycle.

Fig. 1.1 Objectives of OM



Other objectives of Operations Management

- Maximum satisfaction of customers by quality, reliability, cost and delivery time period.
- Minimum scrap/rework resulting in newer and good quality of products.
- Minimum possible inventory levels.
- Maximum resource utilization as per the needs.
- Minimum outflow of cash.
- Maximum satisfaction of the employees.
- Higher efficiencies in operations.
- Minimum possible cycle production.
- Maximum possible profit.

SCOPE OF OPERATIONS MANAGEMENT

Operations Management includes Forecasting, Capacity planning, Scheduling, Managing inventories, Assuring quality, Motivating employees, Deciding where to locate facilities, etc.

The other scopes include the following:

- It is applicable on activities related to purchase and warehousing.
- It can be applied on activities related to product and administration such as product, design, product engineering, etc.,
- It is applicable on activities related to human resource management.
- It is applicable on activities related to financial control and production.
- It is applicable on activities related to material handling in which movement of materials from the store room to machine and from one machine to the next during the process of manufacturing.
- It is applicable in the inspection of raw materials, parts and components and finished goods.
- It is applicable in the inventory control in which the report is prepared for the available and required inventory in stock.
- It is applicable in plant location and layout related activities.
- It is applicable on PPC i.e. 'Production Planning and Control'; in which planning of production is done in advance and in case of any troubles it is controlled.
- It is applicable in quality control.

CURRENT CHALLENGES OF OPERATIONS MANAGEMENT

Mark Davis, Nicolas Aquilano and Richard Chase (1999) have suggested that the major issues for operations management today are:

- Reducing the development and manufacturing time for new goods and services
- Achieving and sustaining high quality while controlling cost
- Integrating new technologies and control systems into existing processes
- Obtaining, training, and keeping qualified workers and managers
- Working effectively with other functions of the business to accomplish the goals of the firm
- Integrating production and service activities at multiple sites in decentralized organizations
- Working effectively with suppliers at being user-friendly for customers
- Working effectively with new partners formed by strategic alliances

FACTORS AFFECTING PRODUCTION AND OPERATIONS MANAGEMENT

Some of the major factors that influence the performance of production and operations management are discussed as follows.

a. Reality of Global Competition

In the current scenario, nature of the world business is changing and the production /operations management is highly influenced by increased global competition and the advances in information technology. The advancement in information technology had increased the application of internet in business, which help the company to efficiently do the global business. Internet has led the way to Electronic business (e-business), through which the companies are able to do the business globally using e-transactions. E-Commerce is familiar to most of the customers all over the world, through which on-line purchasing or selling is done by many global companies.

Many foreign giant companies also conquer small native companies in the name of mergers and acquisitions which enforces a serious threat to the local companies. Companies have also started following global strategies like joint ventures, strategic alliances to face the competitions from their competitors. Moreover due to the global business situations there occur severe crashes in the global share markets whenever the major nations face finance fluctuations. The production managers nowadays face immense pressure in their profession due to the globalization and advancements in information technology.

b. Quality, Customer Satisfaction, and Cost Challenges

Many companies have included the quality aspects even in their mission and vision statements and they have realized the importance of quality in global competition. Companies started following the concept of 'Total Quality Management (TQM)' to ensure quality products and services. TQM emphasizes more on customer satisfaction, without which the companies cannot retain or add their customers.

Organizations nowadays face serious cost challenges due to the combination of economic pressure and increased competition. Hence production managers are force to identify the cost cutting mechanisms in their organizations.

c. Rapid Expansion of Advanced Technologies

Advancement in technology has had an impact on competition and productivity. Computers and software have brought tremendous changes in the manufacturing sector. They assist the production management in its functions such as new product design and development, production planning, forecasting, routing and scheduling, data processing and communication.

However prediction of technological growth sometimes becomes a burden for the management. New technologies are often expensive and involve high operating cost in the firms. Due to the technological advancements, there exist some conflicting technologies, where the technology choice will be more difficult for the operational managers.

d. Continued Growth of the Service Sector

The service sector is expanding very rapidly and the extraordinary growth of service sector has focused attention on challenges of effective management of service organization since it is completely different from the challenges faced in manufacturing settings. Due to rapid developments in information technology, globalization, changing customer needs/preferences, and the changes in relative wealth between the developed and newly developing economies, the effective management of service systems addressing productivity and quality issues will become even more important in the coming years. The techniques for effective service operations management are not fully developed as in manufacturing and this issue has to be taken care by the managements.

e. Scarcity of Operations Resources

Scarcity of resources occurs due to the layoffs, retrenchment and corporate downsizing, strategies which are generally considered by the organizations to ensure cost reduction in the operations. The above discussed factors force the operation manager to trade-off decisions on resource allocation, and to place increased emphasis on cost control and productivity improvement.

f. Social-Responsibility Issues

Nowadays, Companies face more challenges in the business environment due to the judicial and statuary interventions from the government and regulating bodies related to the key areas such as health and safety, environmental protection, human rights, human resource management practices, corporate governance, community development, consumer protection, labour protection, supplier relations, business ethics, and stakeholder rights. Hence it become the responsibility of the operations management function to carry out the Corporate Social Responsibility (CSR) as a tool for dominating the competitive scenario prevailing in the national as well as international market, for customer retention, and sustainable growth.

Firms must also focus on customer-driven excellence in terms of high-quality products and services while also providing value for money, treating employees and partners as valuable assets, agility, product and service innovation, social responsibility, and developing environmentally friendly production, design, recycling industrial waste-products, and conserving natural resources for Sustainable Business.

g. Agility

Agile manufacturing is defined as the ability to successfully market low-cost, high-quality products with short lead times (and in varying volumes) that provide enhanced customer value through customization. An agile firm manages change as a matter of routine. Agility refers to the ability of an organization to respond quickly to demands or opportunities. The key dimensions of agile competition are enriching the customer, cooperating to enhance competitiveness, organizing to master change and uncertainty, and leveraging the impact of people and information. The organizations face agility when they need to remain competitive and cope with increasingly shorter product life cycles and strive to achieve shorter development time for new products or services.

Discussion Forum

Short Questions:

1. Define Production Management.
2. Mention the challenges of Operations Management.
3. Write any four scope of operations management.
4. Give any four examples for services.
5. Differentiate between goods and services.
6. Brief the current challenges of operations management.

Essay Type Questions:

1. Differentiate Production and Operations Management.
2. Discuss the importance of Operations Management.
3. Explain the importance of Operations Management.
4. Discuss the objectives of OM.
5. Describe the nature of OM
6. Discuss the various factors affecting production and operations management.
7. Portray the evolution of operations management.
8. Critically analyse the nature and scope of operations management.

CHAPTER-2

OPERATIONS STRATEGY

INTRODUCTION

Companies manufacturing products or delivering services rely on a handful of processes to get their products manufactured properly and delivered on time. Each of the processes acts as an operation for the company, which is essential for them. That is the reason why the operation managers find operations management more appealing. Hence, the operations managers formulate many strategies in order to control the various processes in their organization. When the organizational strategy provides the overall direction for the organization, operations strategy deals primarily only with the operations aspect of the organization. It relates to the process, methods, operating resources, quality, costs, lead times, and scheduling.

Operations strategies are derived directly from the corporate mission and business strategy. Corporate strategies are derived from corporate objectives, which reflect the long-range goals of the organization. These are concerned with the survival, growth and profitability of the firm. Business strategies are formulated to make the individual business units achieve their goals and henceforth, the corporate objectives. These strategies are embodied in the organization’s business plan, which includes a plan for all the functional areas of the business, including marketing and production plan. The firms develop business strategies to meet the competition for each product line by considering the strength and weaknesses of all the functional areas.

Operational objectives are long-range goals for each product line that the operation function must achieve to attain the corporate objectives. The operation function concentrates on several competencies in order to fulfill its objectives. Some of them are

- Achieving low manufacturing costs
- Fast delivery of products and services
- High-quality products
- Flexibility in production systems

Operation policies give the guidelines to achieve the objectives. Separate policies for processes, quality system, capacity planning and inventory management. Operation strategies provide a road map for achieving the operation’s objectives. Operation strategies include decisions about each significant product line on such issues as the new facilities required, technologies required, the process required and the production schemes followed to produce according to the sales forecast.

Operations strategy has a long-term concern for how to determine best and develop the firm’s significant operations resources so that there is a high degree of compatibility between these resources and the business strategy. Comprehensive questions are addressed regarding how significant resources should be configured to achieve the firm's corporate objectives. Some of the issues of relevance include long-term decisions regarding capacity, location, processes, technology, and timing.

The achievement of world-class status through operations requires that operations be integrated with the other functions at the corporate level. In broad terms, an operation has two essential roles in strengthening the firm's overall strategy. One option is to provide processes that give the firm a distinct advantage in the marketplace. Operations will provide a marketing edge through distinct, unique technology developments in processes that competitors cannot match.

The second role that operations can play is to provide coordinated support for the fundamental ways the firm’s products win orders over their competitors, also known as distinctive competencies. The firm's operations strategy must be conducive to developing a set of policies in both process choice and infrastructure design (controls, procedures, systems and so on) that are consistent with the firm’s distinctive competency. Most firms share access to the same processes and technology, so they usually differ little in these areas. What is different is the degree to which operations match its processes and infrastructure to its distinctive competencies.

Operations Strategy- Meaning

Operations strategy is an aspect of operations management concerned with long-term planning for a company's customer service and business strategies. An operation strategy is concerned with setting broad policies and plans for using a firm's resources to best support its long-term competitive strategy. Operations strategy is guided by business strategy. The operations strategy leads to operations decisions about process, quality, capacity, and quality. In simpler terms, the operations strategy specifies how the firm will employ its operations capabilities to support the business strategy.

Operations Strategy- Definition

According to Slack and Lewis, Operations strategy is defined as "the total pattern of decisions which shape the long-term capabilities of any type of operations and their contribution to the overall strategy, through the reconciliation of market requirements with operations resources."

STRATEGIC MANAGEMENT PROCESS FOR PRODUCTION AND OPERATION

In every organization, there is a unique mission statement that includes a range of long-term goals. This is termed as a corporate strategy as it contains the detailed description of the type of business that an organization desires to be in, the different type of customers that the organization will serve, the basic values and belief system of its business, and the goals and profitability, that are expected to be achieved.

Another long-term business plan similar to the corporate strategy is a business strategy that acts as a roadmap in order to achieve of fulfill the above-mentioned mission of corporate strategy. These long-term plans have to undergo different functions such as marketing, HR, production, finance, etc. Here the role of operations strategy comes in as its main function is to translate whole decision-related processes that facilitate business strategy.

It's the responsibility of operations function to manage the resources required to produce products/services of the organization. To support the business strategy, operations strategy acts like a plan to specify the structure and usage of resources. This consists of required skills and talents of the workforce, technology usage; size, location and type of available facilities, special equipment and processes required, and methods of quality control. So, operations strategy enables the organization to fulfill its long-term plan and for this, it must be aligned with the business strategy of the company.

STRATEGIC MANAGEMENT PROCESS

Operational strategy is essential to achieve operational goals set by organization in alignment with overall objective of the company. Operational strategy is design to achieve business effectiveness or competitive advantage.

Fig- 2.1 Strategic operations management process

For success of organizational strategic objective, strategic planning has to trickle down to various function areas of the business. In order to build strategy management process a sequential process as below is followed:

Competition Analysis

In this step, the company evaluates and studies current competition in the market and practices that are followed in the industry for operations and production vis-à-vis company policies

Goal Setting

Next step involves narrowing down the objective towards which the organization wants to move towards.

Strategy Formulation

The next step is breaking down of organizational goals into operations and production strategies.

Implementation

The final step is to convert operations and production strategies into day to day activities like production schedule, product design, quality management etc.

As organizations are always customer-centric, production and operation strategy for organization are built around them

Productivity

Measurement of formulated operations and production strategy is important to maintain alignment with the organization objectives. In simple terms productivity is defined as sum of total output per employee or per day. Productivity of company is dependent on industry and environmental conditions in which it is operating.

Two essential part of productivity are labor and capital. In scenario of limited resources, optimum and efficient utilization of labor and capital will generate favorable productivity. Productivity measurement also enables company to identify areas which require improvement or special focus. Also productivity provides ready report card to measure status against company's production objective.

Productivity measurement can be classified in three categories based on the inputs used for calculation. Partial productivity ration of output is compared to one of resource used for example, labor productivity where output is compared to the labor wages.

Total productivity measure takes into consideration sum of all input factors which are used for the output. In the modern age technology plays an important part in productivity.

Wastivity

Another important factor is the case of production is wastivity. Not 100% of input would be converted to output, there is going to waste during production. Wastivity is reciprocal of productivity. Classic examples of wastivity are defective products and services which either have to be re-cycled or disposed of completely. Other example is idle capacity of material, man-power equipment etc.

THE NEED FOR AN OPERATIONS STRATEGY

In many instances, a firm's operations function is not geared to the business's corporate objectives. While the system itself may be sound, it is not designed to meet the firm's needs. Instead, operations are seen as a neutral force, concerned solely with efficiency, and have a little place within the corporate consciousness. Steven C. Wheelwright and Robert H. Hayes described four generic roles that manufacturing can play within a company from a strategic perspective. These generic roles are explained below.

Stage 1: Firms are said to be internally neutral, meaning that the operations function is incapable of influencing competitive success. Management, thereby, seeks only to minimize any negative impact that operations may have on the firm. One might say that operations maintain a reactive mode. When strategic issues involving operations arise, the firm usually calls in outside experts.

Stage 2: Firms are externally neutral, meaning they seek parity with competitors (neutrality) by following standard industry practices. Capital investments in new equipment and facilities are seen as the most effective means of gaining a competitive advantage.

Stage 3: Firms are labeled internally supportive; the overall business strategy dictates operations' contribution to the firm, but operations have no input into the overall strategy. Stage 3 firms do, however, formulate and pursue a formal operations strategy.

Stage 4: Firms are at the most progressive stage of operations development. These firms are said to be externally supportive. Stage 4 firms expect operations to make an essential contribution to the competitive success of the organization. An operation is involved in major marketing and engineering decisions. They give sufficient credibility and influence to operations so that their full potential is realized. Firms within Stage 4 are known for their overall manufacturing capability.

The Role of Operations Strategy

The role of operations strategy is to provide a plan for the operations function to make the best use of its resources. Operations strategy specifies the policies and plans for using its resources to support its long-term competitive strategy. The operations function is responsible for managing the resources needed to produce the company's goods and services.

- Operations strategy is the plan that specifies the design and use of resources to support the business strategy.
- This includes the location, size, and type of facilities available; the skills and talents required; the use of technology, unique processes needed, special equipment; and quality control methods.
- The operations strategy must be aligned with its business strategy and enable the company to achieve its long-term plan.

ELEMENTS OF OPERATIONS STRATEGY

The six elements of operation strategy are:

1) Designing of the production system: The designing of the production system involves the selection of the type of product design, processing system, inventory plan for finished goods, etc. The product design has two varieties.

- Customized product design - The design is customized when the volume is low and extraordinary features are inbuilt. Eg: Turbines, boiler, air compressors etc.
- Standard product design - The designer adopts a universal design to have wide acceptance across the customer. Eg: Air conditioners, TV.

There are two types of production systems:

- A product-focused - system is adopted where mass production uses a group of machines. Eg: Automobiles, computers.
- Process focused - the system is based on a single task like painting, packing, heat.

2) Facilities for the production and services: Production allows the firm to provide the customer with low-cost products, faster delivery, on-time delivery. Specific specialization in production allows the firm to provide the customers with products of lower cost, faster delivery, on-time delivery, high product quality, and flexibility.

3) Product & service design and development:

- Generating the idea
- Creating the feasibility reports
- Designing the prototype
- Preparing a production model
- Evaluating the economies of scale for production
- Testing the product in the market
- Obtaining feedback
- We are creating the final design and starting the production.

Product life cycle introduced in the market has its life cycle. a) Introduction stage. b) Growth stage. c) Maturity stage. d) Decline stage.

4) Technology selection and process development: Thorough analysis and planning of the production processes and facilities. Every step in the process of production is planned in detail. The technology to be used in the production process is selected from a range of options

5) Allocation of resources to strategic alternatives: Production companies have to continuously deal with the problem of scarce resources like capital, machine and materials and so on. As these resource inputs are vital to production activities, their shortages can influence production performance significantly. Hence, the operation manager has to plan the optimal use of resources, both in minimizing wastage and in terms of their allocation to the best strategic use.

6) Facility planning: The location of the production facilities is one of the critical decisions an operation manager has to make since it is critical to the organization's competitiveness. Setting up production facilities with adequate capacity involves massive initial investment. Strategically suitable options should be carefully weighed against all available alternatives. These decisions also influence the future decisions on probable capacity expansions plans. Operation managers also make decisions, i.e., decisions on the internal arrangement of workers and departments within the facility.

CORE OPERATIONAL STRATEGY AREAS

Some of the core operational strategy areas are identified as follows:

- *Corporate:* Overall company strategy, driving the company mission and interconnected departments
- *Customer-Driven:* Operational strategies to meet the needs of a targeted customer segment
- *Core Competencies:* Strategies to develop the company's key strengths and resources

Competitive Priorities: Strategies that differentiate the company in the market to better provide a desired product or service

Product or Service Development: Strategies in product design, value, and innovation
Another way to frame strategic areas is by these "distinctive" competencies:

- Price
- Quality, such as performance, features, aesthetics, and durability
- Service
- Flexibility
- Tradeoffs, or competing on one or two distinctive competencies at the necessary expense of others

KEY SUCCESS FACTORS (KSFS)

Industries have characteristics or strategic elements that affect their ability to prosper in the marketplace (i.e., attributes, resources, competencies, or capabilities).

The ones that most affect a firm's competitive abilities are called key success factors (KSFs). They are actually what the firm must be competent at doing or concentrating on achieving to be competitively and financially successful; they could be called prerequisites for success. In order to determine their KSFs, a firm must determine a basis for customer choice. In other words, how do customers differentiate between competitors offering the same or similar products or services, and how will the firm distinguish it from these competitors? Once this is determined, the firm has to decide what resources and competitive capabilities it needs to compete successfully and what it will take to achieve sustainable competitive advantage.

These KSFs can be related to technology, operations, distribution, marketing, or certain skills or organizational capability. For example, the firm may derive advantages from superior ability to transform material or information (technology or operations), to quickly master new technologies and bring processes online (technology or organizational capability), or to quickly design and introduce new products, service a broad range of products, customize products or services on demand, or provide short lead times (skills).

The set of KSFs delegated totally or substantially to the operations function has been termed the manufacturing mission. It represents what top management expects from operations in terms of its strategic contribution. All decisions made relative to system design, planning, control and supervision must accomplish the manufacturing mission. As such, the manufacturing mission is the principal driver of the operations function and gives it its reason for existence. All world-class manufacturers have an explicit, formal manufacturing mission.

The operations function derives its distinctive competencies (competitive priorities). Distinctive competence is the characteristic of a given product/service or its producing firm that causes the buyer to purchase it rather than the similar product/service of a competitor. It is generally accepted that the distinctive competencies are cost/price, quality, flexibility, and service/time. Various experts include other competencies, such as location, but these can usually be categorized within one of the generally accepted four. Some experts also feel that innovation is quickly becoming a fifth distinctive competency if it has not already. It should be noted that a firm’s position on the product-process matrix is a controlling factor for the manufacturing mission and the firm's competitive priority or priorities.

Table- 2.1 Key Success Factors

KSF	Description
Goals	Goal for every operation to give the operation direction and may help them with decisions regarding the operation, which may help achieve their larger goals.
Employees	Right employees for each task can improve the quality of the finished task.
Innovation	Innovation can help the organizations find better ways to operate and potentially gain an advantage over their competitors..
Analysis	All operations require regular analysis, and with an analysis, you can learn which operations are running well and which need improvement.

DISTINCTIVE COMPETENCIES

Details relative to each distinctive competency are provided, along with the implications of each and some examples.

Price/Cost

A firm competing on a price/cost basis can provide consumers with an in-demand product at a price that is competitively lower than that offered by firms producing the same or similar good/service. In order to compete on a price basis, the firm must be able to produce the product at a lesser cost or be willing to accept a smaller profit margin. Firms with this competency are generally able to mass-produce the product or service, thereby giving substantial economies of scale that drive the production cost per unit down considerably.

Commodity items are mass-produced at such volume that they utilize a continuous process, thus deriving tremendous economies of scale and very low prices. Consumers purchasing commodity type products are usually not greatly aware of the brand difference and will buy strictly based on price. Wal-Mart can offer low prices by accepting a lower profit margin per unit sold. The large volume of sales ensures high levels of profit even at the lower profit margin.

Quality

David Garvin lists eight dimensions of quality as follows:

1. ***Performance:*** Performance refers to a product's primary operating characteristics. This could mean fast acceleration, easy handling, a smooth ride, or good gas mileage for an automobile. It could mean bright color, clarity, sound quality, or several channels it can receive for television. For a service, this could merely mean attention to details or prompt service.

2. ***Conformance:*** Conformance is the degree to which a product's design and operating characteristics meet predetermined standards. When a manufacturer utilizing coils of steel receives a shipment from the mill, it checks the width of the coil, the gauge (thickness) of the steel, the weight of the coil and puts a sample on a Rockwell hardness tester to check to ensure that the specified hardness has been provided. Receiving inspection will also check if specified characteristics are met (e.g., hot-rolled, pickled, and oiled). Services may have conformance requirements for repair, processing, accuracy, timeliness, and errors.

3. ***Features:*** Features are the bells and whistles of a product or service. In other words, characteristics that supplement the essential function of the product or service. Desirable but unnecessary features on a VCR include four heads, slow-motion capability, stereo or surround sound, split screens or inset screens, and 365-day programming ability. Service examples include free drinks on an airline flight or free delivery of flowers.

4. ***Durability:*** Durability is defined as the meantime until replacement. In other words, how long does the product last before it is worn out or has to be replaced because the repair is impossible? The repair is impossible for some items, such as light bulbs, and replacement is the only available option. Durability may be had by the use of more extended life materials or improved technology processes in manufacturing. One would expect home appliances such as refrigerators, washers, dryers, and vacuum cleaners to last for many years. One would also hope that a product representing a significant investment, such as an automobile, would have durability as a primary quality characteristic.

5. ***Reliability:*** Reliability refers to a product's mean time until failure or between failures. In other words, the time until a product breaks down and has to be repaired but not replaced. This is an important feature for products that have expensive downtime and maintenance. Businesses depend on this characteristic for items such as delivery trucks and vans, farm equipment and copy machines since their failure could conceivably shut down the business altogether.

6. ***Serviceability:*** Serviceability is defined by speed, courtesy, competence and ease of repair. This can be a fundamental characteristic as witnessed by the proliferation of toll-free hotlines for customer service. Several years ago, a major television manufacturer advertised that its product had its "works in a box." This meant that the television set was assembled out of modular units. Whenever there were problems with the set, a repairman making a house call simply had to replace the problem module, making the product easily and quickly serviceable.

7. ***Aesthetics:*** A product's looks, feel, smell, sound, or taste are its aesthetic qualities. Since these characteristics are strictly subjective and captive to preference, it is virtually impossible to please everyone on this dimension.

8. ***Perceived Quality:*** Perceived quality is usually inferred from various tangible and intangible aspects of the product. Many consumers assume products made in Japan are inherent of high quality due to the reputation of Japanese manufacturers, whereas 50 years ago, the perception was the complete opposite. Other characteristics such as high price or pleasing aesthetics may imply quality.

Firms competing on this basis offer products or services superior to the competition on one or more of the eight dimensions. It would be undesirable if not impossible for firms to compete on all eight quality dimensions at once. This would be prohibitively expensive, and there are some limitations imposed by tradeoffs that must be made due to the nature of the product. For example, a firm may sacrifice reliability in order to achieve maximum speed.

SERVICE STRATEGY

Service can be defined in a number of ways. The term customer service can characterize superior service or mean rapid delivery, on-time delivery, or convenient location.

Flexibility

Firms may compete on their ability to provide either flexibility of the product or volume. Firms that can easily accept engineering changes (changes in the product) offer a strategic advantage to their customers. This can also apply to services. A number of years ago, a well-known fast-food restaurant advertised, “hold the pickles, hold the lettuce, special orders don't upset us,” which meant that ordering a non-standardized version of the product would not slow down the delivery process. Also, some firms can absorb wide fluctuations in volume, allowing customers with erratic demand the luxury of not holding excessive inventories in anticipation of a change in demand.

Trade-Offs

Firms usually focus on one distinctive competency (rarely more than two). For some competencies, there are tradeoffs involved. An automobile manufacturer producing a product that is considered high quality (leather seats, real wood trim, and an outstanding service package) will not be able to compete on a cost/price basis as the cost of manufacture prohibits it. An automotive parts house would like to keep its customers happy by offering the lowest prices possible. However, if the automotive parts house also wants to fill almost every single order from walk-in customers, it must maintain an extensive inventory. The expense of this inventory could preclude the parts house from offering prices competitive with other similar firms not choosing to provide this level of service. Therefore, one part house is competing based on service (but not cost/price) while the other is competing based on cost/price (but not service). The customer may have to wait a few days to get the desired part; if the customer cannot wait, he or she can pay more and purchase the part immediately from the competitor.

Order Winners/Qualifiers

Operations strategist and author Terry Hill introduced the terms qualifier and order winner (1989). A qualifier is a competitive characteristic a firm or product must exhibit to be a viable competitor in the marketplace. An order winner is a competitive product or service characteristic that causes a customer to choose this firm's product or service rather than that of a competitor (distinctive competence). For example, say a consumer in the market for a new automobile has a predetermined level of quality that the automobile must possess before being considered for purchase. The consumer has narrowed his or her choice down to five automobile models that all meet this minimum quality requirement. From this point, the consumer, with all else being equal, will probably purchase the automobile that he or she can get for the least cost. Therefore, quality is the qualifier (must be present to be considered), and cost/price is the order winner (the basis for the final choice).

Table: 2.2 Components of the Operations Strategy

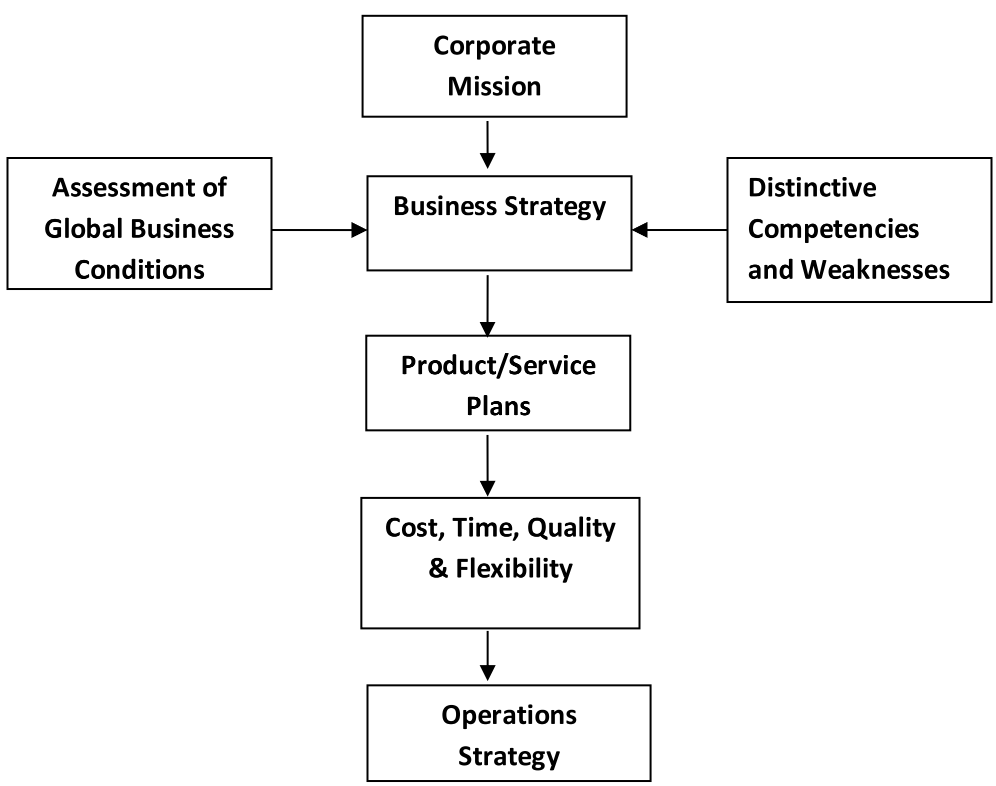
Structural decision categories	Capacity Facilities Vertical integration Technology
Infrastructural decision categories	Workforce Organization Information/control systems
Capabilities	Unique to each firm

Competitive priorities	Cost Quality High-performance design Consistent quality Time Fast delivery time On-time delivery Development speed Flexibility Customization Volume flexibility

DEVELOPING OPERATIONS STRATEGY

Corporate mission describes the purpose of the organization. It gives the external environment an idea of what business an organization is in? Operation mission has to contribute to the business mission. Corporate strategies are formulated based on the corporate mission. Then the business-level strategies are formulated by assessing the global business conditions and the environmental analysis. Distinguish competence such as products patents, technology, delivery, etc., distinguishes a company by pinpointing where it excels. Operation objectives are identified, which usually relate to cost, quality, delivery, and flexibility. These objectives are derived from the business mission. Plans regarding the products and services are done, and finally, the operation strategies are formulated.

Fig.2.1 Developing Operations Strategy



CRITERIA FOR EVALUATING AN OPERATIONS STRATEGY

Consistency (internal and external)

- Between the operations strategy and the overall business strategy
- Between the operations strategy and the other functional strategies within the business
- Among the decision categories that make up the operations strategy
- The operations strategy and the business environment (resources available, competitive behaviour, governmental restraints, etc.)

Contribution (to competitive advantage)

- Making trade-offs explicit, enabling operations to set priorities that enhance the competitive advantage
- Directing attention to opportunities that complement the business strategy
- Promoting clarity regarding the operations strategy throughout the business unit, so its potential can be fully realized
- Providing the operations capabilities that the business will require in the future

OPERATIONS STRATEGY DECISION AREAS

Capacity Strategy

- This concerns how capacity and facilities, in general, should be configured.
- It includes questions such as 'What should be the overall level of capacity?
- How many sites should the capacity be distributed across, and what size should they be?
- Should each site be engaged in a broad mixture of activities, or should they specialize in one or two?
- Exactly where should each site be located?'; 'When should changes be made to overall capacity levels?
- How big should each change in capacity be?
- How fast should capacity expansion or reduction be pursued?

Supply Network Strategy

- This concerns how operations relate to its interconnected network of other operations,
- Including customers, customers' customers, suppliers, suppliers' suppliers, and so on.
- Should we attempt to manage the network differently depending on the types of the market we are serving?
- How many suppliers should we have?
- What should be the nature of our relationship with our suppliers, purely market-based or long-term partnerships?
- What are the appropriate ways of managing different types of supplier relationships?
- Process Technology Strategy
- This concerns the choice and development of the systems, machines, and processes that act directly or indirectly on transformed resources to convert them into finished products and services.

Development and Organization

This concerns the set of broad- and long-term decisions governing how the operation is run continuingly.

- How do we enhance and improve the processes within the operation over time?
- How should resources be clustered together within the business?
- How reporting Relationships should be organized between these resources?

Table- 2.3 Operations Strategy Examples

Amazon	Once known for books, Amazon is now known as the go-to platform for online shoppers of any product. Its distribution network is widely touted and even includes experiments with drone delivery.
Apple Computers	Apple is long recognized in operations circles for its operational excellence and supply chain management.
Walmart	This retailing giant managed to undercut many competitors on the price and variety of a wide range of products.
FedEx	FedEx made speed of delivery its calling card, achieving it with excellent operations.
IKEA	The world's largest furniture retailer undercut many home goods competitors on price and variety with its warehouse concept.

STATEMENT OF MCDONALD'S OPERATIONS STRATEGY

"To provide unmatched consistency in operations in support of high product quality. This must be accomplished with adequate speed, low cost, and process innovation to accommodate changes in consumer tastes."

From McDonald's operations strategy statement, it is clear that both consistent and high-performance quality is considered order winners, while speed, cost, and innovation are considered order qualifiers.

Table- 2.4 McDonald's Operations Strategy

DIMENSION	STRATEGY
Capacity	Growth as needed through additional stores - but capacity added carefully Well-utilized - franchisee's well-being depends on it being used heavily
Facilities	Distributed facilities, each facility being very similar to the next, all focused around the same menu - although the uniformity is beginning to change.
Process Technology	The high degree of process understanding, emphasis on "fool-proof" processes A leader in the technology of fast-food delivery
Vertical Integration	Partnership arrangement Long-term relationship with suppliers to promote innovation and quality improvement
Workforce	***Franchisees:*** well-trained, carefully selected entrepreneurs ***Operators:*** high-turnover, cheap
Organization	A corporation provides guidelines, but franchisees push to optimize locally.
Control Systems	Centralized buying Bulk contracts "Push" system for essential supplies, "pull" system day-to-day in the restaurants.

MANUFACTURING STRATEGIES

To manufacture products, various types of competitive priorities are being used. Demand is the main criteria to choose or adopt systems in a manufacturing concern. Different production systems that are in current practice include:

- Batch production
- Customized production
- Mass production
- Assembling the products, testing, and supply.

For the above, the operations manager takes decisions related to which manufacturing strategies will be adopted as these strategies vary from industry to industry. The three main manufacturing strategies are as under:

Make-to-stock (MTS)

This is a conventional production strategy in which commodities or goods are produced on a large scale to meet the anticipated customer demand. In other words, Make-to-stock termed as producing goods for inventory according to demand forecasts. In this, organizations are required to keep a stock of finished products in order to deliver them to the customers on-demand or at the time of purchasing.

So, by adopting this manufacturing strategy, manufacturing organizations are able to deliver products on an immediate basis whenever the demand arises and this helps in minimizing the delivery time. This strategy is more suitable for standardized products that are produced in bulk and the forecast is also accurate at a reasonable level.

For example, different products such as electronics, groceries, medicines, chemicals, etc. have demand in high volume. So, a Make-to-stock strategy is feasible in producing such products.

Assemble-to-order

In this manufacturing strategy, sub-assembly parts and components are kept as stock by manufacturers and parts are assembled into final customized goods or products according to the order placed by customers. The Assemble-to-order strategy depends on the organization’s ability to assemble and deliver products in a fast manner. Different processes include in this strategy as fabrication processes, assembly processes, cleaning, painting, etc. To ensure the smooth functioning of these processes, a suitable inventory of sub-assembly parts is created.

For example, Dell Computer Company works on an assemble-to-order manufacturing strategy for its products such as laptops, personal computers (PCs). In this, customers are allowed to choose options from various available options for different parts of laptops or PC such as monitors, hardware, software, CPUs, processors, etc. as per their suitability. The system is assembled after receiving orders from customers and further delivery of the system

Make-to-order (MTO)

The manufacturing strategy using which organizations produce products or offer services as per the specifications given by each customer; is termed as make-to-order strategy. This includes different processes according to customer requirements. Using this strategy, a high level of customization can be achieved which is considered one of the main competitive priorities. Both variety and flexibility can be offered by the company.

For example, some special medical equipment is manufactured as per the special demand from customers like hospitals, doctors, etc. Similarly, the construction of a house is based on customer demand.

GLOBAL STRATEGIES AND ROLE OF OPERATIONS STRATEGY

Organizations may adopt a global strategy of importing parts or services from abroad and counter domestic competitions at the corporate level. A global perspective is required to identify external environment threats and opportunities and evolve operations strategy. Analyzing different other factors are also required such as market segmentation that includes psychological, demographic, and industry factors; also, the identification of different needs of goods, volume, delivery, etc.

Drafting a business strategy from a global point of view requires considering the global conditions and existing competencies, strengths, and weaknesses. Different factors such as existing competition, market potential, developmental factors i.e. social, political, economic, technological, etc. are part of global conditions and are considered at the time of defining the business strategy.

There are two main strategies that organizations adopt as a part of their global strategy i.e. strategic alliance and placing operations in a foreign market and after-sales service.

Strategic Alliance

When two parties or organizations enter into an agreement for promoting their products or services then it is considered as a strategic alliance and partners act as joint partners. Different main forms of the strategic alliance are:

Collaboration

Two companies are said to be into collaboration agreement when one company holds core competency in a specific product, joints with the other company that wants to promote the product in its country. So, rather than designing their own duplicate product, both companies collaborate for promoting the product based on their mutual interest. Also, to keep the product's reputation, the local company follows the operations strategy of a collaborated company. A few examples of such companies are IBM, HP, etc.

Joint venture

This is considered as an agreement between two companies to produce products in joint form. Joint venture strategy supports in gaining foreign market access. In this, technology and expertise are supplied by an external company and required resources such as processing, operations, infrastructure, manpower, etc. are provided by the local company. Different car manufacturing companies like Honda, Maruti Suzuki, etc. have adopted this strategy.

Transfer of Technology and Licensing

Transfer of technology describes different processes using which movement of technological knowledge is possible between or within organizations. This knowledge can be in different forms such as services and people, design and technical documents, etc. Wherein, licensing is related to a business agreement that allows an organization to grant permission to another organization for the manufacturing of its product on defined payment terms.

Placing Operations in Foreign Market and After Sales Service

In order to penetrate the new markets, organizations locate their manufacturing operation abroad. For this, companies are supposed to do a techno-economic survey in a detailed way before entering into foreign countries because of the political and economic environment; customer needs may be different and vary. Operations strategy may also be different than the current operations strategy of the company. If the product is a standardized one, then its methodology and operations strategy can be similar. Domino's Pizza, McDonald's are a few examples of this.

Discussion Forum

Short Questions

1. Define Operations strategy.
2. What is the need for operations strategy?
3. What do you mean by KSF?
4. Mention any four core operations strategy areas.

Essay Type Question

1. Explain the different stages involved in strategic operations management process.
2. Discuss the various elements of operations strategy.
3. What are the distinctive factors considered in strategic operation management process?
4. Discuss some of the global operations strategies followed in MNCs.

Mini Case – DELL

Dell impressed many in its early years with its distinct model of supply chain management, selling customized computers directly to customers to meet burgeoning PC demand. By using this innovative sales model, Dell became an industry and shareholders' darling as well as a high-tech pioneer. As a multinational enterprise, Dell competently executed its global strategy, giving the company a competitive advantage that was unrivaled in the first half of the 2000s.

Inventory Management

During this time, almost all its competitors started pre-built standard machines based on market forecasts and stuffed their channels with inventory. However, Dell made each machine to order and maintained only 12 days of inventory. Dell's just-in-time (JIT) strategy allowed it to operate with the lowest inventory level in the industry. Reducing excess inventory provided Dell with a significant cost advantage as component costs depreciate as much as 1% weekly in the electronics industry.

Direct selling

Direct selling has also allowed Dell to bypass intermediaries such as wholesalers and retailers, reducing costs even further. In addition, Dell offered customization options that proved to be customer-centric and attractive. Dell's network of 200 suppliers had access to real-time information, such as demand trends and volume expectations for different components. This close integration with suppliers and the direct selling model has allowed Dell to balance demand and supply remarkably well.

Manufacturing locations

Dell's successful direct sales business model, superior supply chain management, and its choice of manufacturing locations gave it a superior competitive advantage. Dell chose to locate its manufacturing plants close to such regional markets for better market access, lower shipping costs, and improved responsiveness in delivery. The success of Dell in India was attributed to having a manufacturing plant in the country, which cut delivery time by 50% and improved its sales dramatically. In the past, customers in India would have to wait for up to a month for their computers, which were manufactured in Malaysia.

Source: https://thinkinsights.net/strategy/operational-strategy/

CHAPTER-3

MANUFACTURING AND SERVICE OPERATIONS

MANUFACTURING OPERATIONS

The term "manufacturing operations" refers to a framework in which man, machine and material come together to produce a tangible product. People, processes and equipment combine to add value to materials and produce products for sales. Manufacturing operations are concerned with the operation of a facility to produce final goods. It deals with all the supply chain activities such as gathering requirements from customers, procuring raw materials, allocating resources, scheduling the production, maintaining the inventory, and delivering end products to customers. Manufacturing operation starts with the entrance of raw materials to the manufacturing site and ends when the processed material leaves. It can be defined as a process that occurs at a specific location. Here are some examples of manufacturing operations:

- Conversion of iron ore into steel- value is added.
- Conversion of sand to glass.
- Conversion of petroleum to plastic.

Process manufacturing and discrete manufacturing are the two types of manufacturing operations. Process manufacturing is a production method that involves following a set of stages or a formula to make things. Individual finished goods that are distinct from one another are the focus of discrete manufacturing. Automobile and smartphone manufacturers use the discrete production approach, whereas pharmaceutical and food and beverage companies use the process manufacturing method.

TYPES OF MANUFACTURING PROCESSES

The different types of manufacturing operations are discussed as follows:

Repetitive Manufacturing

Basic manufacturing that creates the same product on an assembly line is engaged in the repetitive manufacturing process. These types of rapid manufacturing operations will produce the same or very similar products 24/7. The manufacturing industries that utilize this type of production process include:

- Automotive
- Electronics
- Semiconductor
- Durable consumer goods

These mass production industries are ideal for repetitive manufacturing because the consumer demand for the finished product is stable and predictable. The assembly line will remain fairly constant, with few changes as one product is manufactured over a period of time.

Master plans are made for a specific amount of time and in a specific number.Repetitive manufacturing is commonly employed for make-to-stock production or in a large volume, sales order-oriented setting like automotive. Robots and other automated high-volume manufacturing equipment are utilized to boost throughput and decrease manufacturing costs in these types of plants.

Discrete Manufacturing

Discrete manufacturing is the cousin of repetitive manufacturing. It too runs on production lines, but the finished goods that are created during this process often vary considerably. When switching between different product models, the assembly line configuration must often be changed. In manufacturing facilities, this is known as a changeover and carries setup cost in the form of time, labor, and resources.

For example, in the computer industry, technology not only develops at a constantly rapid rate but the customers demand mass customization. The manufacturing process for producing newer computers and laptops will require modifications to the assembly line to produce and assemble orders that call for the latest electronic components.

Job Shop Manufacturing

In the job shop manufacturing process, production areas, like workstations and workshops, are used instead of an assembly line. Each worker may add something to the product when it passes through their station, before it is moved on to another, and until eventually the final product is finished. This method of manufacturing is ideal for custom manufacturing because it tends to be slower and produces a low volume of highly customized products.

Take for example a job shop that builds custom cabinets. Workers will be stationed at their workstations, and they will add to the cabinet as it is brought to them. One may be in charge of sawing the lumber, another of applying resin, others in charge of polishing the varnish, and others still in charge of assembly.

Keep in mind that job shop manufacturing is not just for low technology products. This process is also used in the advanced manufacturing of fighter jets and rockets for the aerospace and defense industry. To assure a high-quality build, these products are made by highly trained specialists who use innovative manufacturing techniques and place a heavy emphasis on quality control.

Continuous Process Manufacturing

Continuous process manufacturing is very similar to repetitive manufacturing because it runs 24/7, creates the same or similar products repeatedly, and creates larger order quantities. The key difference here is that the raw materials used are gases, liquids, powders, and slurries, instead of solid-state components.

It works almost exactly the same as repetitive manufacturing besides the difference in raw materials. An example of this in practice might be a pharmaceutical company that produces painkillers in larger quantities.

Traditional industrial manufacturing industries that widely utilize continuous processes include:

- Pharmaceutics
- Chemicals/industrial gases
- Fertilizers
- Power stations
- Oil refining
- Paper
- Furnace - Steel, Iron, and Alloys

Batch Process Manufacturing

The batch process of manufacture differs quite a bit from continuous process manufacture and is more similar to discrete and job shop manufacturing. The number of batches that are created will be enough to serve a particular customer's needs. In-between batches, the equipment will be cleaned and left alone until another batch is required. The raw materials used are more similar to continuous process manufacturing as they are liquids, gases, powders, and slurries too.

A prominent example of this is a sauce manufacturer. They may be capable of creating many sauces - BBQ, ketchup, mayonnaise - but a customer's order may only require one of them. Whilst they make one batch of ketchup for a customer to a specific quantity, the mayonnaise and other sauces won't be in production - instead, the machines will be cleaned and left until it is time to create another batch of that sauce.

3D Printing

Many in the industry now recognize 3D printing as a sixth manufacturing process with widespread use. Developed in the 1980s, 3D printing uses various composites and materials like plastics and metals to make three-dimensional goods layer by layer based on a digital model, rather than using physical labor or mechanization. There has been an enormous expansion in this field, with dozens of equipment manufacturers and hundreds of thousands of 3D-printed items already on the market.

While 3D printing can be expensive, it also offers the potential to reduce financial capital, raw materials and waste and lets companies create and test products before committing to them on a larger scale. This growing manufacturing process is already being used for products such as:

- Medical and dental devices
- Prosthetic limbs
- Firearms
- Shoes
- Musical instruments
- Buildings

OTHER TYPES OF MANUFACTURING PROCESSES

1. Molding in Manufacturing

For liquid products, molding is used by the manufacturer. It involves casting which is one popular type of molding. The plastic is heated until it becomes liquid and then it is poured into a mold. The mold is removed once the plastic cools down and desired shape is obtained.

Molding can further be categorized into following four types:

a. **Injection Moulding-** It melts to create 3-D materials, like toys, etc.

b. **Blow Moulding-** It is used for making piping and milk bottles.

c. **Compression Moulding-** It is used for making large-scale products like car tyres, etc.

d. **Rotational Moulding-** It is used for making furniture and shipping drums.

2. Machining In Manufacturing

Machines are used for making metal parts. Tools like saws, sheers and rotating wheels are used y the manufacturers to achieve the desired results. Some tools use heat to shape the items:

1. Laser machines cut a piece of metal by using a high-energy light beam.
2. Plasma torches can urn gas into plasma using electricity.
3. Erosion machines apply the same principle using electricity or water.
4. Computer numerical control machines introduce computer programming into manufacturing mix.

3. Joining In Manufacturing

The next step is to put multiple parts together i.e. assemble to make one piece. For e.g.- furniture needs to be assembled, part by part. Welding and soldering processes are used to join the parts together using heat. Adhesive bonding or fasteners can also be used to join the pieces.

4. Shearing and Forming In Manufacturing

Shearing uses cutting blades for making straight cuts into a piece of metal. It is also known as die cutting. Shearing is often used on aluminum, brass, bronze and stainless steel. Another method of shaping metal is forming; it uses compression or other form of stress to shape the materials in desired shape.

MANUFACTURING OPERATIONS MANAGEMENT

Manufacturing Operations Management (MOM) is the art of setting the policies and rules necessary to maintain production value and ensure that everyone and everything operates accordingly. It involves the continuous improvement of inventory, production, quality control, maintenance, and staffing around strategic objectives such as cost reduction, product innovation, sustainability, quality, and regulatory compliance.

SERVICE OPERATIONS

Services are intangible and non-physical products offered by one party to another in exchange for money. Service-providing operations aim to deliver an experience that leads to customer satisfaction. Service operation surrounds the day-to-day activities, processes and infrastructure, which are liable for delivering value to the organization through technology.

Service operations engage a wide range of teams to deliver services, including professional service teams, customer support teams and customer experience teams. Organizations that engage in hospitality, travel, media, sports, health care and entertainment are service-providing organizations. Service-providing operations send employees to their customers' locations or meet the customers at the company's premises to facilitate the service provision. The important components of service-providing operations are labor, service model and service environment. Labor could be a skilled workforce or semi-skilled workforce that directly engages with customers to provide services

Table 3.1 Examples of Services

Elements	Examples
Core Services	
Supporting Facilities	Facilities Layout, décor, support technology and equipment, branch network, branch network, roller coasters, etc.
Facilitating Goods (Physical Items)	Food, ATM cards, forms, receipts, golf clubs, cheque book, etc.
Facilitating Information	Schedules, fees structure, data, medical records, web page design, diagnostics, etc.
Explicit Services (experiential/Sensational)	Satisfy hunger, transportation, surgery, transactions, entertainment
Implicit Services (Psychological benefits)	Status, comfort, convenience, well-being, delight
Peripheral Services	Services/facilities that are supplement or 'surround' the core service (e.g. valet parking for hospital services, shopping at terminals for air transportation services)

Key factors in service operation are as follows:

1. Consumerization
2. Service experience

The goal of service operations is to maintain day-to-day services in such a form so that no issues arise. Service operations ensure that the services are delivered effectively and efficiently. All the designs and transition plans are executed and measured under service operations. From the view point of the customer, service operation is where actual value is observed.

CHARACTERISTICS OF SERVICE OPERATIONS

Distinctive characteristics of service operations can be categorized as follows-:

1. Customer participation
2. Simultaneity
3. Perishability

4. Intangibility
5. Heterogeneity
6. Non-transferable ownership.

1. Customer participation

a) Customers are a participant in the service process requires an attention to facility design, physical environment of the service facility, which is not necessary for the factory.

b) For the customer, service is an experience which occurs in the front office of the service facility, and the quality of the service increases if the service facility is designed as per the customer's perspective.

c) Customer's perception regarding the service can even influenced by the interior decoration, furnishings, layout, noise and colour. While providing a service an important point to be considered is that the customer can play an active part in the process.

d) Performance of the service system is directly affected by the knowledge, experience, motivation and honesty of the customer.

e) However now it is becoming a common practice to take the customer out of the process.

2. Simultaneity

a) The fact that services are created and consumed simultaneously and thus, cannot be stored is a critical feature in managing the services.

b) Leveraging the inventory in the factory is operated as a closed system, with inventory separating the productive system from customer demand. Services create an open system, with the full impact of demand variations being transferred to the system.

c) Inventory control is a major issue in manufacturing operations, whereas in services, the corresponding problem is customer waiting. The problems of selecting service capacity, facility utilization, and use of idle time all are balanced against writing time.

d) The simultaneous production and consumption in services also eliminates many opportunities for quality-control intervention.

3. Perishability

a) A service is a perishable commodity. Because a service cannot be stored, it is lost forever when not used.

b) Consumer demands for services typically exhibits very cyclic behaviour over short duration, with considerable variation between the peaks and valleys. For e.g.- the custom of eating lunch between noon and one places a burden on restaurants to accommodate the noon rush.

c) Manager can smooth the demand by using reservations or appointments. Using price incentives and de-marketing peak times like advertising to shop early and avoid the festival rush.

d) Manager can adjust service capacity by using part time help during peak hours and scheduling work shifts to vary workforce needs according to demand.

4. Intangibility

a) The customer is able to see, feel and test the performance of the product before purchasing it.

b) In many service areas, the government has intervened to guarantee acceptable service performances. Through the use of registration, licensing and regulation the government can give assurance to the consumers that the training and test performance of some service providers meet certain standards.

c) Services are ideas and concepts, products are things. Therefore, it follows that service innovations are not patentable.

5. Heterogeneity

a) The combination of the intangible nature of services and the customers as a participant in the service delivery system results in variation of service from customer to customer.
b) A customer expects to be treated fairly and to be given the same service that others receive.
c) The development of standards and of employees training in proper procedures is the key to ensure consistency in the service provided.
d) The customer feedback is the key to understand service quality.
e) A disgruntled service employee, however, can do irreparable harm to the organization because the employee is the firm's sole contact with customers.

6. Non-transferable ownership

a) Services unlike goods, do not involve transfer of ownership. If customers do not receive ownership they purchase a service, and then what are they buying? One view is that customers gain access or rental of resources for a period of time.
b) Service industries share their resources among customers by allocating the use of them. Customers do not purchase an asset but, instead, have use of the asset for a specific time, whether it is the use of human labour, technology or a physical asset.
c) For a price, customized services are offered to the customers to make them feel proud about the service.
d) Management of queues and crowd control is a challenge for managers of physical facilities that are shared by a large number of customers.

SERVICE OPERATIONS MANAGEMENT

Services operations management is related with delivering service to the customers of the service. It involves understanding the service needs of the target customers, managing the processes that deliver the services, ensuring objectives are met, while also paying attention to the constant improvement of the services. As such operations management is a central organizational function and one that is critical to organizational triumph.

Service organisations react to the wants of customers and leave certain experiences in the minds of the customer through a service delivery system. It was found in research study that growth of service industry is rapid at global level. Service organization is one when two or more people are engaged in systematic efforts to provide services to customers. These organizations exist to serve customers and satisfy their need. Functions of service operation are to restore the normal service to the user as quickly as possible. There is service desk that made up dedicated number of staff responsible for dealing with variety of services events, often made via telephone call, web interface or automatically reported infrastructure events.

In 1999, Wight identified that key attribute of marketing strategy of service organization is the interaction between the customers and the organization itself. Factors such as high consumer contact, consumer participation in the process, labour intensiveness, intangibility of output, difficulty of measuring quality, difficulty of measuring productivity, and a site dictated by consumers' location, are some of the explanatory characteristics of service operations. Therefore, service quality must identify what sensual benefits, physical items, and psychological benefits the customer is to receive from the service.

Key objectives of service operation are to synchronize and perform the activities and processes required to deliver and manage services at agreed levels to business users and customers. Service operation is also responsible for on-going management of the technology that is used to deliver and support services. Management scholars sated that highly designed and well implemented processes will be worthless if day to day operation of those processes is not suitably conducted, controlled and managed, nor will service improvements be possible if day to day activities to monitor performance assess metrics and gathering data are not systematically conducted during service operation.

Other objectives of service organizations include:

- Approachable stable services
- Robust end to end operational practices
- Business as usual - day to day
- Implementation of processes and services
- Responsive and operational validation
- Realising value
- Accomplishing service excellence

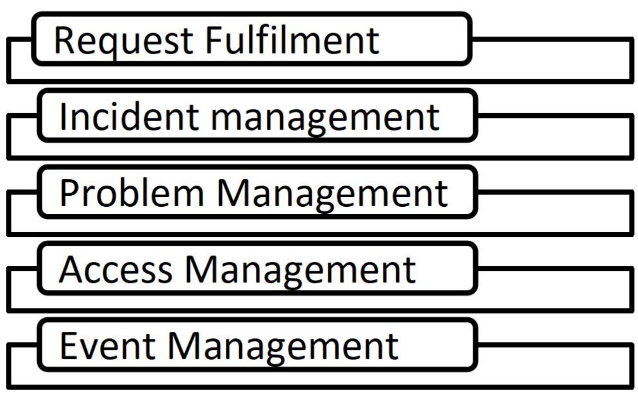
There are numerous factors in implementing service operation. Service Organizations must perform a feasibility study first.

- Use technique that is already good in the organization
- Take it slowly and concentrate on small steps and quick wins
- Appoint a strong project manager with end to end focus to drive the implementation program
- Keep in mind organization change management issues
- Keep communicating WHY organization needs this
- Measure successes continuously

Service operations are mainly associated with efficiency, effectiveness, Quality and Cost. Dimensions of service quality are Reliability, Responsiveness, Assurance, Empathy and Tangibles.

FIVE TYPES OF SERVICE OPERATION PROCESSES

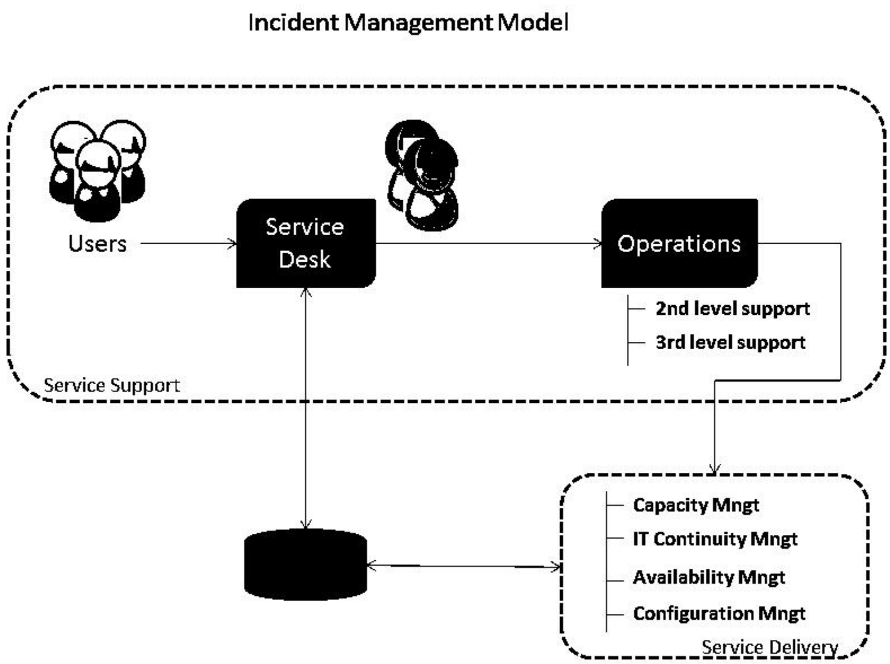
Fig 3.1 Type of Service Operations Process



1. Request fulfilment: Request fulfilment is the process to deal with service requests via the Service Desk, using a process similar but separate to that of incident management. Request fulfilment records/tables are linked, where necessary, to the incident or problem records that initiated the need for the request. Major aims of the request fulfilment process to provide a channel for users to request and receive standard services for which a predefined approval qualification process exists, to give information to users and customers about the availability of services and the procedure for obtaining them, to source and deliver the components of requested standard services and help with general information, complaints or comments. It effectively decreases the bureaucracy involved in requesting and receiving access to existing or new services, thereby reducing the cost of providing these services.

2. Incident management: Incident management is highly noticeable to companies and it is easier to demonstrate its value than in most areas of service operation. Incident management is often one of the first processes to be implemented in service management projects. The major benefit of doing this is that incident management can be used to high spot other areas that need attention, thus providing a reason for implementing processes. The purpose of incident management is to reinstate normal service operation as quickly as possible and diminish the adverse impact of the Incident on business operations, thus ensuring that the best possible levels of service quality and availability are maintained.

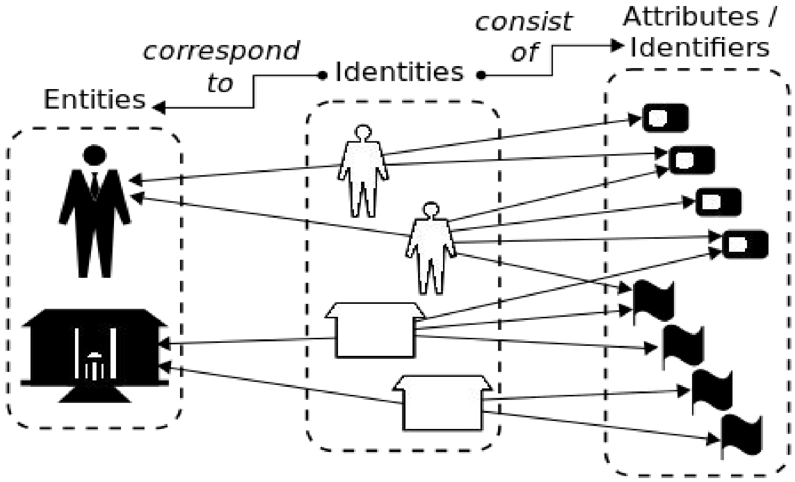
Fig 3.2 Incident Management Model



3. Problem management: This is vital for companies. Problem management comprises of the activities required to identify the root cause of incidents and to determine the resolution to the problems. It is also responsible for ensuring that the resolution is implemented through the appropriate control procedures. Effective problem management stops the recurrence of incidents and has benefits to the individual and the organization as it improves availability and user productivity. Major aim of this service process is to lessen the adverse impact of incidents and problems on the business that are caused by errors within the information technology infrastructure, and to prevent recurrence of incidents related to these errors.

4. Access management: Access management is the procedure to grant authorized users the right to use a service, while preventing access to non-authorised users. It is, therefore, the execution of policies and actions are defined in information security and availability management. The objectives of access management are Protecting Confidentiality, Integrity and Availability (CIA), sometimes knowing as Rights Management or Identity, Management, Security incidents and problems related to access management is discreetly recorded. Access management ensures that users are given the right to use a service, but it does not ensure that this access is available at all agreed times. This is provided by availability management.

Fig 3.3 Access Management Model

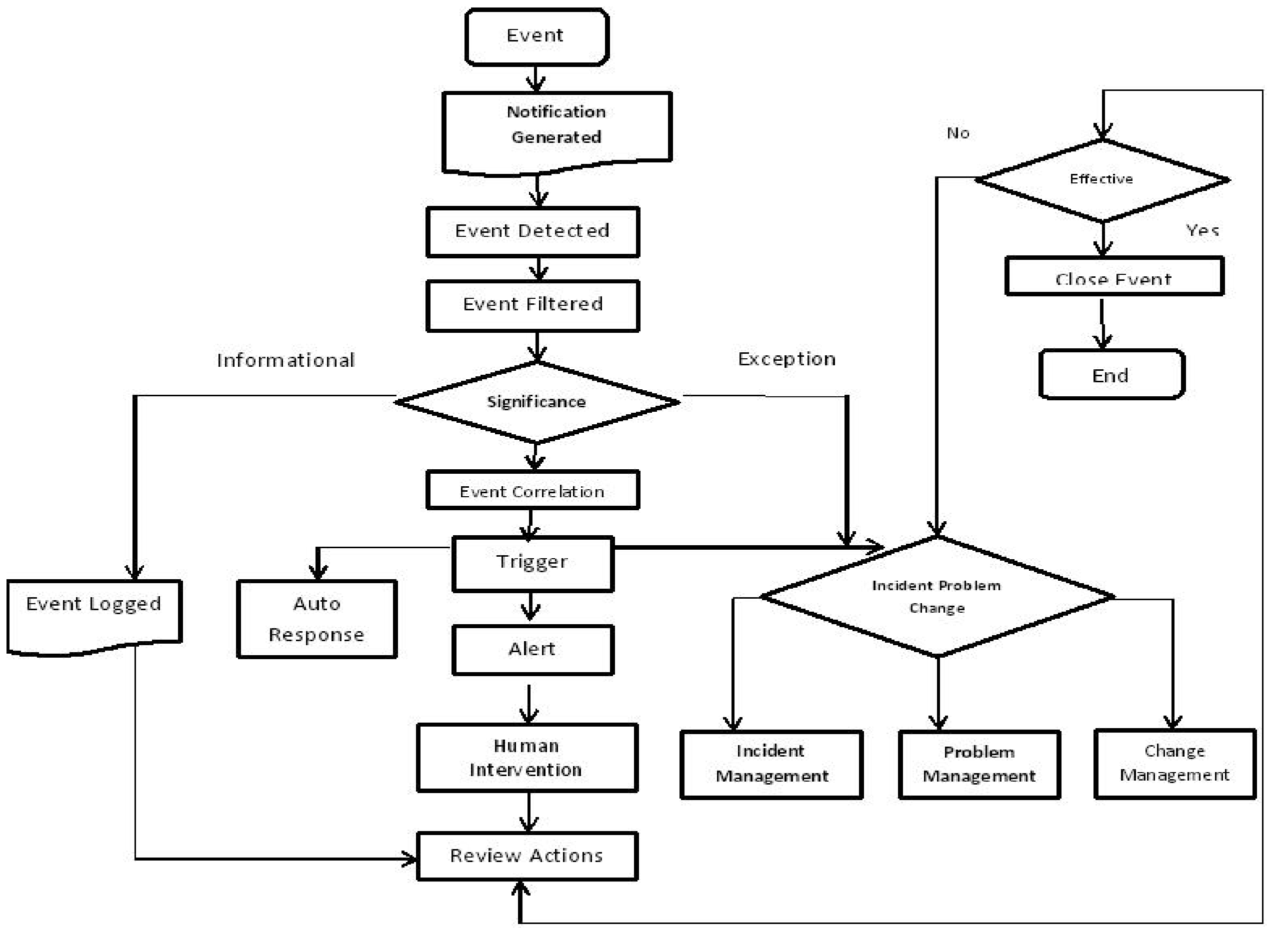


5. Event management: In this process, effective service operation is dependent on knowing the status of the infrastructure and detecting any deviation from normal or expected operation. The objectives of event management to provide the entry point for the execution of many service operation processes and activities. Additionally, it provides a way of comparing actual performance and behavior against design standards and Service Level Agreements.

Other aims include the ability to detect, interpret and initiate appropriate action for events, basis for operational monitoring and control and the entry point for many service operation activities, offer operational information as well as warnings and exceptions to aid automation and supports continual service improvement activities of service assurance and reporting.

Event management can be applied to any aspect of service management that needs to be controlled and which can be automated such as configuration Items, environmental conditions, software license monitoring for usage to ensure optimum/legal license utilization and allocation, security and normal activity.

Fig 3.4 Event Management Model



Major advantages within service operation are as follows:

- ***Scalability:*** Service organization can be adapted for any size of organization.
- ***Reduction in costs:*** Service organization has established its value in reducing the overall cost of managing services.
- ***Improved quality:*** Service organization helps improve the quality of IT services through sound management practices.
- ***Alignment to standards:*** Service organization may well align to the ISO/IEC 20000 Standard for Service Management.
- ***Return on Investment (ROI):*** Service organization helps IT organizations demonstrate their return on investment and measurable value to the business. This helps establish a business case for new or continuing investment in IT.
- ***Seamless sourcing partnerships:*** Outsourcing, often with multiple service providers, is increasingly common today and service organization offers a common practice base for improved service chain management.

There are numerous issues in service operation management:

- New service development
- Managing service experiences
- Front-office/Back-office
- Analysing processes

- Service quality
- Yield management
- Inventory management
- Waiting time management

MANUFACTURING V/S SERVICE OPERATIONS

Generally speaking, process efficiency is the most important to manufacturing operations while production and marketing are inseparable to service operations.

Manufacturing's tangible output can be consumed overtime, less labor and more equipment are used in production, since automation has increased capital intensity while as a result reduced customer contact. Consumers rarely take part in the manufacturing process, many manufacturing operations have emphasized efficiency while compromising flexibility, the methods for monitoring and using resources are sophisticated while producing.

On the other hand, service operations are different from those of manufacturing operations. Consumption and production of services takes place simultaneously or closely, and there are more labor and more customer participation, which means service businesses, usually are more customer-oriented. While elementary methods are frequently used for monitoring and using resources.

SIMILARITIES BETWEEN MANUFACTURING AND SERVICE

The similarities between manufacturing and service operations are given the following:

- Manufacturers do not just offer products, and service organizations do not just offer services. Both types of organizations normally provide a package of goods service
- Generally, service organization cannot inventory their outputs, but manufacturing firms that make customized product also cannot inventory their output.
- Everyone in an organization has some customers, whether in service or manufacturing.
- Both of the organizations require hard labor.
- Both have a very good return on investment.
- Both have huge marketing potential.
- Both have forecasting and capacity planning to match supply and demand.

DIFFERENCE BETWEEN MANUFACTURING AND SERVICE OPERATIONS

To be specific, there are mainly six differences between manufacturing operations and service operations.

1. Basic organize style in operation

Basically, manufacturing companies usually make production and purchase plans based on the demand of the market and their customers. Then human resources and equipment are settled to produce. So the manufacturing companies operation management is mainly product-cantered the aim is to control the process of production, keep the quality of outcomes and reduce cost. Yet the service organizations seem organized differently as they have greater amount of interaction with their customers. There are more uncertainties in the process, so specific plans cannot be made in advance, and the results are diverse if the service personals or the customers change. For that reason, the service operations are human-centered.

2. Design of products and operation systems

In manufacturing factories, the products and production systems can be designed separately because one same product can be produced by different manufacturing systems (i.e. two equipments with different automation degree). However in the service operations, the service provides system is part of the whole "service" itself. Different service provides system have different characteristics which make the service not the same, so those two systems must be designed together within the service operations.

3. The use of inventory in adjusts supply and demand

Since the companies cannot decide the demand of the market while their productivities are controllable, the manufacturing companies can use their inventory to deal with unexpected demand increases. So those companies should pay more attention to plan reasonable inventory strategy. To most of those service companies, their products cannot be inventoried as readily as goods. They cannot produce service in advance and store them for later customers, so what they can do is to make better use their service abilities while the demand happens.

4. Customers effect

The production systems in the manufacturing companies are usually enclosed to customers, manufacturing firms generally evaluate their products quality from internal perspective rather than external (customer's) perspective, and thus they can have few influences on the manufacturing operations. However, customers take part in the service operations; they may have positive and negative effects to the process. So the service companies need to make full use of those good effects and try to minimize the undesirable ones.

Table-3.2 Difference between Manufacturing and Service Operations

Key point	Manufacturing	Service
Physical nature of the product	Manufacturing organization provides physical and durable products.	Service organization provides the intangible and perishable product.
Inventory	Output can be inventoried.	Output cannot be inventoried.
Customer contact	It involves low customer contact.	It involves high customer contact.
Response time	It requires a long response time to meet customer demand.	It requires a short response time to meet the customer's demand.
Location and size of the operation	It serves the regional, national, even international market.	It serves in the local market.
Facilities	It requires a larger facility, more automation, and greater capital investment.	It requires small facilities.
Intensive	It is capital intensive organization.	It is a labor-intensive organization.
Quality	Quality can be easily measured.	Quality can't be easily measured.
Nature	Manufactured goods are physical, durable products	Services are intangible, perishable products often being ideas, concepts, or information.
Facilities	Manufactured goods are output that can be produced, stored, and transported in anticipation of future demand.	By contrast, service cannot be produced.

Contact	Most customers for manufactured products have little or no contact with the production system.	However, in many service organizations, the customer is input and active participation.
Time	While manufacturers generally have days or weeks to meet customer demand.	Many services must be offered within minutes of customer arrival.
Transport	Manufacturing facilities often serve regional, national, or even international markets.	Service cannot be shipped to distant locations.
Quality	As manufacturing systems tend to have tangible products and less customer contact, quality is relatively easy to measure.	By contrast, the quality of service system which generally produces intangible is harder to measure.

Discussion Forum

Short Questions

1. What do you mean by manufacturing operations?
2. Give any four examples of services.
3. Mention any four objectives of services organization.
4. Give any five factors that affect the service operations management.
5. Write any five similarities between manufacturing and services.
6. What do you mean by event management?

Essay Type Questions

1. Explain the different types of manufacturing process with suitable illustrations.
2. Discuss the characteristics of service operations.
3. Illustrate the various types of services operations processes.
4. Differentiate between manufacturing and services.
5. Describe the major advantages of service operations.

CHAPTER-4

PRODUCTION AND OPERATIONS AS A SYSTEM

INTRODUCTION

The production system is the series of subsystem such as inputs, outputs, transformation processes, facilities, etc. Also, the production function operates in a well-defined inner and exterior environment. It is the system that is accountable for the creation of products and services for the organizations. Production is the basic exercise and all other functions revolve around this function. In this system the inputs like workers, managers, equipment, facilities, materials, land, energy, information, etc. are processed the use of the quite a number facilities to get transformed into finished goods or services along with some value-added services.

Production/Operation management is the system which combines and transforms various resources used in the production/operation subsystem of the organization into value added goods and services in a controlled method as per the policies of the enterprise.

Resources used in production/ operation → Value added goods and Services

In controlled method as per the policies of the enterprise

Production/Operation function:

Range of inputs → Required output (product/service) (Having the requisite quality level)

The set of interrelated management activities which are concerned in manufacturing certain product is called production management and for service management, then corresponding set of management activities is referred to as operation management.

Goods:
- Building Construction
- Tank with a specific capacity
- Transport Vehicle, Grinder, TV etc.,

Services:
- Banking Service
- Hospital Service
- Travel Agency etc.,

The production system operates with the following characteristics:

1. Production is a planned activity with its own objectives.
2. Production system operates in each external and internal environment along with different organizational functions such as marketing, finance, HRM, IT, etc.
3. Production system is controlled the use of effective feedback system which is very helpful in enhancing the effectivity of the system.

SYSTEMS APPROACH

In the 1960, a strategy to management seemed which tried to unify the prior schools of thought. This approach is commonly known as “System Approach”. Its early contributors include-

- Ludwing Von Bertalanfty
- Lawrence J.Henderson
- W.G. Scott
- Deniel Katz
- Robert L.Kahn
- W.Bcukley
- J.D. Thompson

Systems approach is primarily based on the generalization that the whole thing is inter-related and inter-dependent. A system is composed of related and dependent factor which when in interaction, forms a unitary whole. A device is actually an assemblage or combination of things or parts forming a complicated whole.

One its most vital characteristic is that it is composed of hierarchy of sub-systems. That is the components forming the major system and so on. For example, the world can be considered-to be a system in which a range of national economies are sub-systems.

FEATURES OF SYSTEMS APPROACH

1. It is a system consisting of interacting elements. It is a set of interrelated and interdependent parts, which are organized in such manner that produces a unified whole.
2. The range of sub-systems can be studied using the interrelationships.
3. An organizational system is having boundary which determines the internal and external parts.
4. A system does not exist in vacuum form. It receives information, material, etc. from different systems in structure of inputs. These inputs further undergo a transformation process within a system and go away the system as output to other systems.
5. An organisation is a dynamic system as it can respond to the surroundings and is inclined to change in its environment.

ADVANTAGES OF SYSTEMS APPROACH IN MANAGEMENT

- It focuses in end results instead than the means.
- It gives an orderly and efficient design of action.
- It develops coordination of the specialized activities.
- It affords an excellent basis of control.
- It frees the management from a range of day-by-day details of the operations management.
- It targets at meaningful analysis of groups and their management.
- It facilitates the interplay between employer and its environment.
- It guides the manager for keeping off evaluation of problems in isolation and to develop a built-in approach.

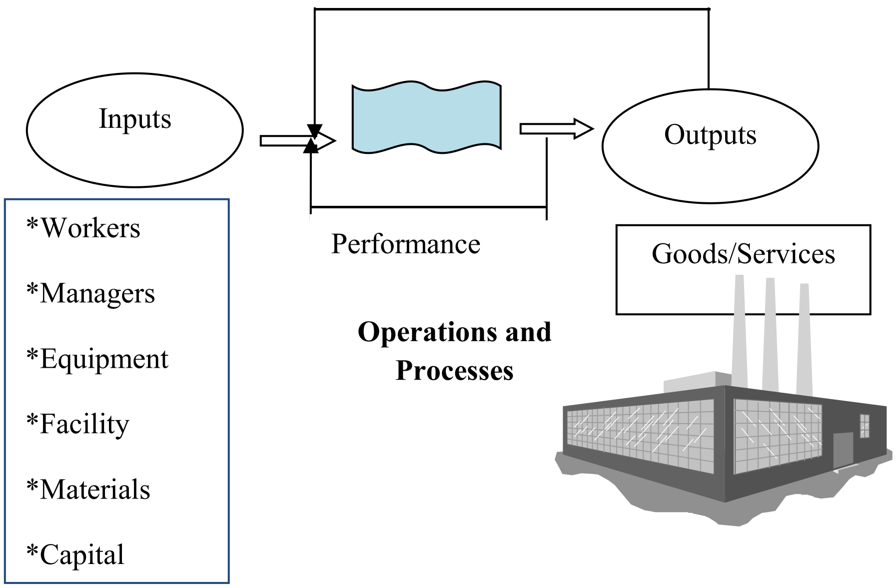
PRODUCTION AS A SYSTEM

The following are the three objectives or criteria of the production and operations system:

1. Customer satisfaction
2. Effectiveness
3. Efficiency

An organization is assumed to have efficiency if there is most suitable utilization of resource. But effectiveness has greater dimensions associated with it. It involves optimality in fulfillment of more than one targets with suitable prioritization. Production management system needs to fulfill many groups such as customers, employees as well as society. The system ought to be now not only 'Profitable' and or 'effectives have to additionally be viewed in terms of time horizons, considering that the business is running in an unsure environment.

Fig.4.1 Production/Operations system

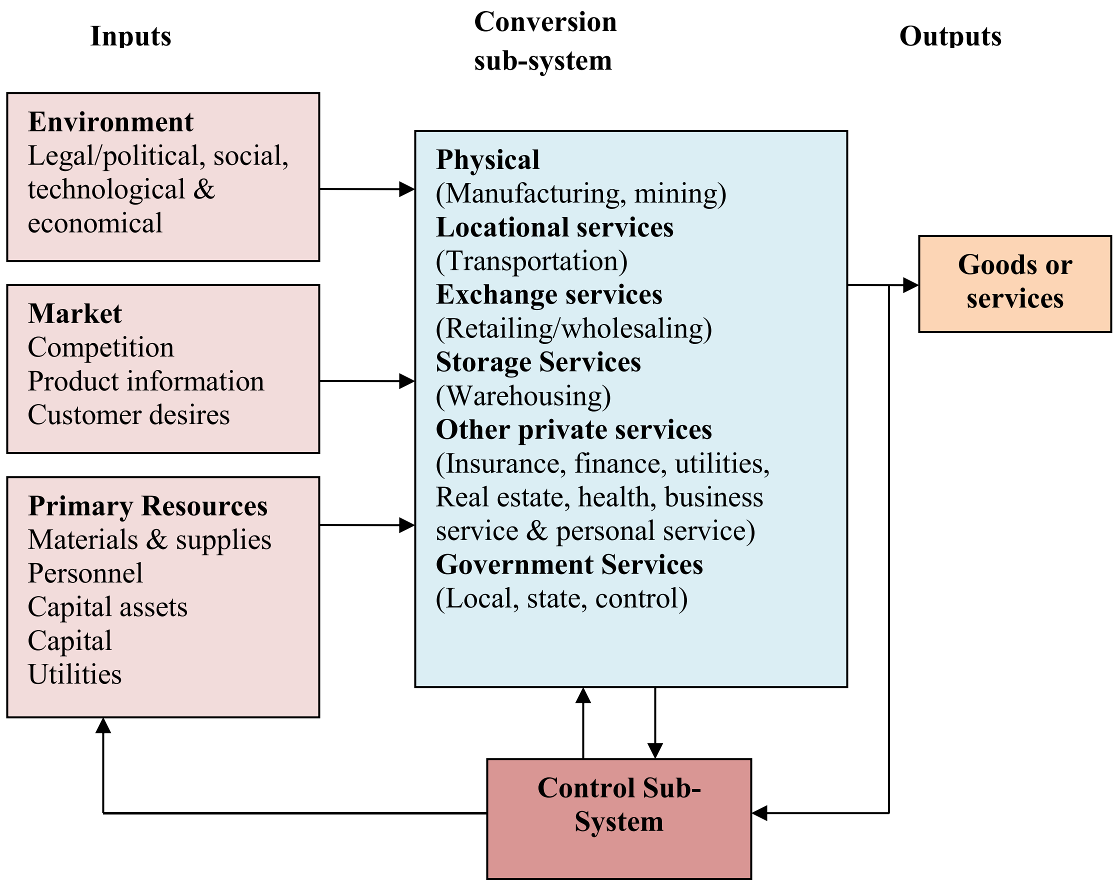


A system is a collection of interrelated entities that work together. The entire business organization can be viewed as a system, comprising of the various sub systems such as marketing, operations, finance, Human Resources, etc, which have their own lower subsystems. A system should always understand as a whole and the main theme of system is that the whole is greater than the sum of its individual parts. The production management can also be viewed as a system. The production management is further break down into two subsystems as follows:

1. Conversion sub-system
2. Control sub-system

The conversion sub systems consist of the various inputs, processes and outputs in the production processes. The products and processes are designed on the basis of various factors like environmental factors (legal, political, technological, economical, etc.), market conditions (competition, product information, customer expectations, etc.) and the primary resources (Materials and supplies, personnel, capital assets, capital, utilities, etc). The relationships between environmental factors are very much essential to decide the primary resources required for manufacturing the product. The various environmental factors determine the market conditions of the company's product. Based upon the expected finished products or services, the primary resources are decided for the manufacturing function and based upon all the above components the conversion process and the value added services are designed and implemented. Similarly the relationships between the sub components can be understood and incorporated in the business decisions to do the business successfully.

Fig 4.2 Systems Approach



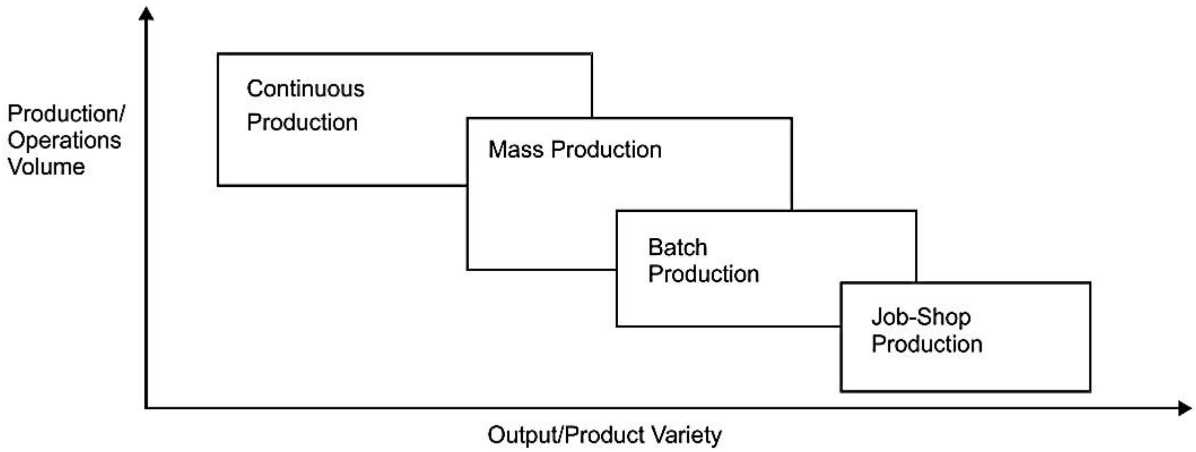
The control sub system ensures that the production process is carried out successfully in the firms as per the production plans. It ensures the quality of the products or services in all dimensions and carries out the corrective actions whenever deviations occur in the process.

TYPES OF PRODUCTION SYSTEM

Production system is the framework within which the production activities of an enterprise take place. Production systems can be classified as Job Shop, Batch, Mass and Continuous Production systems. An appropriate designing of production system ensures the coordination of various production operations. There is no single pattern of production system which is universally applicable to all types of production system and it varies from one enterprise to another. The major types of production system are discussed as follows:

1. Line Flow Process
2. Job or unit production
3. Intermittent production

Fig- 4.3 Classification of production systems



1. **Line Flow Process:**

Line flow process is subdivided into processes:

a) Assembly line

b) Continuous

a. Assembly line

Ford was the first company to introduce the concept of assembly line. Assembly line technique is used in mass production which helps the industry to manufacture goods at low unit costs. It reduces labor costs because unskilled workers are trained to perform specific tasks. An assembly line is a manufacturing process in which interchangeable parts are added to a product in a sequential manner using optimally planned logistics to create a finished product much faster than with handcrafting-type methods.

Advantages

- Speed & Mass Production
- Fair Product Cost
- Affordable
- Uniformity of finished products
- Ease of repair
- Standardized Parts Employee
- Specialization (in a specific task)
- Average Skill level sufficient
- Ease of job rotation
- Able to share Improvements in Process, Product etc.

Disadvantages

- Higher initial capital investment
- Inflexible Production facility
- Need of specialized machines
- Significant Space is required Employee
- Monotonous Work (Repetitive Work)
- Missing of unique craftsmanship (Luxury items).

- Motivational problems exists
- Skill level balancing will be a problem
- Overconfidence

b. Continuous production

Continuous production refers to the production of standardized products with a standard set of process and operation sequence in anticipation of demand. It is also known as mass flow production. This system ensures less work in process inventory and high product quality but involves large investment in machinery and equipment. The system is suitable in plants involving large volume and small variety of output e.g. oil refineries, cement manufacturing etc.

Characteristics of Continuous Production System

1. Standard products are manufactured, which have large demand throughout the year.
2. Standardized inputs and standardized sequence of operations, machine tools and equipment are used.
3. Division of labour is made more efficient.
4. Minimum and constant material handling.
5. Minimum flow of work at any point of time.
6. Small work in progress is involved.
7. Use of productivity techniques is feasible.
8. Minimum cost of production per unit is possible.
9. Rigid quality control is exercised.
10. More maintenance is required.

Types of Continuous Production

There are three types of continuous production viz., mass production, process production and assembly production.

1. Mass Production

In this type of continuous production, only one type of product or a maximum of two or three types are manufactured in large quantities, as much emphasis is not given to orders of the consumers. Standardization of product, process, materials, machine and uninterrupted flow of materials are the main characteristics of this system.

Mass production system is employed in several industries where the production is carried on without any interruption. Electronics, electrical, automobiles, bicycles and container industries are a few examples of mass production industries.

Mass production system offers economies of scale as the volume of output is large. Quality of products tends to be uniform and high due to standardization and mechanization. In a properly designed and equipped process; individual expertise plays a less prominent role. Of course, the exact quality level depends upon the quality control systems and management policy of the plant.

2. Process Production

This system is used for the manufacture of those items whose demand is continuous and high. Here, single raw material can be transformed into different kinds of products at different stages of the production process e.g., processing of crude oil in refinery — we get kerosene, gasoline, etc., at different stages of production. On the basis of the nature of production process, flow of production may be classified into

- Analytical process of production and
- Synthetic process of production.

Analytical Process of Production: In analytical process of production, a raw material is broken into different products. For example, crude oil is analyzed into gas, naphtha, petrol, etc. Similarly, coal is processed to obtain coke, coal, gas, coal-tar, etc.

Synthetic process of production: Synthetic process of production, on the other hand, involves the mixing of two or more materials to manufacture a product. For instance, lauric acid, myristic acid, plasmatic acid, stearic acid, linoleic acid, etc., are synthesized to manufacture soap.

3. Assembly Production

In assembling process, two or more components are combined to manufacture a finished product. Manufactured parts are joined into sub-assemblies or final assemblies. Such process is employed in assembling automobiles, radio sets, television sets, bicycles, watches, cameras, etc.

Assembly line is a type of flow production which was developed in the automobile industry in the U.S.A. A manufacturing unit prefers to develop and employ the assembly line because it helps to improve the efficiency of production. The use of flow production methods results in cost reduction. Assembly line is particularly useful when a limited variety of similar products is to be produced on a mass scale or in fairly large batches on a regular or continuous basis.

In any production system, the most vital decision is the proper layout of assembly line. The design of assembly line involves the proper balancing of technology and other manufacturing facilities so as to develop a rational approach for optimization of results. The assembly line design depends largely upon product design and location of production. In order to develop an assembly line, machines are positioned keeping the following considerations in view:

- The rate of flow of work
- The direction of manufacturing operations
- The inconvenience and comfort of operators or workers
- The availability of service facilities like water, electricity, compressed air, oxygen, etc.
- The supply and demand of materials.
- In an assembly line, each machine must directly receive material from the previous machine and pass it on directly to the next machine. Therefore, the location of machines is automatically regulated by the sequence of operations.

Machines and equipment should be arranged in such a manner that every operator has a free and safe access to each machine. Space should be provided for free movement of fork lifts, trucks, etc., which deliver materials and collect the finished products. The passage should not be blocked and workers must not be in danger of being hit by the moving trollies, etc. At the same time, there should be commercial utilization of floor space.

Assembly line process is employed in assembling automobiles, radios, television sets, computers and other electrical and electronic products.

Advantages of Continuous Production System

1. Reduced Labour cost
2. High accuracy
3. Reduced material handling
4. Simple control process
5. Minimum wastage
6. Better materials /inventory control
7. Higher return on investments

Disadvantages of Continuous Production System

1. Heavy loss during slack demand period
2. Rigid maintenance and upkeep of machines
3. Customers' tastes cannot be met as only one standard product is manufactured.
4. Difficult to adjust to new situations and specifications.
5. Special purpose machine tools are required.

Suitability of Continuous Production System

Continuous system is best suited to organizations which intend to produce a limited variety of products on a large scale. The heavy fixed costs of specialized equipment that are utilized for operating at low cost per unit can be distributed over a high volume of output.

Continuous production system can be applied to those industries which satisfy the following requirements:

- Uniform demand,
- High volume of production,
- product standardization, and
- Process balancing.

2. Job or Unit production:

Job production is a manufacturing process which involves workers making a single unique customized product for a single customer. Depending upon the customer needs, job production method is used to create a product from start to finish. This method of production is not used for producing goods in mass quantity. It involves production as per customer's specification and expectations. Each batch or order consists of a small lot of identical products and is different from other batches. The system requires comparatively smaller investment in machines and equipment. It is flexible and can be adapted to changes in product design and order size without much inconvenience.

Fig-4.4 Job Production

Characteristics of Job Production

Manufacturing goods or products based on this method is characterized by the following features:

1. Low production volume: Job production focuses on delivering goods for one customer at a time.

2. Varied timelines: Since the product is dependent on individual customer needs, there is no fixed time in completion of the product.
3. Highly skilled workers: Since the product has to be customized, the workers need to have special skills & expertise to carry out job production.
4. Detailed planning: As compared to mass or batch production, where you can plan once, job production requires planning as per the customer order received.

Examples of Job Production

Some examples of job production, to create customized products for customers are:

1. Building construction is a job production where each building has a different architecture, design, landscape, geography, investments, materials etc.
2. Creating customized clothes like wedding gowns, tuxedos require custom planning, design & execution, and uses expertise of tailors to stitch these special clothes.
3. Jewellery items like necklaces, bracelets, rings etc. are often customized using special designs, metals, gems etc.

Advantages & Disadvantages of Job Production

Some advantages of this method of manufacturing are:

1. Higher quality of finished product.
2. Customizations can be done based on exact customer requirement.
3. Higher customer satisfaction for a high-quality product.
4. Because of expertise of skilled workers, companies can charge higher for job production.

Some disadvantages of job production are:

1. Higher cost of production.
2. Requires special planning every time a new customer comes.
3. Very slow volumes of production.

4. Intermittent or Batch Production:

According to APICS (American Production and Inventory Control), intermittent production is defined as a form of manufacturing in which the job pass through the functional departments in lots or batches and each lot may have a different routing. Under this system the goods are produced partly for inventory and partly for customer's orders. E.g. components are made for inventory but they are combined differently for different customers. Automobile plants, printing presses, electrical goods plant are examples of this type of manufacturing.

Characteristics

- Falls between mass production and jobbing.
- All components are completed at a workstation before they move to the next one
- One batch of products must be completed before work on the next one may begin.
- Customers give their specifications.
- Similar products produced on a batch basis, in large quantities.

Advantages

- It can reduce initial capital outlay because a single production line can be used to produce several products.
- Be useful for small businesses who cannot afford to run continuous production lines
- Greater flexibility in terms of quantity produced, factory layout and manufacturing process.
- Can adjust to changes in demand.

- Less time wasted during machinery-breakdowns.
- Less expensive machinery.

Disadvantages

- Products take longer to produce.
- Larger quantities of semi-finished goods must be kept, hence increasing stockpiling costs.
- Cost per unit is generally higher.

MANAGING OPERATIONS

Managing operations can be enclosed in a frame of general management function as shown in the following figure. Operation managers are concerned with planning, organizing, and controlling the activities which affect human behaviour through models.

Planning

The activity that establishes a course of action and guide future decision-making is planning. The operations manager defines the objectives for the operations subsystem of the organization, and the policies, and procedures for achieving the objectives. This stage includes clarifying the role and focus of operations in the organization's overall strategy. It also involves product planning, facility designing and using the conversion process.

Organizing

It refers to the activities that establish a structure of tasks and authority. Operation managers establish a structure of roles and the flow of information within the operations subsystem. They determine the activities required to achieve the goals and assign authority and responsibility for carrying them out.

Controlling

Activities that assure the actual performance in accordance with planned performance. To ensure that the plans for the operations subsystems are accomplished, the operations manager must exercise control by measuring actual outputs and comparing them to planned operations management. Controlling costs, quality, and schedules are the important functions here.

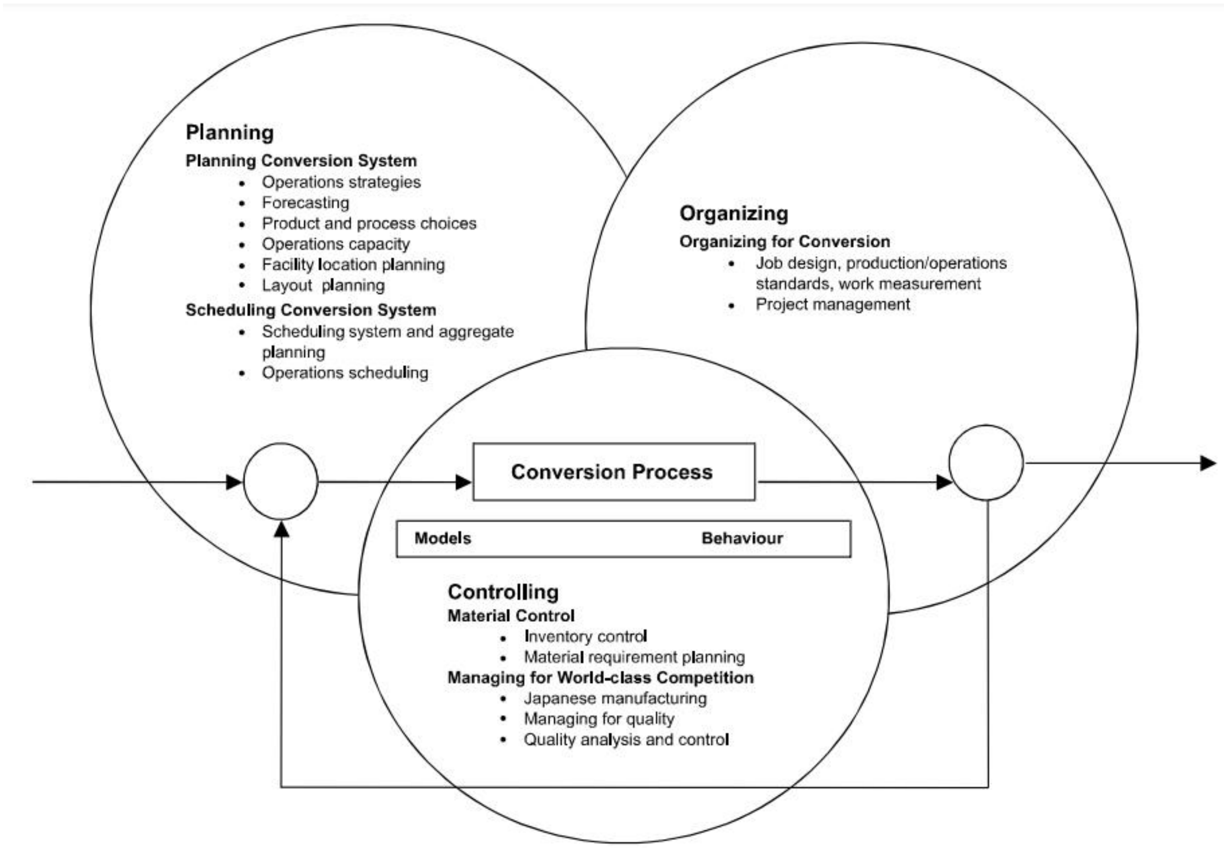
Behaviour

Operation managers are concerned with how their efforts to plan, organize, and control affect human behaviour. They also want to know how the behaviour of subordinates can affect management's planning, organizing, and controlling actions. Their interest lies in decision making behaviour.

Models

As operation managers plan, organize, and control the conversion process, they encounter many problems and must make many decisions. They can simplify their difficulties using models like aggregate planning models for examining how best to use existing capacity in short-term, break-even analysis to identify break even volumes, linear programming and computer simulation for capacity utilization, decision tree analysis for long-term capacity problem of facility expansion, simple median model for determining best locations of facilities etc.

Fig-4.5 General model for managing operations



OBJECTIVES OF OPERATIONS MANAGEMENT

Objectives of operations management can be categorized into customer service and resource utilization.

a. Customer Service

The first objective of operating systems is the customer service to the satisfaction of customer wants. Therefore, customer service is a key objective of operations management. The operating system must provide something to a specification which can satisfy the customer in terms of cost and timing. Thus, primary objective can be satisfied by providing the 'right thing at a right price at the right time'.

These aspects of customer service specification, cost and timing are described for four functions in the following Table. They are the principal sources of customer satisfaction and must, therefore, be the principal dimension of the customer service objective for operations managers.

Table- 4.1 Aspects of customer service

Principal function	Principal customer wants	
	Primary considerations	**Other considerations**
Manufacture	Goods of a given, requested or acceptable specification	**Cost**, i.e., purchase price or cost of obtaining goods. **Timing**, i.e., delivery delay from order or request to receipt of goods.
Transport	Management of a given, requested or acceptable specification	**Cost**, i.e., cost of movements. **Timing**, i.e., 1. Duration or time to move. 2. Wait or delay from requesting to its commencement.
Supply	Goods of a given, requested or acceptable specification	**Cost,** i.e., purchase price or cost of obtaining goods. **Timing,** i.e., delivery delay from order or request to receipt of goods.
Service	Treatment of a given, requested or acceptable specification	**Cost,** i.e., cost of movements. **Timing,** i.e., 1. Duration or time required for treatment. 2. Wait or delay from requesting treatment to its commencement.

Generally, an organization will aim reliably and consistently to achieve certain standards and operations manager will be influential in attempting to achieve these standards. Hence, this objective will influence the operations manager's decisions to achieve the required customer service.

b. Resource Utilization

Another major objective of operating systems is to utilize resources for the satisfaction of customer wants effectively, i.e., customer service must be provided with the achievement of effective operations through efficient use of resources. Inefficient use of resources or inadequate

Customer service leads to commercial failure of an operating system.

Operations management is concerned essentially with the utilization of resources, i.e., obtaining maximum effect from resources or minimizing their loss, underutilization or waste. The extent of the utilization of the resources' potential might be expressed in terms of the proportion of available time used or occupied, space utilization, levels of activity, etc. Each measure indicates the extent to which the potential or capacity of such resources is utilized. This is referred as the objective of resource utilization.

Operations management is also concerned with the achievement of both satisfactory customer service and resource utilization. An improvement in one will often give rise to deterioration in the other. Often both cannot be maximized, and hence a satisfactory performance must be achieved on both objectives. All the activities of operations management must be tackled with these two objectives in mind, and many of the problems will be faced by operations managers because of this conflict. Hence, operations managers must attempt to balance these basic objectives.

The following Table summarizes the twin objectives of operations management. The type of balance established both between and within these basic objectives will be influenced by market considerations, competitions, the strengths and weaknesses of the organization, etc. Hence, the operations managers should make a contribution when these objectives are set.

The twin objectives of operations management

1. **The customer service objective.** To provide agreed/adequate levels of customer service (and hence customer satisfaction) by providing goods or services with the right specification, at the right cost and at the right time.
2. **The resource utilization objective.** To achieve adequate levels of resource utilization (or productivity) e.g., to achieve agreed levels of utilization of materials, machines and labour.

RELATIONSHIP OF OPERATIONS MANAGEMENT WITH OTHER MANAGEMENT FUNCTIONS

The term operations management refers to the systematic design, direction, and control of processes that transform inputs into services and products for internal as well as external, customers. Operation is one of the functions within on organization. Each function possesses its own knowledge and skill areas, responsibilities, processes and decisions. Department and functions are linked together through processes. Hence proper co-ordination is essential among the functional departments in order to ensure proper attainment of organizational goals.

Fig-4.6 Relationship of Marketing, Operations and Finance Functions

Operations function is having close relationship with the marketing function, which determines the need for new services/ products and the customer's satisfaction. Marketing function does the demand forecast based on market research which helps the operation managers to plan the output and capacities. Marketing, design and production departments need to co-ordinate and work together to successfully develop new products and implement changes in the design. Marketing function also gives the idea regarding competitors and their products. Operation function also gets the help from the other functional areas such as Finance, Accounting, Human Resource Management, Engineering etc.

Financial management helps the operations managers through financial measures which help them to assess the various cost associated with production, the long –term benefits of new technologies and quality improvements. It also influences decision about design, expansions, inventory control and quality control. Finance and operations departments co-operate each other by mutually exchanging the information regarding budgeting, economical analysis of investment proposals and provision of funds. Accounting function helps the operations managers to monitor the production systems vital signs with multiple tracking methods.

HRM helps the operations management to recruit, select and train employees for the processes involved in the function, engineering assists OM in designing new products or services by considering technical trade-offs and economy. Henceforth, marketing, operations, finance and human resource departments must co-ordinate on the various functions of the organizations such as product and process design, forecasting, setting realistic schedules, quality and quantity decisions, etc. in order achieve the organizational goals. The operations also interacts with other functional areas of the management such as legal, Management Information System (MIS), public relations etc.

MANAGING GLOBAL OPERATIONS

The term 'globalization' describes businesses' deployment of facilities and operations around the world. Globalization can be defined as a process in which geographic distance becomes a factor of diminishing importance in the establishment and maintenance of cross border economic, political and socio-cultural relations. It can also be defined as worldwide drive toward a globalized economic system dominated by supranational corporate trade and banking institutions that are not accountable to democratic processes or national governments. There are four developments, which have spurred the trend toward globalization. These are:

1. Improved transportation and communication technologies;
2. Opened financial systems;
3. Increased demand for imports; and
4. Reduced import quotas and other trade barriers.

When a firm sets up facilities abroad it involves some added complexities in its operation. Global markets impose new standards on quality and time. Managers should not think about domestic markets first and then global markets later, rather it could be thought globally and act locally. Also, they must have a good understanding of their competitors. Some other important challenges of managing multinational operations include other languages and customs, different management style, unfamiliar laws and regulations, and different costs. Managing global operations would focus on the following key issues:

- To acquire and properly utilize the following concepts and those related to global operations, supply chain, logistics, etc.
- To associate global historical events to key drivers in global operations from different perspectives.
- To develop criteria for conceptualization and evaluation of different global operations.
- To associate success and failure cases of global operations to political, social, economic and technological environments.
- To envision trends in global operations.
- To develop an understanding of the world vision regardless of their country of origin, residence or studies in a respectful way of perspectives of people from different races, studies, preferences, religion, politic affiliation, place of origin, etc.

Discussion Forum

Short questions:

1. What do you mean by 'Production'?
2. What do you mean by production system?
3. Mention the different types of production systems.
4. What is job shop production?
5. What is batch production?
6. What is mass production?
7. What is continuous production?
8. Mention any four advantages of job shop production.
9. Mention any four limitations of job shop production.
10. Mention any four advantages of batch production.
11. Mention any four limitations of batch production.
12. Mention any four advantages of mass production.
13. Mention any four limitations of mass production.
14. Mention any four advantages of continuous production.
15. Mention any four limitations of continuous production.
16. Define production management.

17. Mention any four objectives of production management.
18. Define operating system.
19. How do you manage operations?
20. What do you mean by operations?
21. What do you mean by manufacturing operations?
22. What do you mean by service operations?
23. What do you mean by ‘globalization’?

Essay Type Questions:

1. Briefly explain the production system and its characteristics.
2. What is job shop production? What are its characteristics, advantages and limitations?
3. What is batch production? What are its characteristics, advantages and limitations?
4. What is batch production? What are its characteristics, advantages and limitations?
5. What is mass production? What are its characteristics, advantages and limitations?
6. What is continuous production? What are its characteristics, advantages and limitations?
7. Explain in brief the objectives of production management.
8. Explain in brief the objectives of operations management.
9. Distinguish between manufacturing operations and service operations.
10. Explain the key issues to be considered for managing global operations.
11. Explain the different types of production systems.
12. Explain the framework of managing operations.
13. Explain the scope of production and operations management.

Skill Development

Visit a fast-food restaurant like Pizza hut, Pizza corner to understand the concept of this chapter by getting the information for the following questions.

1. Identify the type of production system followed.
2. Check how production system is managed.
3. Find out utilization of the resources namely manpower, capacity and material.
4. How the customer services are rendered (feedback system exists or not)

CHAPTER -5

FACILITY LOCATION AND FACILITY LAYOUT

FACILITY LOCATION

The location where companies' setup their operations is called as facility location. Facility location refers to the choice of place and the determination of a specific site for setting up a enterprise or factory. But the choice is made solely after considering cost and advantages of distinctive alternative sites. It is a strategic decision that cannot be changed once taken. If at all modified only at considerable loss, the location should be chosen as per its personal requirements and circumstances. Each individual plant is a case in itself. Businessman need to attempt to make a strive for ideal or ideal location.

Need for selecting a suitable location:

A suitable location has to be selected in the following two situations:

- When starting a new factory
- When expanding the existing firms for increasing its capacity.
- In case of Global Location

Facility location is the process of identifying the best geographic location for a service or production facility. It is crucial to select suitable location for economic and effective operations.

CHOICE OF FACILITY LOCATION

a. In Case of Location Choice for the First Time or New Factory:

Cost economies are always important while selecting a location for the first time, but should keep in mind the cost of long-term business/organizational objectives. The following are the factors to be considered while selecting the location for the new organizations:

1. Identification of region: The organizational objectives along with the various long-term considerations about marketing, technology, internal organizational strengths and weaknesses, region specific resources and business environment, legal-governmental environment, social environment and geographical environment suggest a suitable region for locating the operations facility.

2. Choice of a site within a region: Once the suitable region is identified, the next step is choosing the best site from an available set. Choice of a site is less dependent on the organization's long-term strategies. Evaluation of alternative sites for their tangible and intangible costs will resolve facilities-location problem. The problem of location of a site within the region can be approached with the following cost-oriented non-interactive model, i.e., dimensional analysis.

3. Dimensional analysis: If all the costs were tangible and quantifiable, the comparison and selection of a site is easy. The location with the least cost is selected. In most of the cases intangible costs which are expressed in relative terms than in absolute terms. Their relative merits and demerits of sites can also be compared easily. Since both tangible and intangible costs need to be considered for a selection of a site, dimensional analysis is used.

Dimensional analysis consists in computing the relative merits (cost ratio) for each of the cost items for two alternative sites. For each of the ratios an appropriate weightage by means of power is given and multiplying these weighted ratios to come up with a comprehensive figure on the relative merit of two alternative sites, i.e.,

When starting a new factory, plant location decisions are very important because they have direct bearing on factors like, financial, employment and distribution patterns. In the long run, relocation of plant may even benefit the organization. But, the relocation of the plant involves stoppage of production, and also cost for shifting the facilities to a new location. In addition to these things, it will introduce some inconvenience in the normal functioning of the business. Hence, at the time of starting any industry, one should generate several alternate sites for locating the plant. After a critical analysis, the best site is to be selected for commissioning the plant. Location of warehouses and other facilities are also having direct bearing on the operational performance of organizations.

The existing firms will seek new locations in order to expand the capacity or to place the existing facilities. When the demand for product increases, it will give rise to following decisions:

- Whether to expand the existing capacity and facilities.
- Whether to look for new locations for additional facilities.
- Whether to close down existing facilities to take advantage of some new locations.

b. In Case of Location Choice for Existing Organization

In this case a manufacturing plant has to fit into a multi-plant operations strategy. That is, additional plant location in the same premises and elsewhere under following circumstances:

1. Plant manufacturing distinct products.
2. Manufacturing plant supplying to specific market area.
3. Plant divided on the basis of the process or stages in manufacturing.
4. Plants emphasizing flexibility.

The different operations strategies under the above circumstances could be:

1. Plants manufacturing distinct products: Each plant services the entire market area for the organization. This strategy is necessary where the needs of technological and resource inputs are specialized or distinctively different for the different product-lines.

For example, a high-quality precision product-line should not be located along with other product-line requiring little emphasis on precision. It may not be proper to have too many contradictions such as sophisticated and old equipment, highly skilled and semi-skilled personnel, delicate processes and those that could permit rough handlings, all under one roof and one set of managers. Such a setting leads to much confusion regarding the required emphasis and the management policies. Product specialization may be necessary in a highly competitive market. It may be necessary to exploit the special resources of a particular geographical area. The more decentralized these pairs are in terms of the management and in terms of their physical location, the better would be the planning and control and the utilization of the resources.

2. Manufacturing plants supplying to a specific market area: Here, each plant manufactures almost all of the company’s products. This type of strategy is useful where market proximity consideration dominates the resources and technology considerations. This strategy requires great deal of coordination from the corporate office. An extreme example of this strategy is that of soft drinks bottling plants.

3. Plants divided on the basis of the process or stages in manufacturing: Each production process or stage of manufacturing may require distinctively different equipment capabilities, labour skills, technologies, and managerial policies and emphasis. Since the products of one plant feed into the other plant, this strategy requires much centralized coordination of the manufacturing activities from the corporate office that are expected to understand the various technological aspects of all the plants.

4. Plants emphasizing flexibility: This requires much coordination between plants to meet the changing needs and at the same time ensure efficient use of the facilities and resources. Frequent changes in the long-term strategy in order to improve be efficiently temporarily, are not healthy for the organization. In any facility location problem, the central question is: ‘Is this a location at which the company can remain competitive for a long time?’

c. For an established organization in order to add on to the capacity, following are the ways:

(i) Expansion of the facilities at the existing site: This is acceptable when it does not violate the basic business and managerial outlines, i.e., philosophies, purposes, strategies and capabilities. For example, expansion should not compromise quality, delivery, or customer service.

(ii) Relocation of the facilities (closing down the existing ones): This is a drastic step which can be called as 'Uprooting and Transplanting'. Unless there are very compelling reasons, relocation is not done. The reasons will be either bringing radical changes in technology, resource availability or another destabilization.

All these factors are applicable to service organizations, whose objectives, priorities and strategies may differ from those of hardcore manufacturing organizations.

d. In Case of Global Location

Because of globalization, multinational corporations are setting up their organizations in India and Indian companies are extending their operations in other countries. In case of global locations there is scope for virtual proximity and virtual factory.

(i) Virtual Proximity

With the advance in telecommunications technology, a firm can be in virtual proximity to its customers. For a software services firm much of its logistics is through the information/ communication pathway. Many firms use the communications highway for conducting a large portion of their business transactions. Logistics is certainly an important factor in deciding on a location—whether in the home country or abroad. Markets have to be reached. Customers have to be contacted. Hence, a market presence in the country of the customers is quite necessary.

(ii) Virtual Factory

Many firms based in USA and UK in the service sector and in the manufacturing sector often out sources part of their business processes to foreign locations such as India. Thus, instead of one's own operations, a firm could use its business associates' operations facilities. The Indian BPO firm is a foreign-based company's 'virtual service factory'. So a location could be one's own or one's business associates. The location decision need not always necessarily pertain to own operations.

REASONS FOR A GLOBAL/FOREIGN LOCATION

A. TANGIBLE REASONS

The tangible reasons for setting up an operations facility abroad could be as follows:

Reaching the customer: One of the most important reasons for companies to locate facilities in other countries is to expand their market share through global business expansion strategy. The phenomenal growth of India's GDP is a major reason for multinational corporations to establish operations in our country. One of the most important reasons is to provide timely and cost-effective service to customers, which is logistically dependent. As a result, cost and logistics are reasons for locating manufacturing facilities outside of the United States. By logistics set of activities closes the gap between production of goods/services and reaching of these intended goods/services to the customer to his satisfaction. Reaching the customer is thus the main objective. The tangible and intangible gains and costs depend upon the company defining for it as to what that 'reaching' means. The tangible costs could be the logistics related costs; the intangible costs may be the risk of operating is a foreign country. The tangible gains are the immediate gains; the intangible gains are an outcome of what the company defines the concepts of reaching and customer for it.

The other tangible reasons could be as follows:

a) The host country may offer substantial tax advantages compared to the home country.

b) The costs of manufacturing and running operations may be substantially less in that foreign country. This may be due to lower labour costs, lower raw material cost, better availability of the inputs like materials, energy, water, ores, metals, key personnel etc.

c) The company may overcome the tariff barriers by setting up a manufacturing plant in a foreign country rather than exporting the items to that country

B. INTANGIBLE REASONS

The intangible reasons for considering setting up an operations facility abroad could be as follows:

1. Customer-related Reasons

a) With an operations facility in the foreign country, the firm's customers may feel secure that the firm is more accessible. Accessibility is an important 'service quality' determinant.

b) The firm may be able to give a personal tough.

c) The firm may interact more intimately with its customers and may thus understand their requirements better.

d) It may also discover other potential customers in the foreign location.

2. Organizational Learning-related Reasons

(a) The firm can learn advanced technology. For example, it is possible that cutting-edge technologies can be learn by having operations in a technologically more advanced country. The firm can learn from advanced research laboratories/universities in that country. Such learning may help the entire product-line of the company.

(b) The firm can learn from its customers abroad. A physical location there may be essential towards this goal.

(c) It can also learn from its competitors operating in that country. For this reason, it may have to be physically present where the action is.

(d) The firm may also learn from its suppliers abroad. If the firm has a manufacturing plant there, it will have intensive interaction with the suppliers in that country from whom there may be much to learn in terms of modern and appropriate technology, modern management methods, and new trends in business worldwide.

3. Other Strategic Reasons

(a) The firm by being physically present in the host country may gain some 'local boy' kind of psychological advantage. The firm is no more a 'foreign' company just sending its products across international borders. This may help the firm in lobbying with the government of that country and with the business associations in that country.

(b) The firm may avoid 'political risk' by having operations in multiple countries.

(c) By being in the foreign country, the firm can build alternative sources of supply. The firm could, thus, reduce its supply risks.

(d) The firm could hunt for human capital in different countries by having operations in those countries. Thus, the firm can gather the best of people from across the globe.

(e) Foreign locations in addition to the domestic locations would lower the market risks for the firm. If one market goes slow the other may be doing well, thus lowering the overall risk.

NEED FOR FACILITY LOCATION PLANNING

- Facility location planning is also required for providing a cost benefit to the organisation.
- The location planning should help in reducing the transportation cost for the organisation.
- This ultimately helps in decreasing the cost of production and generating cost advantage for the organisation.
- It is also needed to identify proximity to the sources of raw materials and transportation facilities.
- A facility should ideally be located at a place where raw materials are available. This is necessary for maintaining continuity in the production process.

What is an ideal location?

An ideal location is one where the cost of the product is kept to minimum, with a large market share, the least risk and the maximum social gain. It is the place of maximum net advantage or which gives lowest unit cost of production and distribution. For achieving this objective, the management can make use of locational analysis for this purpose.

FACTORS INFLUENCING THE LOCATION

Facility location is the right location for the manufacturing facility. It will have sufficient access to the customers, workers, transportation, etc. Facility location determination is a business critical strategic decision. There are several factors, which determine the location of facility among them competition, cost and corresponding associated effects. Overall goal of an organization is to satisfy the customers by providing quality products and services. Thus, it becomes essential for an organization to have appropriate strategy around its manufacturing unit.

Manufacturing Unit: It is the place where all the inputs like- labor raw, materials, equipment, etc. combine together to manufacture products for the end users i.e. customers. Therefore, one of the most crucial factors in determining the success of the manufacturing unit is the location of the operations.

Facility location involves various scientific process using different-different techniques.

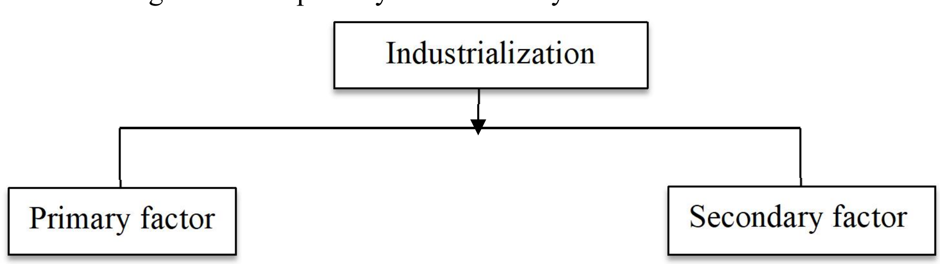
1. Location Selection Factors

For a company working in global environment some factors are very important such as- cost available infrastructure, labor skill, government rules and environment. Any location is considered to be appropriate if it ensures- access to customers, skilled labors, and transportation.

Organization can easily move towards success in the global competitive environment by selecting perfect location.

2. Industrialization

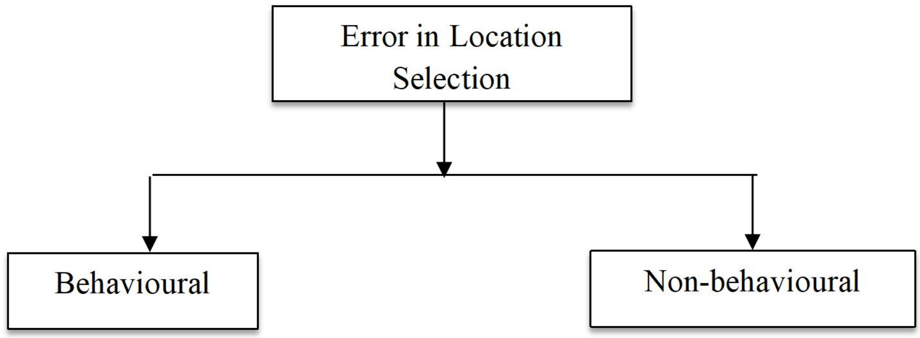
Geographical area is also a focal point for different facility locations depending on many parameters or factors. These factors can be categorized into primary and secondary factors:



i Primary Factors
A primary factor which leads to industrialization of a particular geographic area for a particular goods manufacturing is material, labour, presence of similar manufacturing facilities.
ii Secondary Factors
These factors include the availability of credit finance, communication infrastructure and insurance.

3. Errors in location selection

Facility location is very important for the continuation and growth of organization. So, it is better to avoid mistakes while selecting the location. Error in location selection can be divided into 2 broad parts-:



i. Behavioral errors

When executives of the company make decisions relying more on personal factors rather than success of location, it can be referred to as behavioral errors.

Example-: Facility of movement of personal establishment from hometown to new location.

ii. Non-behavioral errors

These types of errors occur when the critical factors are ignored; there is lack of proper investigation and analysis.

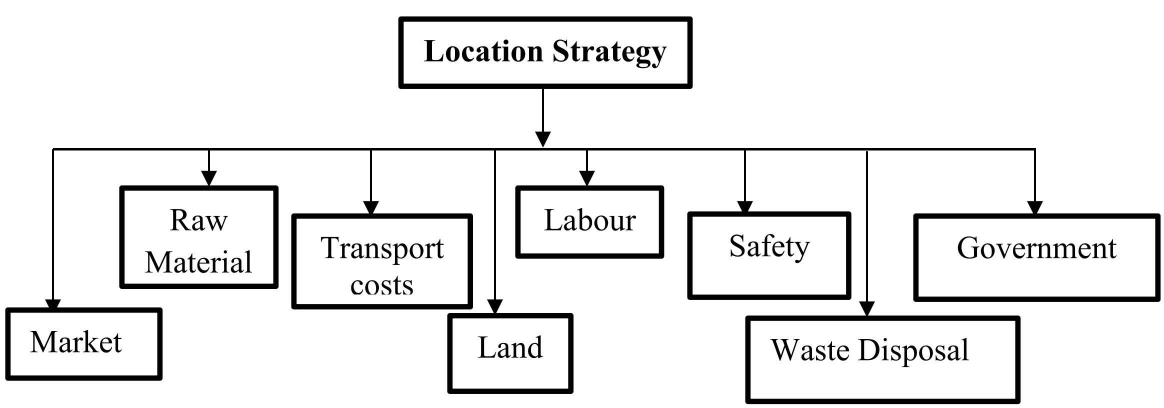
4. Location Strategy

It is important for the business to have access to the customers at minimum possible cost. This can be achieved by preparing location strategy. Location strategy is helpful for the company in determining the market, demand, different markets, etc.

Some critical factors to be considered before configuring the right location are as follows:

i. **Market:** The nearness of the market from the location and the cost of delivering the goods are important factors.
ii. **Raw materials;** Raw materials may be bulky or expensive to transport, so it is beneficial to locate near to them.

Fig- 5.1 Location Strategy



iii. **Transport Costs:** 'Pull of the market and 'Pull of the raw materials', are the two major influences. These are determined by whether the industry is bulk-increasing or bulk decreasing or not.
iv. **Land:** Plant location is affected by the topography area, shape of the site, costs, drainage facilities, probability of floods, etc.

v. **Labour:** The availability of skilled labour in any particular area is an attraction for the entrepreneurs as it is in their interest.

vi. **Safety:** Some industries need to locate their unit far away from density population and thus, their choice gets limited.

vii. **Waste disposal:** Some industries produce considerable waste and the cost of disposal might affect the location.

viii. **Government:** Government gives importance to areas of high unemployment.

Apart from the above discussed factors, some more factors also need due consideration in making choice of facility location:

1. Climatic conditions: With the developments of technology, in the field of heating, ventilating, air-conditioning, etc. climate of the area does not create much problem, but its control requires heavy expenses.

2. Community attitude: Attitude of local people and whether they want the work or not has much impact on the success of the industry.

3. Financial and other aids: Some states provide aids as- loans, feed money, machinery, etc. in order to attract the entrepreneurs.

4. Customers: Is the location convenient for customers? This is the basic question to be answered appropriately. Since customers are the end users of the products or services, their convenience must be given due importance.

5. Staff: It should be ensured that staff can be easily available with all required skills and capabilities and who will to work at the right wage?

6. Free Trade Zone/Agreement: Free-trade zones promote the establishment of manufacturing facility by providing incentives in custom duties and levies. On another hand free trade agreement is among countries providing an incentive to establish business, in particular, country.

7. Nearness to adequate banking and credit facilities: For the efficient and smooth running of the business and for meeting working capital requirements, banking facilities play an important role. Nearness to banks and other financial institutions is an important consideration now-a- days in deciding location of an industrial unit. This is because banking has become indispensable part of modern business. In case of rural and small-scale industries, banks and financial institutions play an important role and provide invaluable service in order to cater their financial needs.

8. Facilities of repairs, water, fire, lighting, etc.: In order to maintain uninterrupted production, facilities with regard to repairs of machinery, plant and other components (in case of breakdown), must be kept in mind before setting a factory. A large-scale concern can afford to install its own repair workshops, whereas small concerns may rely on various repair shops working near the factory.

Appropriate firefighting capabilities must be established to protect the factory from the risk of fire. Fire extinguishers, sand buckets, and other firefighting equipment must be organized on an internal level. In the event that it becomes necessary to summon the fire department, suitable preparations must be taken.

Soil and climatic conditions are very important for the establishment of various types of industries like tea, coffee, rubber and tobacco. On account of this factor, jute industry developed in West- Bengal and tea industry in Assam. Similarly, topography (e.g., hilly or rocky surface) of a place also influences location of an industry.

Areas which are frequently subjected to earthquakes and other natural calamities may not attract many industries. Climate of a place also considerably affects the efficiency of workers. Efficient workers are found in cool climatic regions.

On the other hand, workers from tropical regions are not generally so efficient. This also affects the establishment of an industrial unit. Another important point in this regard is that means of transportation and communication are more in plains rather than in hilly areas. That is why industries have developed largely in plains rather than in hilly areas.

9. Possibility to expand as per the requirements in future: The area for location should be such as to provide all possible opportunities for future development and expansion of the industrial unit without involving extra cost. Every industrial undertaking is established with the aim to expand in future.

10. Availability of research facilities: The main aim of any industrial undertaking is to have maximum production with minimum cost. Constant research and experimentation are undertaken to develop products and improved methods of production. Large concerns can afford to have a separate research department to meet this end, but in case of small and medium industrial units such facilities may be provided by specialized scientific and research institutions. Existence of such specialized institutions must be kept in mind before starting an industrial unit.

Table-5.1 Factors influencing Location Decisions

General Factors: 1. Availability of raw materials 2. Proximity to the market 3. Labor supply 4. Transportation and communication. 5. Power and fuel. 6. Climate and topography. 7. Momentum of an early start 8. Supply of capital 9. Government policy 10. Strategic considerations 11. Miscellaneous.	**Supply Factors** These are concerned with the operating costs of the location which include: 1. Labor costs. 2. Land costs. 3. Energy costs. 4. Transport cost. 5. Community factors. Local amenities and services. Local government attitude to support the business. Language. Political stability.
Demand Factors: These are the factors affecting customer service and revenues like: 1. Customer Convenience. 2. Labor Skills. 3. Site Availability. 4. Image. 5. Expansion Potential	**Company Requirement:** Some of the basics requirement of a company is as follows which need due consideration in location selection: 1. Size 2. Traffic. 3. Population. 4. Infrastructure. 5. Total costs. 6. Labor. 7. Suppliers.

LOCATIONAL ANALYSIS

Locational analysis is a dynamic process where the management analyses and compares the appropriateness or otherwise of alternative sites with the aim of selecting the best site for a given enterprise.

It consists the following:

(a) **Demographic Analysis:** It involves study of population in the area in terms of total population (in no.), age composition, per capita income, educational level, occupational structure etc.

(b) **Trade Area Analysis:** It is an analysis of the geographic area that provides continued clientele to the firm. He would also see the feasibility of accessing the trade area from alternative sites.

(c) **Competitive Analysis:** It helps to judge the nature, location, size and quality of competition in a given trade area.

(d) **Traffic analysis:** To have a rough idea about the number of potential customers passing by the proposed site during the working hours of the shop, the traffic analysis aims at judging the alternative sites in terms of pedestrian and vehicular traffic passing a site.

(e) **Site economics:** Alternative sites are evaluated in terms of establishment costs and operational costs under this. Costs of establishment is basically cost incurred for permanent physical facilities but operational costs are incurred for running business on day-to-day basis, they are also called as running costs.

Illustration

Two sites A and B are evaluated in terms of above mentioned two costs as follows:

Costs	**Site A (Rs.)**	**Site B (Rs.)**
Cost of establishments:		
Land and Buildings	350000	230000
Equipment	60000	60000
Transport facilities	20000	30000
Cost of operations:		
Materials, freight and Carriage	34000	24000
Taxes and insurance	10000	7500
Labour	100000	70000
Water, power and fuel	10000	8000
Total	**584000**	**429500**

The above cost statement indicates that site 'B' is preferable to site 'A' keeping in mind economic considerations only although in some respects site A has lower costs. By applying the definition of ideal location which is the place of maximum net advantage or which gives lowest unit cost of production and distribution, site B would be preferred.

SELECTION CRITERIA

The important considerations for selecting a suitable location are given as follows:

a. Natural or climatic conditions.
b. Availability and nearness to the sources of raw material.
c. Transport costs-in obtaining raw material and also distribution or marketing finished products to the ultimate users.
d. Access to market: small businesses in retail or wholesale or services should be located within the vicinity of densely populated areas.
e. Availability of Infrastructural facilities such as developed industrial sheds or sites, link roads, nearness to railway stations, airports or sea ports, availability of electricity, water, public utilities, civil amenities and means of communication are important, especially for small scale businesses.
f. Availability of skilled and non-skilled labour and technically qualified and trained managers.
g. Banking and financial institutions are located nearby.
h. Locations with links: to develop industrial areas or business centres result in savings and cost reductions in transport overheads, miscellaneous expenses.

i. Strategic considerations of safety and security should be given due importance.
j. Government influences: Both positive and negative incentives to motivate an entrepreneur to choose a particular location are made available. Positive includes cheap overhead facilities like electricity, banking transport, tax relief, subsidies and liberalization. Negative incentives are in form of restrictions for setting up industries in urban areas for reasons of pollution control and decentralization of industries.
k. Residence of small business entrepreneurs want to set up nearby their homelands. One study of locational considerations from small-scale units revealed that the native place or homelands of the entrepreneur was the most important factor.

Significance

From the discussion above, we have already learnt that location of a plant is an important entrepreneurial decision because it influences the cost of production and distribution to a great extent. In some cases, location may contribute to even 10% of cost of manufacturing and marketing. Therefore, an appropriate location is essential to the efficient and economical working of a plant. A firm may fail due to bad location or its growth and efficiency may be restricted.

TYPES OF BUSINESS LOCATIONS

The various types of business locations are as follows:

1. Downtown / central shopping district.
2. Neighbourhood shopping Centre.
3. Community shopping Centre.
4. Regional shopping Centre or mall.
5. Super-regional shopping Centre.
6. Industrial park.
7. Stand-alone/ freestanding
8. Home-based.

1. Downtown / Central Shopping District:

A downtown or central business district (CBD) in the main Centre of trade and commerce in the city. It can be said as the business hub of a city. These are considered as diverse region in metro cities which include offices, retail spaces, financial institutions, government centres, medical centers, entertainment hubs, residential areas, hotels, etc. Some of the examples of CBD's In India are Connaught Place, New Delhi and World Trade Park, Jaipur.

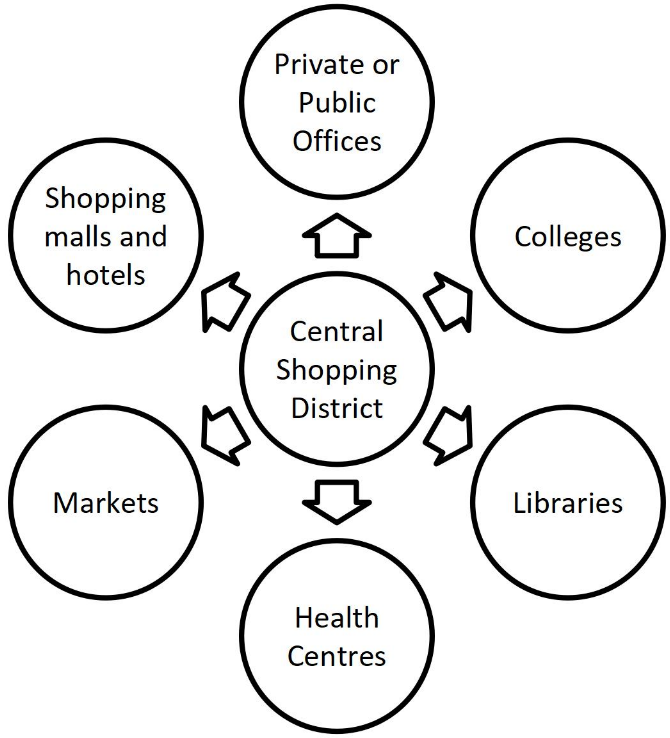
2. Neighbourhood Shopping Centre:

It is the smallest type of Shopping Centre. Here one can purchase all types of convenience goods and personal services. Convenience goods like food, drugs, sundries etc. and personal services meet the daily requirements of an immediate neighborhood trade area. These types of centers can serve around 25,000 to 40,000 people within a five-minute drive.

3. Community Shopping Centre:

Community shopping centers are larger as compared to neighborhood shopping centers. It can usually serve 40,000 to 1, 50,000 people, residents of many neighborhoods. It combines both convenience goods and shopping goods. Example-: Wal-Mart, Dmart, etc.

Fig- 5.2 Central Shopping District



4. Regional Shopping Centre or Mall:

Regional shopping centers provide complete range of shopping services. They are also called as shopping mall, or shopping plaza. It's a collection of complete range of shopping services.

5. Super Regional Shopping Centres:

Super regional shopping centers are extremely large exceeding 7,50,000 square feet. These centers contain many anchor stores as well as hundreds of smaller stores. Example-: Mall of America.

6. Industrial Parks:

Industrial Park refers to the business properties developed on less expensive sections of land away from housing developments and downtown areas. These may be subsidized by communities in order to attract industrial business.

7. Stand- Alone/ Free Standing:

These shopping centers are often but not always, located just outside and separate from other businesses. These shopping centers are dependent on drive-by traffic.

8. Home- Based:

These are suitable for businesses requiring less personal contact with the customers, where work is picked up or dropped off. These centers are located in a private residence.

International location

Some reasons for international location

- *Historical* - a sugar refining firm is likely to own plant in countries where sugar is grown, as well as a network to market and service the business worldwide
- *Service* - many products and services need local country support - e.g. Bosch washing machines.

- *Access to markets* - companies manufacturing in EU have access to the whole market. Nissan opened in Sunderland for this reason, and this also explains why they started making trucks in the USA, to access that market.
- *Access to raw materials* - extraction of natural resources in countries where they are found.
- *Access to labour* - usually this means cheap labour where regulations are less stringent than in the UK.
- *Tax avoidance* - by means of transfer pricing, multinationals organise their affairs to minimise their overall tax liability.
- *Local incentives* - regional grants and incentives are sometimes given to encourage overseas firms to set up locally and boost the economy.

OBJECTIVES OF BUSINESS LOCATION

The objectives of business location can be classified as follows-

1. Economic Objectives

Economic objectives refer to the goals of earning profit and other objectives which are necessary to be pursued in order to achieve the profit objectives. It includes-

- Profit earning
- Creation of customers
- Regular innovation
- Best possible use of resources

2. Social Objectives

Social objectives refer to those objectives of businesses which are desired to be achieved for the benefit of the society. It includes:

- Production and supply of quality goods and services
- Adoption of fair-trade practices
- Contribution to general welfare of the society

3. Human Objectives

Human objectives refer to those objectives which aim for the well-being and fulfilment of employee's expectations. It also aims for the benefit and well-being of handicapped and deprived of proper education and training. It includes:

- Employee's well-being of the employees
- Social and psychological satisfaction of employees
- Development of human resources
- Economic well-being of socially and economically backward people

4. National Objectives

National objectives of the business refer to the objectives of fulfilling national goals and aspirations. It includes:

- Creation of employment.
- Promotion of social justice:
- Production according to national priority
- Contribution to the revenue of the country
- Self-sufficiency and export promotion

5. Global Objectives

Today, in the era of globalization the entire world has become a market. Goods which are produced in one country are available in other countries. Thus, to face the competition in the global market every business has certain objectives, which are termed as the global objectives. It includes:

- Raised general living standard
- Reductions of disparities among nations make available globally competitive goods and services

PLANT / FACILITY LAYOUT AND DESIGN

Layout problems are fundamental to every type of organization/enterprise and are experienced in all kinds of undertakings. The efficiency of production depends on how well the various machineries, production facilities and employee's amenities are located in a plant. Also, plant should be properly laid out to ensure the smooth and rapid movement of material, from the raw material stage to the end product stage. The adequacy of layout affects the efficiency of subsequent operations. It is an important perquisite for efficient operations and also has a great deal in common with many of the problems.

Plant layout encompasses new layout as well as improvement in the existing layout. Plant Layout is a technique of locating machines, processes and plant services within the factory so as to achieve the right quantity and quality of output at the lowest possible cost of manufacturing. Plant layout refers to the arrangement of physical facilities such as machinery, equipment, furniture etc. within the factory building in such a manner so as to have quickest flow of material at the lowest cost and with the least amount of handling in processing the product from the receipt of material to the shipment of the finished product.

Facility Layout- Meaning

Facility layout and design is one of the crucial components of an organization's overall operations, both in the terms of maximization of the production processes effectiveness and meeting the requirements of the employees. Facility is the space in which the business conducts all its activities. The layout and design have a great impact on the flow of work, materials and information through the system. Thus, it can be said that layout refers to the configuration of departments, work centre and equipment with particular focus on the movement of materials or customers i.e. work through the system. It is the physical arrangement of the industrial facilities.

Definitions

1. "Office layout is the arrangement of equipment within the available floor space."

-According to Littlefield.

2. "The problem of layout relates to the arrangement in the space involved so that all equipment, supplies, procedures and personal can function at maximum efficiency."

- According to Hicks and Place.

3. "The overall objective of plant layout is to design a physical arrangement that most economically meets the required output - quantity and quality."

- According to Riggs.

4. "Plant layout ideally involves allocation of space and arrangement of equipment in such a way that overall operating costs are minimized."

- According to J.L. Zundi.

CHARACTERISTICS OF GOOD LAYOUT

- A good layout should provide a safe working condition and promote safety by reducing the health hazards to employees.

- A well-designed layout should ensure optimum material handling by reducing wastages, spoilage and mix up of material. It should also minimize material handling cost by keeping total movement of material at absolute minimum.
- A good plant layout should be able to prevent noise, heat and dust in the working environment.
- A good layout should ensure arrangement of work areas in such a way as to ensure smooth flow, no back tracking and no hindrance to work.
- A good plant layout should ensure economical use of space in all the three dimensions.
- A well-designed layout should be flexible enough so that changes, expansion, etc can be made quickly without excess investment in time and money.
- A good layout should be integrative of all aspects of production such as men, material, and money.

IMPORTANCE OF LAYOUT

- Plant layout is an important decision as it represents long-term commitment.
- An ideal plant layout provides the optimum relationship among output, floor area and manufacturing process.
- It facilitates the production process, minimizes material handling, time and cost, and allows flexibility of operations, easy production flow, makes economic use of the building, promotes effective utilization of manpower, and provides for employee's convenience, safety, comfort at work, maximum exposure to natural light and ventilation.
- It is also important because it affects the flow of material and processes, labour efficiency, supervision and control, use of space and expansion possibilities etc.

NEED OF FACILITY LAYOUT

The need of facility layout is felt when:

1. There are changes in product design.
2. There is expansion of the organization.
3. There is proposed variation in department size.
4. New products to be added to the existing line.
5. There is reallocation of the existing departments and new department is to be added to the organization.
6. A new plant is to be set up.

OBJECTIVES OF LAYOUT

The following are the objectives of an efficient layout:

- To ensure Proper and efficient utilization of available floor space
- To ensure that work proceeds from one point to another point without any delay
- Provide enough production capacity
- Reduce material handling costs
- Reduce hazards to personnel
- Utilise labour efficiently
- Increase employee morale
- Minimise accidents and scraps
- Provide for volume and product flexibility
- Provide ease of supervision and control
- Provide for employee safety and health
- Allow ease of maintenance
- Allow high machine or equipment utilization
- Improve productivity

PRINCIPLES OF PLANT LAYOUT

1. Principle of minimum movement: According to this principle, as far as possible labor and materials should be moved over minimum distances.

2. Principle of flow:

- To ensure continuous flow of materials the work areas should be arranged as per the sequence of the operations.
- The layout should allow for easy movement of materials without congestion.

3. Principle of space: The space must be effectively used both horizontally and vertically.

4. Principle of safety: Safety and convenience of workers should be considered. There should be built-in provision for the comfort and safety.

5. Principle of flexibility: Layout should be designed in such a manner that production facilities can be in case of need for future expansion and technological advancement.

6. Principle of Interdependence: Interdependent operations and process should be located in close proximity to each other.

7. Principle of overall integration: All the facilities and services should be fully integrated into a single operating unit so as to maximize efficiency and minimize the production costs.

8. Principle of Minimum Investment: The layout should yield savings in fixed capital investment by optimum utilization of available facilities.

FACTORS INFLUENCING LAYOUT

While deciding his factory or unit or establishment or store, a small-scale businessman should keep the following factors in mind:

Factory building: The nature and size of the building determines the floor space available for layout. While designing the special requirements, e.g. air conditioning, dust control, humidity control etc. must be kept in mind.

Nature of product: product layout is suitable for uniform products whereas process layout is more appropriate for custom-made products.

Production process: In assembly line industries, product layout is better. In job order or intermittent manufacturing on the other hand, process layout is desirable.

Type of machinery: General purpose machines are often arranged as per process layout while special purpose machines are arranged according to product layout

Repairs and maintenance: machines should be so arranged that adequate space is available between them for movement of equipment and people required for repairing the machines.

Human Needs: Adequate arrangement should be made for cloakroom, washroom, lockers, drinking water, toilets and other employee facilities, proper provision should be made for disposal of effluents, if any.

Plant Environment: Heat, light, noise, ventilation and other aspects should be duly considered, e.g. paint shops and plating section should be located in another hall so that dangerous fumes can be removed through proper ventilation etc. Adequate safety arrangement should also be made.

Thus, the layout should be conducive to health and safety of employees. It should ensure free and efficient flow of men and materials. Future expansion and diversification may also be considered while planning factory layout.

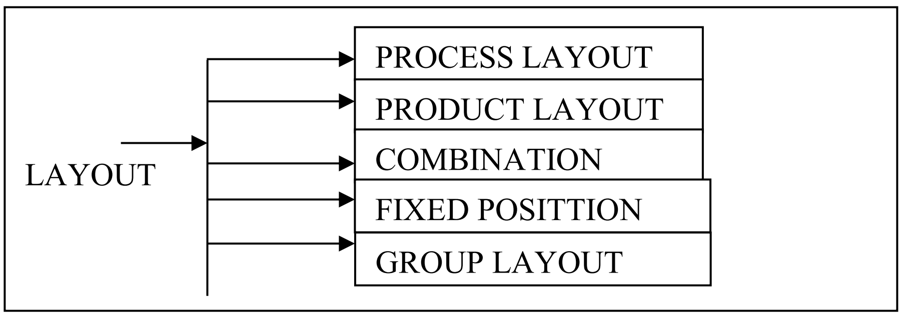
CLASSIFICATION OF LAYOUT

As discussed so far, the plant layout facilitates the arrangement of machines, equipment and other physical facilities in a planned manner within the factory premises. A layout differs from plant to plant, from location to location and from industry to industry. But the basic principles governing plant layout are more or less same. Plant layout for business is closely linked with the factory building and built-up area.

Manufacturing Layouts

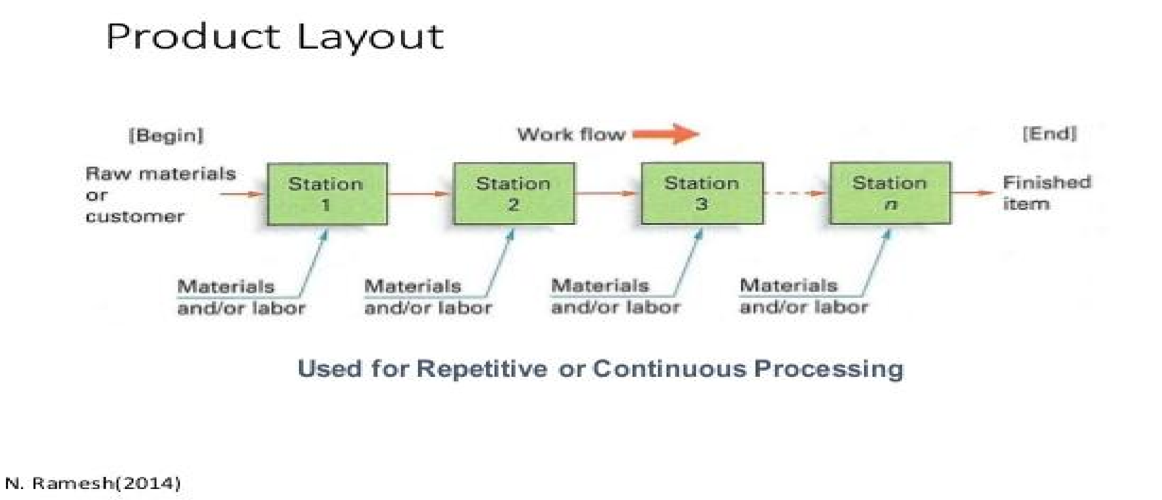
In case of manufacturing units, layouts can be classified under the following categories.

Fig-5.3 Types of Layouts



1. Product layout

Fig-5.4 Example of Product Layout

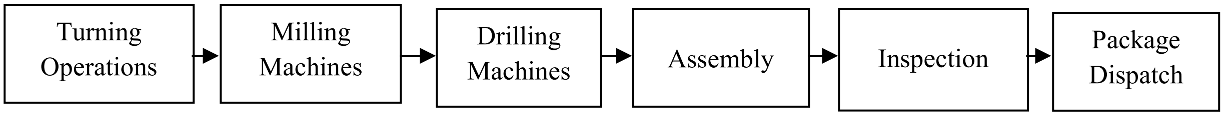


Similar equipment or functions are grouped together in one sequence in this type of layout. Under this, machines and equipment are arranged in one line depending upon the sequence of operations required for the product. The materials move from one workstation to another sequentially without any backtracking or deviation. The materials are fed into the first machine and finished goods from that travel automatically to the next machine, such that the output of one machine becoming input of the next.

The grouping of machines should be done keeping in mind the following general principles.

a) Similar or identical machinery may be placed in each of the product line.
b) There should be no point where one line crosses another line.
c) Materials may be fed where they are required for assembly but not necessarily at one point.
d) All the operations including assembly, testing packing must be included in the line

Example- The figure drawn below depicts a typical product layout.



Product layout is useful under following conditions:

- Mass production of standardized products
- Simple and repetitive manufacturing process
- Operation time for different process is more or less equal
- Reasonably stable demand for the product
- Continuous supply of materials

Therefore, the manufacturing units involving continuous manufacturing process, producing few standardized products continuously on the firm's own specifications and in anticipation of sales would prefer product layout e.g. chemicals, sugar, paper, rubber, refineries, cement, automobiles, food processing and electronics etc.

Merits

- Smooth flow of product in logical flow lines.
- Less in-process inventory.
- Less throughput (time gap between in and out in the process) time.
- Possibility of simplified production, planning and control systems.
- Work transit occupies less space.
- Mechanised handling system reduces the material handling cost.
- Perfect line balancing.
- Uninterrupted flow of materials shortens the manufacturing cycle.
- Small amount of work-in-process inventory.
- Production can be learned and managed by the unskilled workers.

De-merits

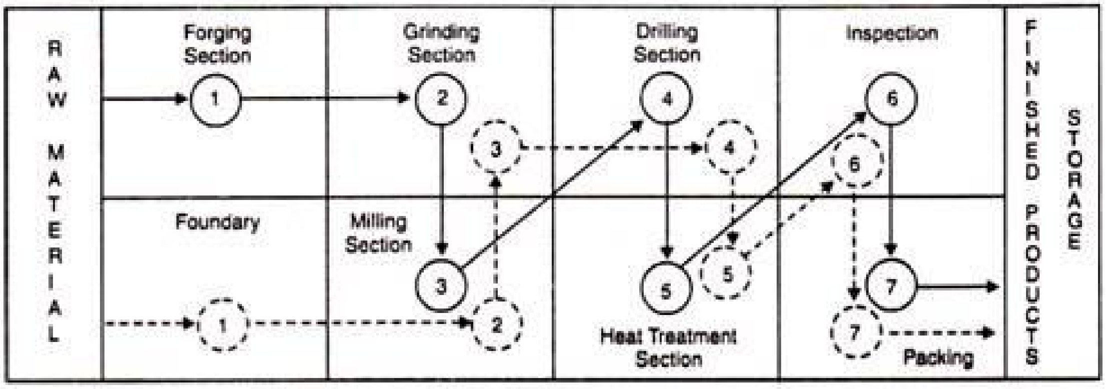
- If there is breakdown of one machine in a product line it may stop the other machines in the downstream of the line.
- If there is any change in product design it may require major changes in the layout.
- Equipment requires higher investment.
- There is lack of flexibility.

2. Process Layout

In this type of layout machines of a similar type are arranged together at one place. E.g. Machines performing drilling operations are arranged in the drilling department, machines performing casting operations be grouped in the casting department. Therefore, the machines are installed in the plants, which follow the process layout.

Hence, such layouts typically have drilling department, milling department, welding department, heating department and painting department etc. The process or functional layout is followed from historical period. It evolved from the handicraft method of production. The work has to be allocated to each department in such a way that no machines are chosen to do as many different jobs as possible i.e. the emphasis is on general purpose machine.

Fig: 5.4 Example of Process Layout



The work, which has to be done, is allocated to the machines according to loading schedules with the object of ensuring that each machine is fully loaded. The grouping of machines according to the process has to be done keeping in mind the following principles

a) The distance between departments should be as short as possible for avoiding long distance movement of materials
b) The departments should be in sequence of operations
c) The arrangement should be convenient for inspection and supervision

Merits:

- Fewer machines are required.
- Machines are better utilized.
- Possibility of equipment and personal flexibility.
- Lower investment in general purpose machines.
- Higher utilization of the production facilities.
- Job becomes challenging and interesting because of the variety of jobs and diversity of tasks.
- Supervisors become highly knowledgeable about the functions under their supervision.

De-merits

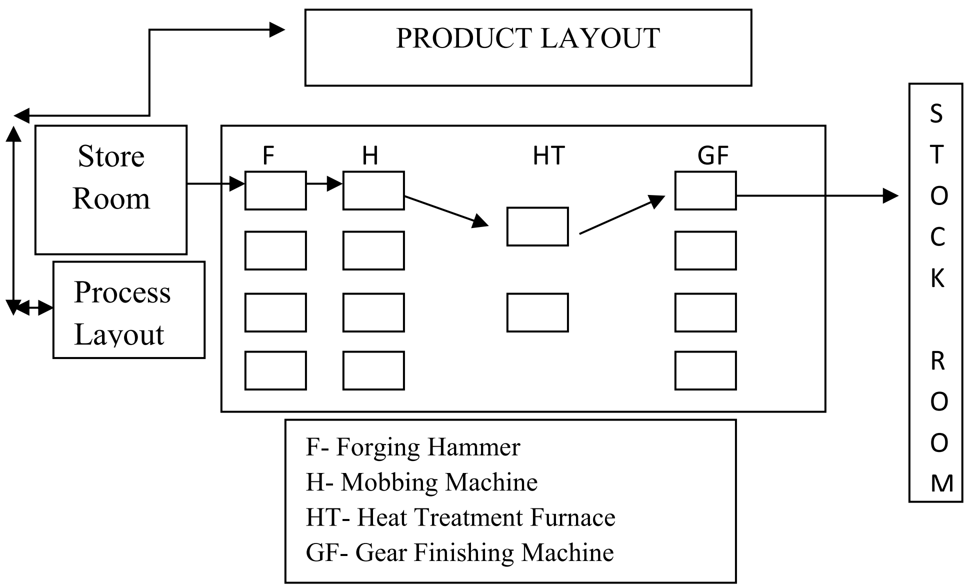
- Material handling efficiency is reduced because of long movements and backtracking.
- Costs increases as the material handling cannot be mechanized.
- Reduction in inventory turnover, increase in the in-process inventory due to prolong process time.
- Number of setups reduces the productivity level.
- Time gap is longer between the in and out process.
- Work-in-process ties up the space and capital.

3. Combination layout

Combination of process and product layout combines the merits of both types of layouts. When an item is to be made in different types and sizes, combination layout is possible. Machines are arranged in a process layout but the process grouping is then arranged sequentially to manufacture various types and sizes of products. Certain manufacturing units may require all three processes namely intermittent process (job shops), the continuous process (mass production shops) and the representative process combined process [i.e. miscellaneous shops]. In most of industries, only a product layout or process layout or fixed location layout does not exist. Thus, in manufacturing concerns where several products are produced in repeated numbers with no likelihood of continuous production, combined layout is followed. Generally, a combination of the product and process layout or other combination are found, in practice, e.g. for industries involving the fabrication of parts and assembly, fabrication tends to employ the process layout, while the assembly areas often employ the product layout. In soap, manufacturing plant, the machinery manufacturing soap is arranged on the product line principle, but ancillary services such as heating, the manufacturing of glycerin, the power house, the water treatment plant etc. are arranged on a functional basis.

Example-: The figure drawn below depicts a combination type of layout for manufacturing different sized gears:

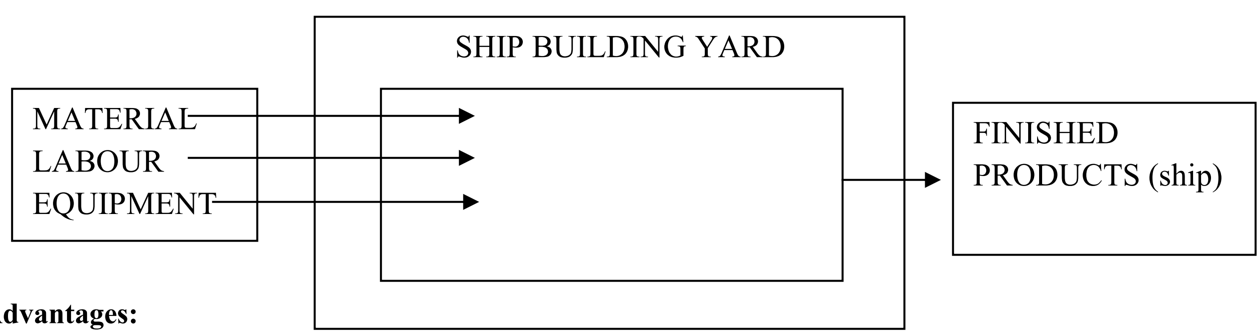
Fig-5.5 Example of Combination Layout



4. Fixed Position Layout

In this type of layout, the material i.e. major components are located in a fixed position and men, machinery, tools and other materials are brought to the fixed position. It is also called as the project type layout. This type of layout is chosen when one or a few pieces of identical heavy products have to be manufactured. Example: The figure drawn below depicts a fixed position layout.

Fig-5.6 Example of Fixed Position layout



Advantages:

Fixed position layout provides the following benefits

- It saves time and cost involved on the movement of work from one workstation to another.
- The layout is flexible as change in job design and operation sequence can be easily incorporated.
- It is more economical when several orders in different stages of progress are being executed simultaneously.
- Adjustments can be made to meet shortage of materials or absence of workers by changing the sequence of operations.

Disadvantages:
Fixed position layout has the following drawbacks

- Production period being very long, capital investment is very heavy
- Very large space is required for storage of material and equipment near the product.
- As several operations are often carried out simultaneously, there is possibility of confusion and conflicts among different workgroups.

Suitability:

The fixed position layout is followed in following conditions

- Manufacture of bulky and heavy products such as locomotives, ships, boilers, generators, wagon building, aircraft manufacturing, etc.
- Construction of building, flyovers, dams.
- Hospital, the medicines, doctors and nurses are taken to the patient (product).

5. Group Technology (Cellular) Layout

Group Technology (GT) refers to the comparison and analysis of items in order to group them into families with similar features.

A group Technology (cellular) layout allocates dissimilar machines into cells to work on products that have similar weights, shapes and processing requirements. Group technology (GT) layouts are now widely used in metal fabricating, computer chip manufacture, and assembly work. The overall objective is to gain the benefits of product layout in job shop kinds of production.

GT can be used for developing a hybrid between pure process layout and pure product layout. Companies producing variety of parts in small batches have greater utility of this technique, to take the benefits of flow line layout. The application of group technology involves two steps:

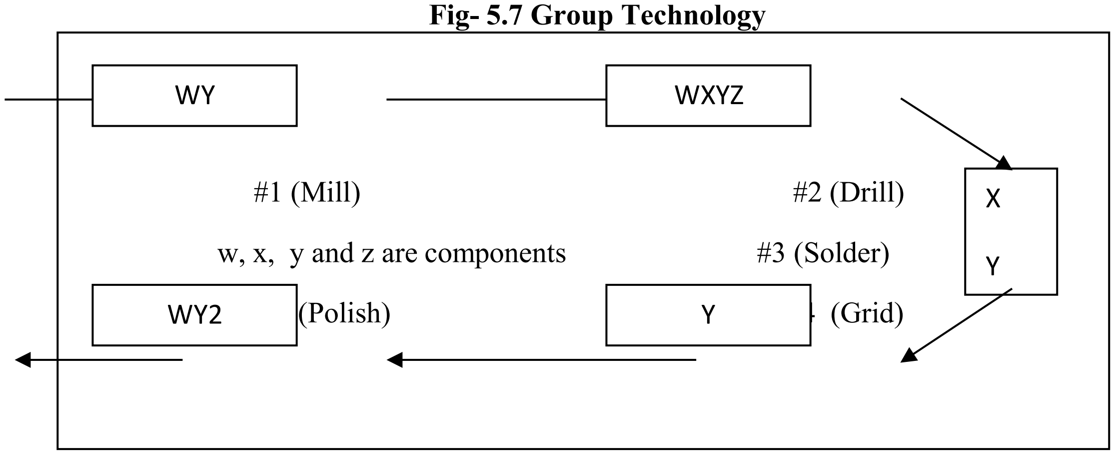
Merits

1. Component's standardization and rationalization.
2. Reliability of estimates.
3. Effective machine operation and productivity.
4. Customer service.

Demerits

1. Decreases paper work and overall production duration.
2. Work in progress and work movements.
3. Overall cost.

Fig- 5.7 Group Technology



According to Mallick and Gandeau advantages of a good plant layout can be described below in table.

Table-5.2 Benefits of a Good Facility Layout

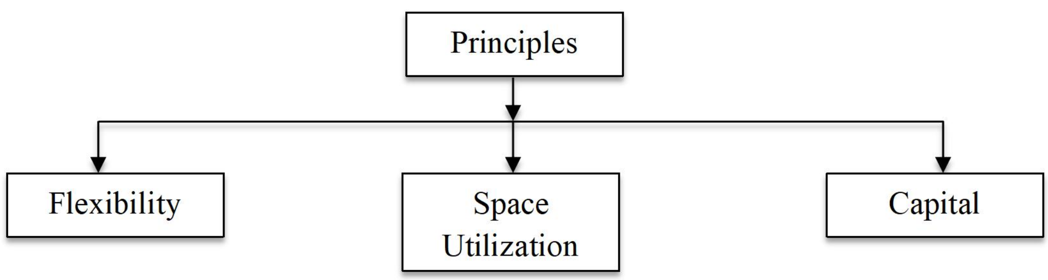
1. To the worker: Reduces workers efforts. Reduces number of handlings. Extends the specialization process. Permits working at optimum conditions by eliminating hurdles. Produces better working conditions. Reduces accidents. Provide better employee service and working conditions. Provides basis for higher earning for employees.	**2. In Labor cost:** Increases the output level per man-hour. Reduces the set-up time involved. Reduces the number of operations by combining some of them. Reduces labour cost by reducing the number of handlers. Reduces the length of hauls. Reduces the lost motions between operations. Eliminates the unnecessary movements. Converts the operator into a producer instead of a handler.
3. In other manufacturing costs. Reduces the costs of costly supplies. Decreases maintenance costs. Decrease tool replacement costs. Saving in power loads. Minimizes waste. Decreases spoilage and scrap. Eliminates some of the waste in consumption of raw materials. Improves the product quality by decreasing handling. Provides better control of cost.	**4. In manufacturing cycle:** Shortens the duration if movement between work-stations. Reduces the manufacturing cycle in each department. Reduces the length of the travel by the product for finishing. Reduces the products total manufacturing time.
5. In Production Control: Facilitates delivery of inputs and finished goods. Facilitates receipts and shipments. Provides adequate facilities of storage. Permits the maximum possible output with same input. Paces production. Makes it possible to predict the production time. Makes scheduling and dispatching automatic. Sets up production centre and allows straight line layout by products for mass production. Moves work in process by most direct lines. Waste minimization. Reduction in lost or mishandled parts. Reduces paper work for production control. Reduces the number of stock chasers. Reduces the production control expenses.	**6. In Supervision:** Eases the supervision burden. Determines the supervisory control. Reduces the cost of supervision process. Reduces cost of piece counts. Decreases the amount of inspection involved.

7. In capital Investment: Holds permanent investment at its minimum level. Keeps the plant free from obsolete before its worn out. Reduces the investment in equipment and machinery. Increases the production per machine. Utilizes idle machine time. Reduces number of operations per machine. Maintains proper balance of departments. Proper space utilization of equipment and material handling required. Reduces the capital investment. Reduces the inventory level of work in process and of the final finished products.	

DESIGN OF FACILITY LAYOUT

Principles which drive design of the facility layout need to consider the goals of the facility layout, the factors influencing facility layout as well as the constraints of layout. These principles are as discussed below-:

Fig- 5.8 Principles of Facility Layout



1. Flexibility: Facility Layout should be capable of providing flexibility for modifications or future expansions.

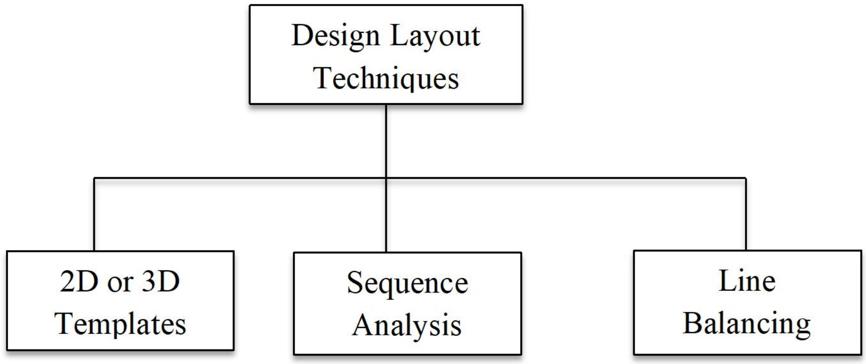
2. Space Utilization: Appropriate and optimum use of the space reduces time in material and people movement and promotes safety too.

3. Capital: There should be minimum capital investment while finalizing different facility layout models.

Design Layout Techniques

The techniques of design layout can be categorized in following 3 parts:

Fig- 5.9 Design Layout Techniques



1. Two- or three-dimensional techniques:

Development of a scaled down model based on approved drawings is utilized in this technique.

2. Sequence analysis:

In this technique computer technology is used for designing the facility layout. All the activities are sequenced and arranged in circular or in a straight line.

3. Line balancing:

This type of technique is utilized for assembly line.

DYNAMICS OF PLANT LAYOUT

Plant layout is a dynamic rather than a static concept meaning thereby if once done it is not permanent in nature rather improvement or revision in the existing plant layout must be made by keeping a track with development of new machines or equipment, improvements in manufacturing process, changes in materials handling devices etc. But, any revision in layout must be made only when the savings resulting from revision exceed the costs involved in such revision.

Revision in plant layout may become necessary on account of the following reasons:
a) Increase in the output of the existing product
b) Introduction of a new product and diversification
c) Technological advancements in machinery, material, processes, product design, fuel etc.
d) Deficiencies in the layout unnoticed by the layout engineer in the beginning.

APPLICABILITY OF PLANT LAYOUT

Plant layout is applicable to all types of industries or plants. Certain plants require special arrangements which, when incorporated make the layout look distinct form the types already discussed above. Applicability of plant layout in manufacturing and service industries is discussed below.

In case of the manufacturing of detergent powder, a multi-store building is specially constructed to house the boiler. Materials are stored and poured into the boiler at different stages on different floors. Other facilities are also provided around the boiler at different stations.

Another applicability of this layout is the manufacture of talcum powder. Here machinery is arranged vertically i.e. from top to bottom. Thus, material is poured into the first machine at the top and powder comes out at the bottom of the machinery located on the ground floor.

Yet another applicability of this layout is the newspaper plant, where the time element is of supreme importance, the accomplishment being gapped in seconds.

Here plant layout must be simple and direct so as to eliminate distance, delay and confusion. There must be a perfect coordination of all departments and machinery or equipment's, as materials must never fail.

Plant layout is also applicable to five-star hotels as well. Here lodging, bar, restaurant, kitchen, stores, swimming pool, laundry, shaving saloons, shopping arcades, conference hall, parking areas etc. should all find an appropriate place in the layout. Here importance must be given to cleanliness, elegant appearance, convenience and compact looks, which attract customers. Similarly plant layout is applicable to a cinema hall, where emphasis is on comfort, and convenience of the cinemagoers. The projector, screen, sound box, firefighting equipment, ambience etc. should be of utmost importance.

A plant layout applies besides the grouping of machinery, to an arrangement for other facilities as well. Such facilities include receiving and dispatching points, inspection facilities, employee facilities, storage etc.

Generally, the receiving and the dispatching departments should be at either end of the plant. The storeroom should be located close to the production, receiving and dispatching centers in order to minimize handling costs. The inspection should be right next to other dispatch department as inspections are done finally, before dispatch.

The maintenance department consisting of lighting, safety devices, fire protection, collection and disposal of garbage, scrap etc. should be located in a place which is easily accessible to all the other departments in the plant. The other employee facilities like toilet facilities, drinking water facilities, first aid room, cafeteria etc. can be a little away from other departments but should be within easy reach of the employees. Hence, there are the other industries or plants to which plant layout is applicable.

Discussion Forum

Short Questions

1. What do you mean by plant location?
2. What is virtual proximity?
3. What is virtual factory?
4. What is agglomeration?
5. What is deglomeration?
6. What is plant layout?
7. Mention any four objectives of plant layout.

Long Questions

1. Explain different operations strategies in case of location choice for existing organization.
2. Explain the factors to be considered while selecting the location for the new organization.
3. Explain the reasons for global or foreign location.
4. Explain the Alfred Weber's theory of the location of industries.
5. Explain the objectives of plant layout.
6. Explain the main principles of plant layout.
7. Explain the factors considered for an industrial building.
8. Explain the need for selecting a suitable location.

9. Explain the factors influencing plant location.

10. Explain the different types of layouts.

11. Explain the physical facilities required in an organization/factory.

Skill Development

FAST FOOD RESTAURANT VISIT: Get the information for the following questions:

1. The locational factors considered for establishing the enterprise.
2. Strategy adopted for identifying the location [Ex: factor rating, load, distances method etc.]
3. Type of layout.
4. Physical facilities existing [line lighting ventilators, type of building etc.]

Mini Case- How Location Decisions Impact a Lean Strategy?

Companies often don't consider the location decision to be a Lean concept, but they should. Moving goods efficiently from raw material sites to processing facilities, manufacturers, distributors, retailers, and customers is critical to remaining competitive in today's global economy.

When manufacturers make location decisions, their priority is to minimize cost. Retailers look to maximize revenue where possible. Locating new facilities is a strategic decision that, once made, cannot be changed easily in the short term. Yet many organizations—especially small and mid-sized businesses—often neglect or delay this decision.

An entire organization can feel the impact of indecision—especially in today's global economy, which is far from static. Risks include demand volatility, omni-channel distribution, shrinking lead times, reduced product development, and shorter product lifecycles.

The decision to open, close, or expand manufacturing or distribution locations can have a long-term impact on a product's total cost. This decision can be heavily influenced not only by forecasted demand, but also by transportation costs, which can average three to five percent of sales, and warehousing costs as much as two percent on average.

The location decision certainly is a Lean concept in regards to your supply chain. Not understanding the importance of that decision in today's business world can result in cost and service inefficiencies, and possibly a business failure.

One main reason why companies often neglect or delay this decision is the significant cost of performing the necessary analysis to optimize a manufacturing and distribution network—consultants can charge upwards of $100,000 for a study. The cost-benefit ratio can be significant, however, with savings often in the millions, and usually with improved service levels. Companies should conduct this analysis once every two or three years.

So, how do you go about this? A range of tools are available to help, from "back of the envelope" simplistic tools to complex optimization systems, including:

- Location cost-volume analysis: A simple location decision tool that looks at a future volume forecast, along with fixed and variable costs known for each location. This helps justify potential sites through predicted throughput volumes.
- Weighted factor rating method: Compares a number of locations using both quantitative and qualitative criteria, and applies ratings to each of the criteria to determine the winning location.
- Center of gravity method: De-termines the approximate location of a distribution center that minimizes logistics costs, while considering the location of markets, volume of goods shipped, and shipping cost.
- Transportation problem model: Deals with distributing goods from several points of supply to multiple points of demand. It looks at the capacity of goods at each source, requirements at each destination, and a

host of materials, manufacturing, transportation, and warehousing costs. The model then determines optimal location(s) that minimize total transport and production costs, while maintaining specified inventory and service level targets.

Companies that do not properly execute location decisions have the potential to create a huge amount of waste.

Source: https://www.inboundlogistics.com/cms/article/how-location-decisions-impact-a-lean-strategy/

CHAPTER-6

FORECASTING

INTRODUCTION

Estimating the different activities level of the future in the organization is known as Forecasting. The managers plan and determine the courses of action for their organizations that will take in the future. Even though the future is uncertain, yet the managers make assumptions or do prediction about the future to have a logical basis for rational action in the present. Forecasts are concerned with the timing, magnitude or efforts of events that are beyond immediate control.

Forecasting is the process of estimation of future/unknown situations. Prediction is a similar, but more general term, and usually refers to estimation of time series, cross-sectional or longitudinal data. Risk and uncertainty are central to forecasting and prediction. In more recent years, Forecasting has evolved into the practice of Demand Planning in everyday business forecasting for manufacturing companies. The discipline of demand planning, also sometimes referred to as supply chain forecasting, embraces both statistical forecasting and consensus process.

According to American Marketing Association, "Forecasting is defined as an estimate of sales in physical units for a specific future period under proposed marketing plan or programme and under the assumed set of economic and other forces outside the organization for which the forecast is made"

Purpose of forecasting

The major purpose of forecasting is to make use of the best available present information to guide future activities towards the organization's goals. It helps the managers in making continuous decisions regarding employment levels, carrying inventories, purchasing new eqipments, developing new products, scheduling production, quality control, plant maintenance, etc.

Applications of forecasting

Forecasting has application in many areas such as

- Supply chain management
- Weather forecasting and Meteorology
- Transport planning and Transportation forecasting
- Economic forecasting
- Technology forecasting
- Earthquake prediction
- Land use forecasting
- Product forecasting
- Player and team performance in sports
- Telecommunications forecasting

CLASSIFICATION OF FORECASTS ON THE TIME HORIZON

We require forecasts of different time spans to serve as the basis for operating plans developed for different planning horizons. They include

1. Short term forecasts: Mostly done upto the period of one year. These are plans for current operations and immediate future.
2. Medium term forecasts: Done for the period of one to three years. Intermediate- range (1-12 months) plans to provide the capacities of personnel, materials and equipment.

3. Long term Forecasts: Done for the period of more than five years. Long range plans are done for planning capacity and locations, changing products and service mix and new product development.

Description	Forecast Horizon		
	Short-range	Medium-range	Long-range
Duration	Usually less than 3 months, maximum of 1 year	3 months to 3 years	More than 3 years
Applicability	Job scheduling, worker assignments	Sales and production planning, budgeting	New product development, facilities planning

TYPES OF FORECASTS

The following are the different types of forecasts:

1. Demand forecast
2. Environmental Forecast
3. Economic Forecast
4. Technological Forecast

DEMAND FORECASTING

Planning and control for operations requires an estimate of the demand for the product or service that an organization expects to provide in the future. Forecasting forms the basis of planning and forecasting enables the organization to respond more quickly and accurately to market changes. A demand forecast is the prediction of what will happen to your company's existing product sales. It would be best to determine the demand forecast using a multi-functional approach. The inputs from sales and marketing, finance, and production should be considered. The final demand forecast is the consensus of all participating managers.

Factors affecting Demand forecast

A company should be aware of the various factors that are related to the demand forecast. Some of the factors are listed below:

- Past demand
- Lead time of the product
- Planning advertising and marketing efforts
- State of Economy
- Planned Price Discounts
- Actions of Competitors.

A company must understand such factors before it can select an appropriate forecast methodology.

BASIC APPROACH TO DEMAND FORECASTING

The following are the steps following in basic approach to demand forecasting

1. Understand the objective of forecasting

The main objective of forecasting is to help decision making process in the organization. Hence the decisions to be made are identified in order to initiate the forecasting process. Some of the decisions include

1. How many products have to be manufactured?
2. How much inventory has to be maintained?
3. How much order has to be placed?

2. Integrate demand Planning and forecasting throughout the supply chain

An organization should link its forecast to all planning activities throughout the supply chain. These include Capacity Planning, Production planning, Promotion Planning, Purchase planning, etc. This link should exist at both the information system and Human Resource Management level. As a Varity of functions are affected by the outcome of the planning process, it's important that all of them are integrated into the forecasting process.

3. Understanding and Identify Customers Segments

A firm must properly identify the customer segments that the supply chain servers. Customers may be segmented and grouped by similarities in Demand Volumes, Service Requirements, Order Frequency, Seasonality etc. Companies should follow different forecasting methods for different segments.

4. Identify major factors that influence the Demand Forecast

A firm must identify demand, supply, and product related phenomena that influence the demand forecast. On the demand side, a company must judge whether demand is growing, stable or declines. On the supply side, a company must consider the availability of supply sources to decide on the accuracy of the forecast desired. On the product side, a firm must identify the number of variants of a product being sold and whether these variants substitute for or complement each other. If demand for a product influence or is influenced by demand for another product, the two forecasts are best made jointly.

5. Determine the Appropriate Forecasting Technique

A company should clearly understand the dimensions that are relevant to the forecast, in order to select on appropriate forecasting technique. The dimensions include Geographic Area, Product Groups and Customers Groups. The company should understand the differences in demand along each dimension and select appropriate forecasting methods for each dimension.

FORECASTING ERRORS

Forecast is always wrong and should thus include both the expected value of the forecast and a measure of forecast error. The forecast error is a key for supply chain decisions. Long term forecasts are less accurate than short term forecasts. i.e. Long term forecasts have a larger standard deviation of error relative to the mean than short term forecasts. Aggregate forecasts are usually more accurate than disaggregate forecasts, as they tend to have a smaller standard deviation of error related to the mean. A forecast error is the difference between the actual or real and the predicted or forecast value of a time series or any other phenomenon of interest.

The different types of errors are summarized as follows:

1. Mean Absolute Deviation (MAD)
2. Mean Forecast Error (MFE)
3. Mean Square Error (MSE)
4. Mean Absolute Percent Error (MAPE)

1. Mean Absolute Deviation (MAD)

It is the average of absolute deviation of forecast demands from actual demand values. The mean absolute deviation is the mean absolute deviation from the mean. It is calculated using the formula:

$$MAD = \frac{\sum |x_i - \bar{x}|}{n}$$

2. Mean Forecast Error (MFE)

A simple measure of forecast accuracy is the mean or average of the forecast error, also known as Mean Forecast Error.

$$MFE = \sum_{t=1}^{n} \left(\frac{Dt - Ft}{n} \right)$$

Where

D_t - Actual Demand for period t

F_t - Forecast Demand for period t

n = No. of years used

3. Mean Square Error (MSE)

Mean Squared Error also avoids the challenge of positive and negative forecast errors offsetting each other. It is obtained by First, calculating the square of the forecast error and then, taking the average of the squared forecast error.

MSE formula = (1/n) * Σ (actual – forecast)^2

Where:

- n = number of items
- Σ = summation notation
- Actual = original or observed y-value
- Forecast = y-value from regression

4. Mean Absolute Percent Error (MAPE)

It measures this accuracy as a percentage, and can be calculated as the average absolute percent error for each time period minus actual values divided by actual values.

$$\mathrm{M} = \frac{1}{n} \sum_{t=1}^{n} \left| \frac{A_t - F_t}{A_t} \right|$$

Where:

n is the number of fitted points

At is the actual value

Ft is the forecast value

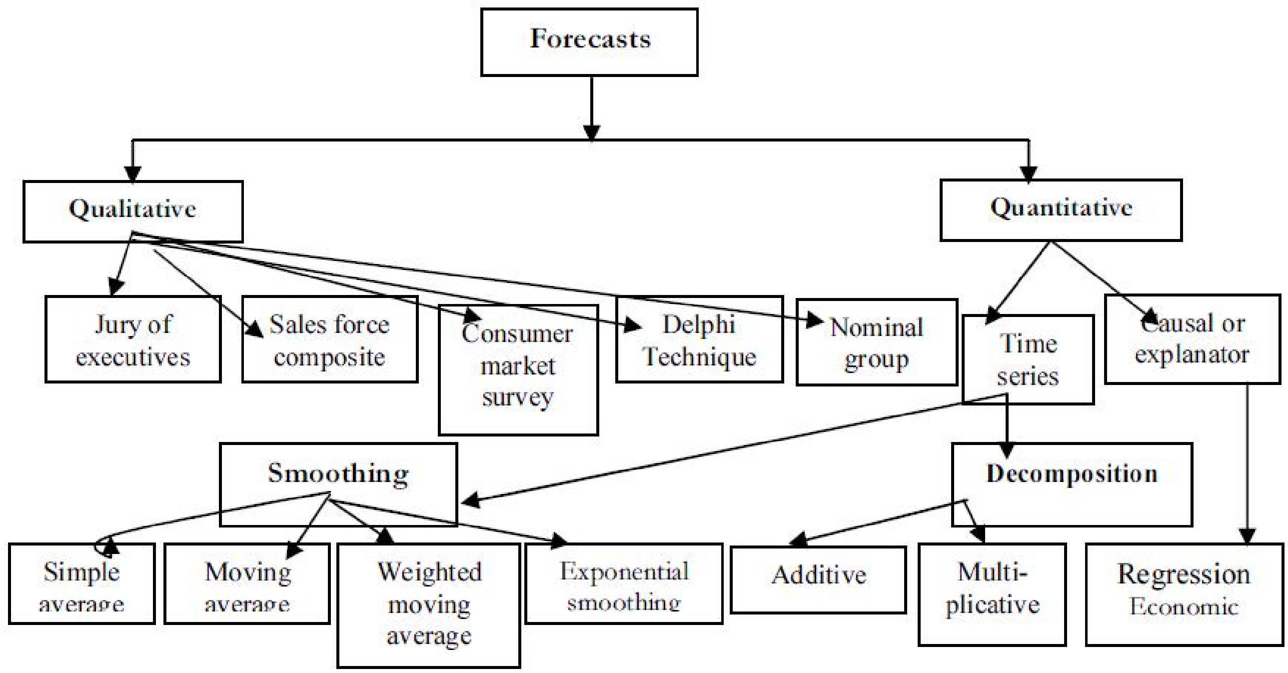
Σ is summation notation (the absolute value is summed for every forecasted point in time)

FORECASTING METHODS

Forecasting techniques are broadly classified into

1. Quantitative Forecasting methods
2. Qualitative Forecasting methods

Fig 6.1 Forecasting Methods



QUALITATIVE METHODS

1) Jury of executive opinion: Under this method, the opinions of a group of high-level managers often in combination with statistical models are pooled to arrive at a group estimate of demand.

2) Sales force composite: In this approach each sales person estimates what sales will be in his/her region. This forecast is then reviewed to ensure they are realistic and then combined at the district and national levels to reach an overall forecast.

3) Consumer market survey: This method solicits input from customers or potential customers, regarding their future purchasing plans. It can help not only in preparing a forecast, but also in improving product design and planning for new products.

4) Delphi method: This is a group process intended to achieve a consensus forecast. There are three different types of participants in the Delphi method

(1) decision-makers/experts

(2) staff personal/coordinator

(3) respondents.

The key to the Delphi technique lies in the coordinator and experts. The decision makers usually consist of a group of five to ten experts who will be making actual forecasts, the staff personal or coordinator assists the decision makers by preparing, distributing, collecting and summarizing a series of questionnaires and survey results. The respondents are a group of people often located in different places, whose judgments are valued and are being sought. This group provides inputs to the decision-makers before the forecast is made. The procedure works as follows:

a. A coordinator poses a question, in writing, to each expert of a panel.
b. Each expert writes a brief prediction.
c. The coordinator brings the written predictions together, edits them, and summarizes them.
d. On the basis of the summary, the coordinator writes a new set of questions and gives them to the experts. These are answered in writing.
e. Again, the coordinator edits and summarizes the answers, repeating the process until the coordinator is satisfied with the overall prediction synthesized from the experts. An advantage of this method is that direct interpersonal relations are avoided. Hence personalities do not conflict, nor does one strong-willed member dominate the group. On the other hand, Delphi technique is time consuming.

5) Nominal group discussion technique: Like Delphi technique, the nominal group discussion involves a panel of experts. Unlike the Delphi technique, the nominal group technique affords opportunity for discussion among the experts. Here seven to ten experts are asked to sit around a table in full view of one another, but they are asked not to communicate with one another. A group facilitator hands out copies of the question needing a forecast. Each expert is asked to write down a list of ideas about the question. After a few minutes, the group facilitator asks each expert in turn to share one idea from his or her list. A recorder writes each idea on a flip chart so that everyone can see it. The experts continue to give their ideas (usually between 15-25) in a round-robin manner until all the ideas have been written on the flipchart. No discussion takes place in this phase of the meeting.

During the next phase of the meeting, the experts discuss all the ideas that have been presented. Often similar ideas are combined. When all discussion has ended, the experts are asked to rank the ideas, in writing, according to priority. The consensus is the mathematically derived outcome of the individually rankings. The advantage of the nominal group discussion is time saving. But this technique can fail if the coordinator fails to allow creativity and encourage discussion. There is also the risk of getting all the experts together. This also can become costly if the experts are to be brought from foreign countries.

QUANTITATIVE METHODS

Naïve (Time Series) Quantitative Models: The time series model predicts the simple assumption that the future is a function of the past. In other words, they look at what has happened over a period of time and use a series of past data for forecasting. Some of the tools are:

a) Simple average

b) Moving average

c) Exponential smoothing

(a) Simple Average

Simple average ($\overline{X}$) is the simplest way to forecast assuming that the demand in the next period will equal to the average of the past demands. Here the demands of the previous periods are equally weighted.

$$\overline{X} = \frac{\text{Sum of demands for all periods}}{\text{Number of periods}} = \frac{\sum_{i=1}^{n} D_i}{n}$$

Where,

D_i = the demand in the 'i'th period

n = number of periods

By averaging, we try to detect the pattern or central tendency of demand. The demand for any one period will probably be above or below the underlying pattern, and demands for several periods will be dispersed or scattered around the pattern. Therefore, if we average all past data the extreme values will be offset and the result will be an average that is representative of the period by reducing the chances of being misled by gross fluctuations that may occur in any single period. But we have to be careful about the fact that, if the underlying pattern changes over time simple averaging will not detect this change.

Example (i)

If a mobile communication company sales 100, 110, and 96 mobile connections in the month of January, February and March respectively, we can assume that the demand for April will be 102 [(100+110+96)/3]. This may not be exact but for a starter it could be on the best-cost effective solution for some organization. In many cases we give different weights to the past data, especially giving more weight to the most recent data, making it simple weighted average.

$$\overline{X} = \frac{\text{Sum of demands for all periods}}{\text{Weight of periods}} = \frac{\sum_{i=1}^{n} W_i D_i}{W_i}$$

Where,

D_i = the demand in the 'i'th period

n = the weights of the 'i'th period

Example (ii)

In the above forecast example if weights of 20%, 30% and 50% are given for the demand figures of January, February and March respectively, then the demand forecast for April will be 101 [(100x0.20 + 110x0.30 + 96x0.50)/1.00].

(b) Moving average

A moving average forecast uses a number of recent actual data values from several of the most recent periods to generate a forecast. Once the number of past periods to be used in the calculations has been selected, it is held constant. Moving average is useful if we can assume that market demands will stay fairly steady over a period of time. A 4-month moving average is found by simply summing the past 4-month data and divided by 4 and so on. The average "moves" over time, in that, after each period elapses, the demand for the oldest period is discarded and the demand for the newest period is added for the next calculation. This overcomes the major shortcoming of the simple averaging model. Moving average can be of two types:

i) Simple moving average, where demands of all periods are equally weighted.

ii) Weighted moving average, which allows varying, not equal, weighting of the old demands.

A simple moving average (SMA) is calculated as follows:

$$SMA = \frac{\text{Sumof demands for periods}}{\text{Chosen number of periods}} = \frac{\sum_{i=1}^{n} D_i}{n}$$

Where,

D_i = the demand in the 'i'th period

n = chosen number of periods

i = 1 is the oldest period in the n-period average

= n is the most recent period

Example: (i)

Month	Actual Sales	3-month moving average forecast
January	120	
February	130	
March	110	
April	150	(120+130+110)/3 = 120
May	-	(130+110+150)/3 = 130

When there is a detectable trend or pattern, weights can be used to place more emphasis on recent values. This makes the technique more responsive to changes because more recent periods may be more heavily weighted. Selection of weights requires experience and luck, because there is no set formula to do so. The Weighted Moving Average (WMA) is calculated by using the following model:

$$WMA = \sum_{t-1}^{n} C_t D_t$$

Where,

n = *chosen number of periods*

t = *1 is the oldest period in the n-period average*

= *n is the most recent period*

Dt = *the demand in the 't'th period*

Ct = *Weight against a particular periodic demand*

Example (ii)

In the previous example if we weight most recent period twice as heavy as other two periods by setting, C1 = 0.25, C2 = 0.25, C3 = 0.50, the demand forecast for the month of May will be; WMA = 0.25 x 130 + 0.25 x 110 + 0.50 x 150 = 135

(c)Exponential smoothing

Exponential smoothing is a sophisticated weighted moving average forecasting method that is still fairly easy to use. It involves very little record keeping of past data. Exponential smoothing is distinguishable by the special way it weights each past demand. The pattern of weights is exponential in form. Demand for the most recent period is weighted most heavily; the weights placed on successively older periods decrease exponentially. The basic exponential smoothing formula for creating a new or updated forecast (F_t) uses two pieces of information:

(i) Actual demand for the most recent period (D_{t-1})

(ii) Most recent demand forecast (F_{t-1})

As each time period expires, a new forecast is made using:

$$F_t = \propto D_{t-1} + (1 - \propto) F_{t-1}$$

Where,

F = Forecast

α = smoothing coefficient (0≤α≤1)

D = demand

t = is the period

t – 1 = immediate previous period.

Why the Model is called Exponential Smoothing?

Since,

$F_t = \propto D_{t-1} + (1 - \propto) F_{t-1}$ ------ (1)

Then,

$F_{t-1} = \propto D_{t-2} + (1 - \propto) F_{t-2}$ ------ (2)

Similarly,

$F_{t-1} = \propto D_{t-2} + (1 - \propto) F_{t-2}$ ------ (3) and so on ….

If we replace F t-1 in equation (1) by its equivalent value from equation (2), we get,

$F_t = \propto D_{t-1} + (1 - \propto)[\propto D_{t-2} + (1 - \propto) F_{t-2}]$

$= \propto D_{t-1} + \propto (1 - \propto) D_{t-2} + (1 - \propto)^2 F_{t-2}$ --------- (4)

If we continue expanding by replacing F t-2 in equation (4) by its equivalent from equation (3), we get,

$F_t = \propto D_{t-1} + \propto (1 - \propto) D_{t-2} + \propto (1 - \propto)^2 D_{t-3} + (1 - \propto)^3 F_{t-3}$

$= \propto (1 - \propto)^0 D_{t-1} + \propto (1 - \propto)^1 D_{t-2} + \propto (1 - \propto)^2 D_{t-3} + (1 - \propto)^3 F_{t-3}$

The above model self-explains why it is called exponential smoothing (please note in each of the terms the exponents are increasing).

Smoothing Coefficient Selection

The selection of smoothing coefficient ($\propto$) is very important for effective use of the exponential smoothing model. We have to be careful while taking the value of $\propto$. A high value of $\propto$ places heavy weight on the most recent demand and a low $\propto$ value weights recent demand less heavily. For example, when $\propto$ = 0.8, the model becomes,

$F_t = \propto (1 - \propto)^0 D_{t-1} + \propto (1 - \propto)^1 D_{t-2} + \propto (1 - \propto)^2 D_{t-3} + (1 - \propto)^3 F_{t-3}$

$= 0.80 D_{t-1} + 0.16 D_{t-2} + 0.032 D_{t-3} + \ldots$

On the other hand, when $\propto$ = 0.2, the model becomes,

$F_t = \propto (1 - \propto)^0 D_{t-1} + \propto (1 - \propto)^1 D_{t-2} + \propto (1 - \propto)^2 D_{t-3} + (1 - \propto)^3 F_{t-3}$

$= 0.20 D_{t-1} + 0.16 D_{t-2} + 0.128 D_{t-3} + \ldots$

Hence, for a new product or for items with a dynamic or unstable demand, a higher value of $\propto$ (0.7 to 0.9) is more justifiable. In case of a product that is in the market for a longer period of time and the demand of the product is of less variance, the value of $\propto$ is to be taken from the range of 0.1 to 0.3, to smooth out any sudden noise (Noise is any dispersion or deviation of demand from the actual demand pattern) that might have occurred. When demand is slightly unstable, smoothing coefficient of 0.4, 0.5, 0.6 might provide most accurate forecasts.

Illustration (i)

Say there is a new product, and the forecast for the month of November has to be calculated considering that the demand of the product in September is 300 and in October is 350. The forecast for September was 200 units. As the product is new, the value of $\propto$ is to be taken from the range of 0.7 to 0.9. In this case let the value be 0.7:

Therefore,

$$F_{October} = \propto D_{September} + (1-\propto) F_{September}$$

$$= 0.7 \times 300 + (1-0.7)\ 200$$

$$= 270$$

$$F_{November} = \propto D_{October} + (1-\propto) F_{October}$$

$$= 0.7 \times 350 + (1-0.7)\ 270$$

$$= 326$$

Therefore, the forecast for the month of November = 326.

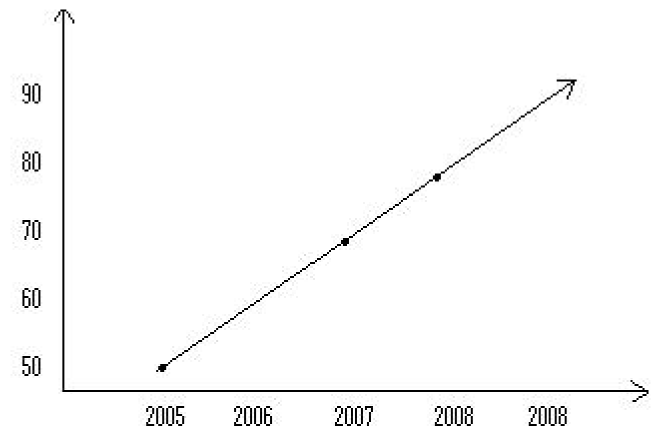
Extrapolative or Time series methods

Extrapolative methods use past data of demand to make demand forecast for the future period. The objective of this method is to identify the pattern in historic data and extrapolate this pattern for the future. This is one of the easiest methods of forecasting and it proves well in short time horizons. This method can be used if all the previous date is linear. Extrapolative or time series is a time-ordered sequence of observations taken at regular intervals. i.e. hourly, daily, weekly, monthly, quarterly, semi-annually, annually. This method is based on the assumption that future values of the series are estimated from the past values. There is quite a number of behaviors exhibited by the time series when the data is plotted on the graph. They are described as follows:

1. Trend – trend refers to the long term upward or downward movement in the data.
2. Seasonality – seasonality refers to short-term, fairly regular variations generally related to factors such as the calendar or time of the day.
3. Cycles – cycles are wave like variations of more than one year's duration.
4. Irregular variations – irregular variations arise due to unusual situations such as sudden changes in weather conditions, strikes and lock outs, or a major technological change in a product or services.
5. Random variations- random variations are residual variations that remain after all other behaviors have been accounted for.

Illustration:

If the sales of a firm are 50, 60, 70, 80, units for the years, 2005, 2006, 2007, 2008 respectively, then the forecast for the year 2008 is identified as 90 units.



Casual or explanatory methods

The causal model uses a mathematical technique known as the regression analysis. Regression means dependence and involves estimating the value of a dependent variable y (for example, demand), from independent variable x (for example, price, advertisement, etc.). This is the mathematical model of obtaining the line of best fit between the dependent variable and independent variable. In simple regression, only one independent variable is used, where as in multiple regressions two or more independent variables are involved. The relationship between the dependent variable (y) and independent variable (x) can be represented by a straight line

$$\boldsymbol{y = a + bx}$$

Where,

a – y intercept

b – Slope of the line

The values of constant 'a' and 'b' can be determined by simultaneous equations

$\sum y = Na + b\sum x$ ------------ (1)

$\sum xy = a\sum x + \sum x^2$ ------------ (2)

Solving the above normal equations 1 and 2 we get

$a = \sum y / N$ $\quad$ $b = \sum xy / \sum x^2$

Model for multiple regressions

$$\boldsymbol{y = a + b_1 x_1 + b_2 x_2 + .. + b_n x_n}$$

y = dependent variable $\quad$ a = y intercept

x_i = i^{th} independent variable $\quad$ b_i = slope of independent variable x_i

Equation for curvilinear regression is given as

$y = a + b_i x + b_2 x + b_3 x$

where y – dependent variable

x, x^2, x^3 – independent variable

a – intercept

Illustration

XYZ Company has the following pattern for various years. Forecast the sales for the year 2017 and 2008.

Year	2010	2011	2012	2013	2014	2015	2016
Sales (Lakhs)	5	8	10	13	17	23	32

Solution:

Year (X)	**Mid Value (x=X–A) A=2013**	**Sales (y)**	**(xy)**	**(x^2)**
2010	-3	5	-15	9
2011	-2	8	-16	4
2012	-1	10	-10	1
2013	0	13	0	0
2014	1	17	17	1
2015	2	23	46	4
2016	3	32	96	9
Total	**$\sum x=0$**	**$\sum y=108$**	**$\sum xy=118$**	**$\sum x^2=28$**

$a = \sum y / N = 108/7 = 15.43$

$b = \sum xy / \sum x^2 = 118/28 = 4.21$

$$y = a + bx$$

$Y_{2017} = 15.43 + 4.21\ (2017\text{-}2013) = 15.43 + 4.21(4) = 32.27$

Sales for the year 2017 is 32.27 Lakhs

Try this for further understanding:

The sales of a company (in million dollars) for each year are shown in the table below.

Year	2015	2016	2017	2018	2019
Sales (in Cr.)	12	19	29	37	45

Forecasting is one of the key elements of operations management. A forecast is an inference of what is likely to happen in the future. It is estimated by systematically combining and casting forward in a predetermined way data about the past. Forecasting involves taking historical data and projecting them into the future with some sort of mathematical model. It may be subjective or intuitive prediction of the future or it may be both, i.e., a combination of mathematical models adjusted by good judgment. But a history of data must exist from which reasonable inferences can be reached for forecasting. Forecasting prepares an organization for a common future objective through department activity coordination. It is important for both short-term and long-term planning.

Organizations use three major types of forecasting (economic, technological and demand forecasting) in planning the future of their operations. All forecasts lead to demand forecasting. Demand of a particular product of a particular company is a result of many forces in the market, like average income of the consumers, price and availability of related goods. Basically, it depends on market size of that product and the captured market share of that company. A number of forces

that are beyond the company's control (environmental factors, political and legal happenings), as well as others that the company can at least influence (Product life cycle), act to determine the level of demand that the company receives. To develop a workable forecasting system, production personnel, inventory control personnel, and marketing personnel should cooperate in determining the forecast. This cooperation provides checks and balances for the forecasting procedure. The key inputs of forecasting are information, analysis, experience, and informed judgment. Economic conditions, competitors' actions, consumers' preferences, and other social phenomena often are whimsical. Judgment must be exercised to see that appropriate forecasting methods are developed and properly applied.

Discussion Forum

1. A company wants to see 10 months moving average for forecasting sales of their product. They will get the average of last 10-month sales. Later after a month they add latest 10-month sales and discard the oldest once. This method is repeated to get the forecast through this method.

Month	**Sales (Units)**
Jan	100
Feb	110
March	95
April	115
May	100
June	105
July	95
August	90
September	115
October	120

$$\text{Moving Average} = \frac{\sum X}{N}$$

Where,

$$\sum X = Sum\ of\ Units$$

$$N = No.\ of\ Months$$

Forecast for November = 1045/10

= 104.5 or 105 units

Forecast for December

Suppose if observed sales for November is 105, then

$$\text{Forecast of December} = \frac{1150}{11}$$

= 105 units

2. Consider the following data:

Year	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
Passenger cars(thousands)	1	2	2	4	5	5	7	9	10	11

Find out the three-year moving average for the sales of cars during the years 1995-2004 and forecast for the year 2005.

Solution:

Year	**Car sales (thousands)**	**Three years moving total**	**Three-year sales moving average**	**Forecast**
1995	1	-	-	-
1996	2	1+2+2=5	1.67	-
1997	2	2+2+4=10	3.33	1.67
1998	4	2+4+5=11	3.67	3.33
1999	5	4+5+5=14	4.67	3.67
2000	5	5+5+7=17	5.67	4.67
2001	7	5+7+9=21	7	5.67
2002	9	7+9+10=26	8.67	7
2003	10	9+10+11=30	10	8.67
2004	11	-	-	10

3. Calculate the forecast of sales for the month of June and using the following data.

Month	Sales	Weightage	Weighted sales
	S	W	S × W
January	100	0.1	10.0
February	110	0.15	16.5
March	95	0.2	19.0
April	115	0.25	28.75
May	100	0.3	30.0
June			104.25

Forecast for month of June is 104 units.

4. Consider the following data:

Year	2010	2011	2012	2013	2014
Passenger Cars (Thousands)	10	12	11	14	15
Weight	0.05	0.1	0.15	0.3	0.4

Find out the weightage average for the sales of car and forecast for the year2015.

Solution:

Year	Car Sales (Thousands)	Weight	Weighted Average
2010	10	0.05	0.5
2011	12	0.1	1.2
2012	11	0.15	1.65
2013	14	0.3	4.2
2014	15	0.4	6
			13.55

Forecast for the year 2015 = 13550 units

5. A company uses exponential smoothing with 2 = 0.2 to forecast demand. The forecast for the month of January was 1000 units, whereas actual sales turner out to be 900. Forecast the demand for the month of February.

$F_t + 1 = \alpha D_t + (1 - \alpha)F_t$

$= 0.2 \times 1000 + (1 - 0.2)\ 900$

$= 200 + 720$

= 920 units

6. Forecasting methods need to be monitored and controlled properly - why?

7. How does correlation play a key role in forecasting?

8. How can a manager evaluate the reliability and the level of confidence of a forecast?

9. In what situation you might use quantitative forecasting method though having historical data?

10. “Forecasting of sales is the key to many other types of forecasts.” Explain.

11. “Forecasting is more focused towards science than just being a simple technique.” Judge the above comment.

12. Why is economic forecast important? In developing an economic forecast, what problems can be encountered?

13. In recent times, technological forecasting has been given great emphasis. Why?

14. How do some investments in forecasting results in a negative return?

15. How accurate should the government forecast need to be and why? Explain with the help of two such situations.

16. Is there any difference between forecasting demand and forecasting sales?

17. Explain how an organization can become confused when the distinction between forecasting and planning is not clear.

CHAPTER- 7

PRODUCTS/ SERVICES PLANNING, DESIGN AND DEVELOPMENT

INTRODUCTION

In the current global scenario, planning, designing and developing the products for the market is one of the great challenges faced by the companies irrespective of their size and nature. In consumer markets, there are varieties of needs, and even within a buying unit, there are multiple customer voices (e.g., children versus parents). There are even multiple customer voices within a single organization: the voice of the procuring organization, the voice of the user, and the voice of the supporting or maintenance organization. These diverse voices must be considered, reconciled and balanced to develop a truly successful product. The product plan helps resolve issues related the markets, the types of products and the opportunities that the company will invest in and the resources required to support product development. More specifically, the product plan is used to:

- Define an overall strategy for products to guide selection of development projects;
- Define target markets, customers, competitive strengths, and a competition strategy (e.g., competing head-on or finding a market niche);
- Position planned products relative to competitive products and identify what will differentiate or distinguish these products from the competition;
- Rationalize these competing development projects and establish priorities for development projects;
- Provide a high-level schedule of various development projects; and
- Estimate development resources and balance project resource requirements with a budget in the overall business plan.

While a product plan is generally prepared on an annual basis, it should be reviewed and updated at least quarterly, if not monthly. Market conditions will change, new product opportunities will be identified, and new product technology will emerge all causing a potential impact to the product plan. These opportunities need to be evaluated and the product plan changed if needed. These changes may result in re-prioritizing development projects or making a decision to hire additional development personnel to undertake a new development opportunity.

Before proceeding to product/services planning, design, and development, it is important to know the meaning of products and services.

Product

A product is anything that is capable of satisfying a felt. A new product is the one which is truly innovative and is significantly different from other existing products. It is a bundle of attributes (features, functions, benefits, and uses) that a person receives in an exchange.

In essence, the term "product" refers to anything offered by a firm to provide customer satisfaction, tangible or intangible. Generally, products are classified into two types:

1. Consumer Products (convenience products, shopping products, specialty products, unsought products).
2. Industrial Products (capital goods, raw materials, component parts, major equipment, accessory equipment, operating supplies, and services).

Service

A service is the non-material equivalent of a good. A service provision is an economic activity that does not result in ownership, and this is what differentiates it from providing physical goods. It is claimed to be a process that creates benefits by facilitating a change in customers, a change in their physical possessions, or a change in their intangible assets.

A service is a transaction in which no physical goods are transferred from the seller to the buyer.

A service is defined as "a set of benefits delivered from the accountable service provider, mostly in close coactions with his service suppliers, generated by the functions of technical systems and/or by distinct activities of individuals, respectively, commissioned according to the needs of his service consumers by the service customer from the accountable service provider, rendered individually to the authorized service consumers on their dedicated request, and, finally, utilized by the requesting service consumers for executing and/or supporting their day-to-day business tasks or private activities".

Unique Characteristics of Services

- ***Intangibility:*** creative advertising, no patient protection, importance of reputation.
- ***Perishability:*** cannot inventory, opportunity loss of idle capacity, need to match supply with demand.
- ***Heterogeneity:*** customer participation in delivery process results in variability.
- ***Simultaneity:*** opportunities for personal selling, interaction create customer perceptions of quality.
- ***Customer Participation in the Service Process:*** attention to facility design but opportunities for co-production.

Table – 7.1 Characteristics of Products and Services

PRODUCTS	SERVICES
Products are tangible, have a form, can be felt, smelled and scanned	Services are intangible, can be experienced and appreciated
Can be produced and stored	Cannot be stored
The manufacturing process of products has minimal contact with customer	The production process has high degree of contact with customer or client
Usually involves complex interrelated processing	Usually involves simple processing
Variation of demand for products can be accounted on weekly, monthly or seasonal basis.	Variation of demand for services should be accounted on hourly, daily or weekly basis
Economy of scale is possible	Economy of scale generally is not possible
Production process for products can be automated	Process for service is usually labour intensive

New products and services are the lifeblood of an organization. They are designed in order to provide a competitive edge by bringing new ideas to the market quickly for satisfying customer needs. Policies regarding the product/services development are formulated and implemented by the organizations to create unique selling proposition (USP) which in turn helps the organization to gain competitive advantage over the competitors.

Some of the product policies developed by the organizations are:

1. The company tries to offer their products comparatively at low cost than their nearest competitor in order to gain cost advantage. Also the companies try to make more profit by producing and selling the products at large volumes.
2. Some organizations offer top quality products and gain special customers who value only the quality as the main criteria to purchase the product.
3. Some organizations offer products at moderate cost and quality and try to capture large customers. i.e. They try to maintain a reasonable balance between the quality and cost.
4. Some organizations give maximum importance to safety. Particularly products like electrical home appliances involve high safety, and the organizations offer maximum safety for such products.

CATEGORIES OF NEW PRODUCTS

There are several general categories of new products. Some are new to the market, some are new to the company, and some are completely novel and create totally new markets. When viewed against different criteria, some new product concepts are merely minor modifications of existing products while some are completely innovative to the company.

a. Incremental or Derivative Products

These types of products are products with least amount of innovation and are typical hybrids or enhancements of existing products. Most of the incremental products are the same existing products with added features or functions.

b. Next generation or Platform Products

These products represent new “system” solution for the customer. They provide a broad base for a product family that can be leveraged over several years.

c. Breakthrough or Radical Products

This type of product requires change in design and process. This type of product when properly introduced in the market creates a new product category, which becomes a new core business for the firm.

CATEGORIES OF NEW SERVICES

There are seven categories of new services in a hierarchy, ranging from major innovations to simple style changes.

1. *Major Service innovations* are new core products for markets that have not been previously defined. These services include both new-service offerings and radical new processes.
2. *Major process innovations* consist of innovative new processes to deliver existing core services in new ways with greater value enhancement to the customer.
3. *Service-line extensions* are additions to existing lines of services.
4. *Process-line extensions* are less innovative than major process innovation, but are new ways of delivering existing services so that they offer greater convenience or a different experience to the customer.
5. *Supplementary-service innovations* take the form of adding new elements to the core service or improving existing supplementary services that accompany the core service.
6. *Basic service improvements* are the most common type of new-service innovation. This involves modest changes in the performance of the current service, like serving customers quicker.

7. *Style changes* are the simplest type of new-service innovation and require no change in the service core or service process.

PRODUCT PLANNING

Product planning is the process of searching ideas for new products, screening them systematically, converting them into tangible products and introducing the new product in the market. It also involves the formation of product policies and strategies.

Product planning includes improvements in existing products as well as deletion of unprofitable or marginal products. It also encompasses product design and engineering which is also called product development. Product planning comprises all activities starting with the conception of product idea and ending up with full scale introduction of the product in the market. It is a complex process requiring effective coordination between different departments of the firm. It is intimately related with technical operations of the organisation, particularly with engineering, research and development departments. Product planning is required for the following reasons:

- To replace obsolete products
- To maintain and increase the growth rate/sales revenue of the firm
- To utilise spare capacity
- To employ surplus funds or borrowing capacity
- To diversify risks and face competition.

Definitions

"Product planning is the act of managing and supervising the search, screening, development and commercialization of new products; the modification of existing lines; and the discontinuance of marginal or unprofitable items.

– Carl H. Titgen

"Product planning involves devising procedures to evaluate the performance of products and planning the modification where necessary, of existing products aimed at extending their lives, the deletion of those products which have reached the terminal stage of their lives and the development and marketing of new products".

– Dale Littler

OBJECTIVES OF PRODUCT PLANNING

Some of the specific objectives set-up during product planning is as follows:

1) *To identify and fulfill customers' needs:*

The very first objective of any product planning is to determine the customers' needs and thereafter designing the required products and services. To fulfill this objective, all the resources and efforts of the firm are directed towards it.

2) *To determine strengths and weaknesses of the firm:*

The next objective of product planning is to determine the strengths and weaknesses of the firm so as to effectively develop the blueprint of the required product. It helps in developing such products which reduce the weaknesses of the firm and empower its strength.

3) *To ensure optimum utilization of resources*:

Ensuring optimum utilization of resources is also an objective of the product planning. Here, the objective is to maintain the minimum cost level of the production while allocating firm's resources in manufacturing the product. Product planning involves development of product by either manufacturing a new product or by modifying the existing one as per the customers' need. This involves use of various resources. The objective here is to economically use the costly and limited resources so as to make the production process cost-effective.

4) *To assure firm's survival*:

Another objective of any product planning process is to assure the firm's survival in the future. A firm's long-term survival is determined by the performance of its products in market. The products that fulfill all the requirements of the customers help in the long-term growth and success of the firm. In order to survive for a longer period of time, the firm needs to incorporate innovation and renovation in its products and services.

5) *To enhance level of sales:*

The main motive of all the firms is to enhance their sales level for earning profit. For achieving this objective, the firm uses product planning as a tool because when the product will be effective then only its sale will increase.

PROCESS OF PRODUCT PLANNING

Product planning encompasses all aspects of a product from generation of ideas to exit strategy. Some of the key product planning phases is enlisted below.

1. Product conceptualization

It is a detailed description of the idea, describing it from a customer perspective. This can be done for a new product or an existing product. This phase is crucial and can be the deciding factor between successful ones and the unsuccessful ones. A product concept also helps in anticipating problems in design or manufacturing or development.

2. Market research

This phase helps the firm to determine whether the product is saleable in the market after ensuring that the idea or concept is a solution for identified problems in the real world. The firm performs a detailed study of about the competition, getting familiar with the competitors' products and figuring out any gaps in their products that the firm's product can plug and eventually take over the market. This usually involves surveys and interviews with customers who are willing to share their experiences. Secondary research also throws up a lot of data, including the product-wise market share of competitors.

3. Prototype or Minimum Viable Product (MVP)

The concept is used to construct a Minimum Viable Product that helps the firm to test and collect the feedback. The firm has to get back to the previous phases in case the feedback is not favorable. Product design and development teams are involved in creating an MVP. It is a phase where the firm gets to assess if its product will be able to fill in the gaps in the marketplace.

4. Market introduction

After a successful MVP and any course correction required after feedback, the products are taken to the market. At this stage, marketing function takes over from product planning.

5. Product maturity plan

A product which becomes stable in the market acquires maturity and the product life cycle management should work out to identify new product in the line. An ongoing study regarding the products sales, competition, features that are not available in the firms' product but are offered by competitor products takes place continuously. A time-bound strategy should be put in place to review such market conditions apart from sales and get a buy-in from design and development teams to innovate further or create an entirely new line of product thereby to put an end to any non-performing ones.

PRODUCT DESIGN PROCESS

Design is a set of fields for problem solving that uses user-centric approaches to understand the user needs to create successful solutions that solve real problems. The quality of a product or service is highly influenced by the design. Poor design may result in customer dissatisfaction. Costly design may result in over priced products, which result in downfall of market share. If the design process is too lengthy, then the competitor may capture the market by being first to introduce new products or services. Hence the design process must be managed effectively. An effective design process:

1. Matches products or services characteristics with customers with customer requirements
2. Ensures that customer requirements are met in the simplest and least costly manner
3. Reduces the time required to design a new product or service and
4. Minimizes the revisions necessary to make a design workable

The design process helps the organization by encouraging them to look outside their boundaries, bringing new ideas, challenging conventional thinking, providing a venue for learning, and breaking down the barriers. Above all, the product design should be dictated by the market demand. It is an important decision and therefore the entrepreneur should pay due effort, time, energy and attention in order to get the best results.

Product design is an essential activity for firms competing in a global environment. Product design drives organizational success because it directly and significantly impacts nearly all of the critical determinants for success. Customers demand greater product variety and are quick to shift to new, innovative, full-featured products. In addition, customers make purchase decisions based on a growing list of factors that are affected by product design. Previously, customers made purchase decisions based primarily on product price and/or quality. While these factors are still important, customers are adding other dimensions such as customizability, order-to-delivery time, product safety, and ease and cost of maintenance. Environmental concerns are expanding to include impacts during production, during the product's operating life, and at the end of its life (recycle-ability). In addition, customers demand greater protection from defective products, which leads to lower product liability losses. Safer and longer lasting products lead to enhanced warrantee provision, which, in turn, impact customer satisfaction and warrantee repair costs.

PRODUCT DESIGN

Product design is defined as “the determination and specification of parts of a product and their interrelationships so that they become unified as the whole.” Product design is a strategic decision as the image and profit earning capacity of a small firm depends largely on it. Once the product to be produced is planned and decided by the entrepreneur the next step is to prepare its design. Product design consists of form and function. The form designing includes decisions regarding its shape, size, color and appearance of the product. The functional design involves the working conditions of the product. Once a product is designed, it prevails for a long time therefore various factors are to be considered before designing it. The following factors are listed below:

(a) Standardization

(b) Reliability

(c) Maintainability

(d) Servicing

(e) Reproducibility

(f) Sustainability

(g) Product simplification

(h) Quality Commensuration with cost

(i) Product value

(j) Consumer quality

(k) Needs and tastes of consumers.

Product design deals with conversion of ideas into reality. New product and services are the life blood of an organization. Every organization has to design and develop new products and services in order to increase their competitive strength in the market. New product design is a critical process for a firm. It capitalizes on a firm's core competencies and determines what new products and service need to be developed. It is also one of the change agents as new products and services can rejuvenate an organization through new markets, technologies etc.

Definition

According to C.S.Deverell, "Product design in its broadest sense includes the whole development of the product through all the preliminary stages until actual manufacturing begins".

Importance of Product Design

Product design is more important than ever because customers are demanding greater product variety and are switching more quickly to products with state-of-the-art technology. The importance of product design is explained through the following points:

- It is a critical factor in organizational success because it sets the characteristics, features, and performance of the service or good that consumers demand.
- It plays a vital role in lowering the cost of manufacture for competitive advantage.
- Product design is important in making more profits by attracting more customers through its design and packaging.
- To enter into the new prospective business through related diversification, product design is essential.
- It can also be an important mechanism for coordinating the activities of key supply chain participants.
- Product design is an essential activity for firms competing in a global environment.
- Product design shapes the product's quality. It defines the way that and service functions.

Characteristics of a Good Product Design

- Functionality: The product must function properly for the intended purpose.
- Reliability: The product must perform properly for the designated period of time.
- Productivity: The product must be produced with a required quantity and quality at a defined and feasible cost
- Quality: The product must satisfy the customer's stated and unstated needs.
- Standardization: The product should be designed in such a fashion so that most of the components are standardized and easily available in the market.
- Maintainability: The product must perform for a designated period with a minimum and defined maintenance. Adequate provisions for maintenance should be kept in the product.

- Safety: The product must be safe to the user and should not cause any accident while using or should not cause any health hazard to the user. Safety in storage, handling, and usage must be ensured by the designer.

- Cost-Effectiveness: The product must be cost-effective. They must be manufactured in the most cost-effective environment.

Objectives of Product Design

The objectives of designing the product may be summarized as follows:

- The first objective of designing is to create attention in products for increasing the sale potentials.
- To enlarge the importance of product from customers' point of view
- To make the product more effective and create more utility in the product for the consumer
- Produce better quality at the lowest possible price.

Advantages of Product Design

Some of the advantages of product design for the organizations are given as follows:

- Attract new customers with a new improved larger product line
- Through continuous product designs we can retain the current existing customers.
- There is a possibility to identify alternative designs
- Limitations of the product can be determined and reduced.

THE NEW PRODUCT DESIGN (NPD)

New product design is a critical process for a firm. It capitalizes on a firm's core competencies and determines what new products and services need to be developed. It is also one of the change agents as new products and services can rejuvenate and organization through new markets, technologies etc. Product design defines the appearance of the product, standards for performance, dimensions and tolerances, materials used for manufacturing, etc.

Service design specifies what physical items, sensual benefits, and psychological benefits the customer is to receive from the service, and defines the environment in which the service will take place.

Reasons for New Product Design

The following are the reasons for which the organizations go for new product design process.

- To continue the business in the environment
- To satisfy the customers
- To improve the sales
- To expand the business
- To increase the profit levels
- To gain competitive advantage over their competitors

TYPES OF PRODUCT DESIGN

Product design is of two types. They are as given below.

1. Customized Product Design

Customized product design is used when the level of customization is high and the quantity produced is low. Products are design to satisfy a particular customer or customer group. Mostly industrial products like boilers, turbines, pipelines etc come under this category.

2. Standard Product Design

Standard product design is employed when the organization needs to produce products in large scale. Standardization is achieved in this product design and the organization tries to achieve economies of scale also. Cost-control and quality control are given more importance rather than flexibility of the system. Almost all the consumer durable goods like cars, bikes, personal computers, televisions, etc. are produced using the standard product design.

THE PRODUCT DESIGN PROCESS

The steps involved in design process are as follows:

1. Idea Generation

The process begins with understanding the customers and their needs. Ideas for new products or improvements to existing products can be generated from many sources such as company's own R&D department, customer complaints or suggestions, marketing research, suppliers, sales persons in the field, factory workers and new technological developments. Competitors are also a source of ideas for new products or services. Techniques such as Perceptual maps, benchmarking and reverse engineering help companies to learn their competitors.

a) Perceptual Maps: Perceptual map is visual method of comparing customer perceptions of a company's products with competitors' products.

b) Bench Marking: Bench marking refers to finding the best – in –class product or process, measuring the performance of a company's product or process against it, and making recommendations for improvement based on the results.

c) Reverse Engineering: Reverse engineering refers to carefully dismantling and inspecting a competitor's product to look for design features that can be incorporated into a company's product. For many products and services, customers, are attracted by superior technology and creative idea. In most of the industries research and development is the primary source of new product ideas. Sometimes the design processes can also be outsourced to a design firm, as shown in the diagram.

2. Screening Ideas

The ideas generated in the previous stage that do not possess potential advantages need to be eliminated and stopped from entering the subsequent stages of the designing process. The ideas are evaluated by scoring dimensions of ideas on a 1-10 scale and adding relative weights to them. The resulting aggregate score can be used to scrutinize the best ideas to be progressed to the further stages.

3. Feasibility Study

A feasibility study consists of a market analysis, an economic analysis, and a technology strategic analysis. The customer's needs and ideas that are generated from the first stage undergo a feasibility study that includes

a) Market Analysis

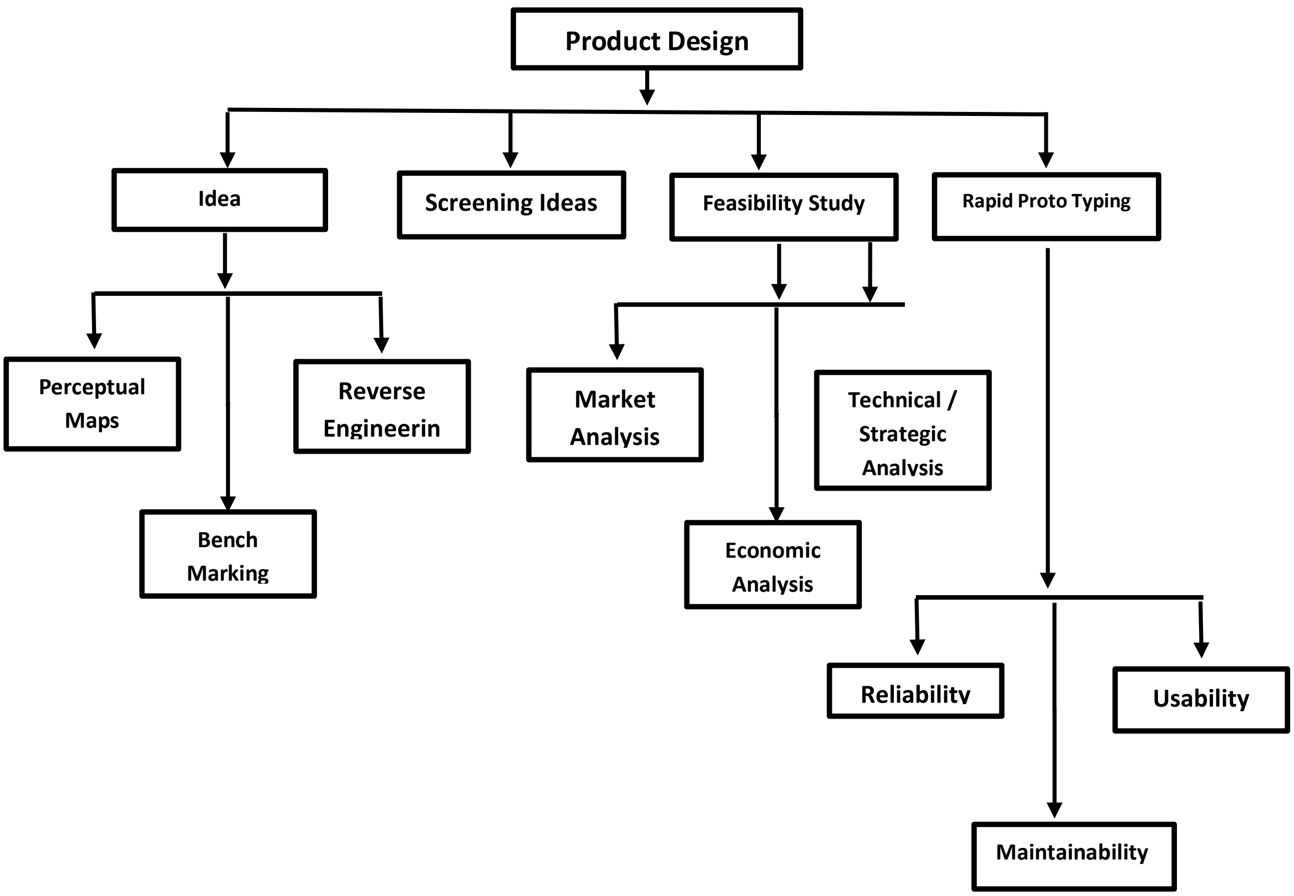
b) Economic Analysis

c) Technical and Strategic Analysis

a) Market Analysis

A market study is carried out to determine the potential demand for the company's new products or services. Usually the market analysis is done with the help of market surveys and customer feedback, which play a major role in the development of alternative product/service concepts.

Fig 7.2 The Product Design Process



b) Economic Analysis

Economic analysis is carried out when the demand potential exists. Economic analysis is done to estimate the production and development costs of the product to compare them with estimated sales volume. Price range of the product service and the profit potential of the project are estimated using the quantitative analysis techniques such as cost benefit analysis, decision Theory, net present value / internal rate of return, etc.

c) Technical and Strategic Analysis

This analysis is carried out in order to identify the feasibility of product with

- New Technology
- Manufacturing process
- Facility availability for production

Strategic analysis is done to assess the Risk & Capital investment (Excessive), Competitive advantage for the company and its Corporate Strengths.

4. Rapid Proto Typing

Product/service designers use the general performance specifications collected from the previous stages and transform them into product / service. The process necessarily involves building a proto type, testing the prototype, revising the design and retesting. Rapid prototyping creates preliminary design models that are quickly tested and either discussed or further refined. The models can be physical or electronic rough facsimiles or full-scale working models. The interactive process involves the follow designs.

a. Form design

b. Functional design

c. Production design

a) Form design:

Form design refer to the physical appearance of product its colour, size shape and style. Aesthetics such as image, market appeal and personal identification are also part of form design.

b) Functional design:

Functional design is concerned with how the product performs. It seeks to meet the performance specifications of fitness for use by the customer. Three performance characteristics considered during the phases of design are

i. Reliability

ii. Maintainability

iii. Usability

i) Reliability: Reliability is the probability that a given part or product will perform its intended function for a specific period under conditions of use. A product or system's reliability is a function of the reliabilities of its components parts and how the parts are arranged. If the all parts function for the product or system to operate, then the system reliability is the product of the component part reliabilities.

Rs = R1 X R2 ………Rn Rn = reliability of nth component

Failure of some component in a system is more critical than others. Eg. The brake in a car. To increase the reliability of individual parts, redundant parts can be built in to back up a failure. Providing mechanical brake is on example.

Consider the following redundant design with R1 representing the reliability of the original component and R2 the reliability of the backup component.

These components are said to operate in parallel. If the original component fails (5% chance of failures), the backup component automatically jumps in to take its place – but only 90% of the time. Thus, the reliability is calculated as

Rs = R1 + (1 – R) R2

= 0.95 + (1- 0.95) (0.995) = 0.995

Reliability can also be expressed in terms of mean time between failures (MTBF) which is the length of time of a product or service in operation before its failure. Reliability can be improved by simplifying product design, improving the reliability of individual components or adding.

ii) Maintainability: Maintainability refers to the ease with which a product service is maintained or repaired. For example, computers can be easily maintained by assembling them in modules so that entire control panels, cards, or disk drives can be replaced when they malfunction. Customers can be given instructions with the product to anticipate malfunctions and the procedure to correct them. The mean time to repair is one of the quantitative indicators of maintainability (MTTR).

iii) Usability: Usability refers to how easy a product or service is to use and how well it fits its intended audience. It is a set of elements that influence a user's experience with a product, such as ease of learning, ease of use, and the ability to recall how to use it, as well as the frequency and severity of errors, and user happiness with the experience.

c) Production Design

Production design is concerned with how the product will be made complex designs often results in poor - quality products. Engineers tend to over design products, with too many features, options, and parts. It can be efficiently carried out only with the help of in depth knowledge in manufacturing capabilities.

Many times, production personnel find themselves redesigning products to the shop floor level. A further change in design is considered very costly and disruptive, as it affects the entire line of production. Hence the production design is considered in the preliminary design phase.

The following are the different approaches to production design: Simplification, Standardization, and Modularity.

i. Simplification: Simplification aims to reduce the number of parts, sub-assemblies, and operations in a product. It also means avoiding tools, separate features and adjustments.

ii. Standardization: Standardization helps the interchangeability of parts among products, resulting in higher – volume production and purchasing, lower investments in inventory, simplify purchasing and material handling, minimize quality inspections and difficulties in production, some products such as batteries, cables etc. are totally standardization.

iii. Modular Design: Modular design consists of combining standardized building blocks, or module, in a variety of ways to create a finished product. For eg. Toyota's camry, Carolla and lixus share the same body chases.

Final Design and Process Plans

The proto types are built and tested for consistency using pilot study during the preliminary design stage. Adjustments are made in the design if needed. In this way, the design specification for the new product is arrived at after few revisions in the design of the product. Design changes, known as engineering change orders (ECOS) are a major source of delay and cost over runs in the product development process. The final design consists of detailed drawings and specifications for the product or service. The process plans are given to provide workable instructions for manufacture including necessary equipment and tooling, component sourcing recommendations, job descriptions and procedure for workers, and computer programs for automated machines.

Introduction

The introduction phase ensures that the product has reached the market and the market has acquired the product as anticipated.

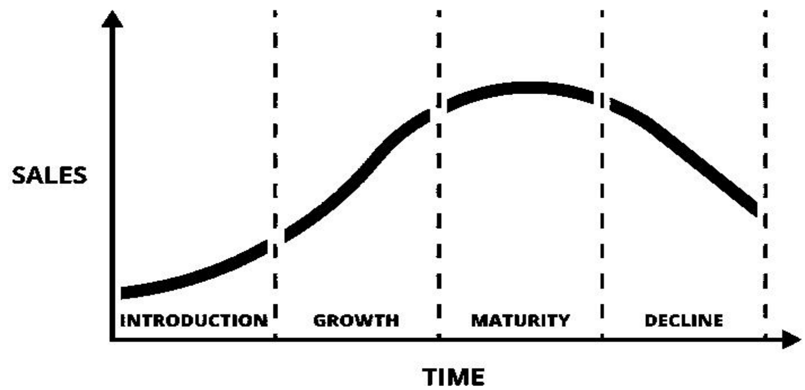
PRODUCT LIFE CYCLE

Product Life Cycle (PLC) has to do with the life of a product in the market with respect to business/commercial costs and sales measures.

A product has a life cycle is to assert four things:

- Products have a limited life.
- Product sales pass through distinct stages, each posing different challenges, opportunities, and problems to the seller.
- Profits rise and fall at different stages of product life cycle.
- Products require different marketing, financial, manufacturing, purchasing, and human resource strategies in each life cycle stage.

Product Life Cycle



The life cycle of a product consists of 4 stages:

1. Introduction
2. Growth
3. Maturity
4. Decline

Table 7.2 Characteristics of Stages in Life Cycle

Introduction	**Growth**	**Maturity**	**Decline**
Costs are high	Costs reduced due to economies of scale	Costs are lowered as a result of production volumes increasing and experience curve effects	Costs become counter-optimal
Slow sales volumes to start	Sales volume increases	Sales volume peaks and market saturation is reached	Sales volume decline or stabilize
Little or no competition - competitive manufacturers watch for acceptance / segment growth losses	Significantly	Increase in competitors entering the market	Prices, profitability diminish

Demand has to be created	Profitability begins to rise	Prices tend to drop due to the proliferation of competing products	Profit becomes more a challenge of production / distribution efficiency than increased sales
Customers have to be prompted to try the product	Public awareness increases	Brand differentiation and feature diversification is emphasized to maintain or increase market share	
	Competition begins to increase with a few new players in establishing market	Industrial profits go down	
	Increased competition leads to price decreases		

PROBLEMS WITHIN PRODUCT DEVELOPMENT PROCESS

Uncertainty and risk are critical characteristics within any product development process. Product development processes can be characterized as creative, innovative, dynamic, interdisciplinary, strongly interrelated, strongly parallel, interactive, communication intensive, anticipatory, planning intensive, uncertain and risky.

Uncertainty and risk

It means that at any time during product development and even later, then characteristics of a system concerning functionality, performance features, etc are planned and specified. However, the actual knowledge about the system at this point, gained and confirmed through testing and verification, always falls below the planned. Consequently, there always exists a knowledge and time gap between assumed and verified characteristics. During this time, unexpected problems can occur and the whole development may be based on wrong assumptions.

Risks in product development not only refer to problems and uncertainties in terms of technical feasibility of a new product but also refer to some risks due to assumptions in time, costs and resources

ROBUST DESIGN

Robust design method was introduced by the quality philosopher Dr. Genichi Taguchi and hence it is also called as Taguchi Method which is used for improving the productivity in the organizations. Robust design focuses on improving the fundamental function of the product or process thus facilitating flexible designs and concurrent engineering. It also helps to ensure customer satisfaction. It is a method available for to reduce product cost, improve quality and reduce developmental interval. Traditional engineering focuses on solving problems through failure analysis usually through the use of repetitive process of design-build-test, i.e testing one factor at a time, firefighting, and studying in-depth the problems associated with interactions of the factors involved. This approach costs more, time consuming and always not successful.

But Taguchi's approach allows experiments to be performed and prototypes to be tested on multiple factors at once so that the product/process becomes insensitive to used-conditions and other uncontrollable factors. This is known as robust design and it provides more efficient, cost effective way to improve products and processes.

Advantages of Robust Design

Robust design helps the organization in the following ways.

- Develop products and processes which performs consistently as expected under a wide range of user conditions throughout their life cycle
- Robustness increases the intended function of the product by developing and increasing insensitivity to noise factors which tends to degrade the performance
- To develop or change the product/process formula and settings to achieve desired performance at the lowest cost in the shortest time.
- To reduce the cost of the product/process by simplifying the designs.

MODERN APPROACHES TO PRODUCT DESIGN

CONCURRENT ENGINEERING

Concurrent engineering is a systematic approach to integrated product development that emphasizes the response to customer expectations. It embodies team values of cooperation, trust and sharing in such a manner that decision-making is by consensus, involving all perspectives in parallel, from the beginning of the product life cycle.

Concurrent engineering is a business strategy which replaces the traditional product development process with one in which tasks are done in parallel and there is an early consideration for every aspect of a product's development process. This strategy focuses on the optimization and distribution of a firm's resources in the design and development process to ensure effective and efficient product development process.

Need for Concurrent Engineering

In today's business world, corporations must be able to react to the changing market needs rapidly, effectively, and responsively. They must be able to reduce their time to market and adapt to the changing environments. Decisions must be made quickly and they must be done right the first time out. Corporations can no longer waits time repeating tasks, thereby prolonging the time it takes to bring new products to market. Therefore, concurrent engineering has emerged as way of bringing rapid solutions to product design and development process.

Concurrent engineering is indisputably the wave of the future for new product development for all companies regardless of their size, sophistication, or product portfolio. In order to be competitive, corporations must alter their product and process development cycle to be able to complete diverse tasks concurrently. This new process will benefit the company, although it will require a large amount of refinement in its implementation. This is because, concurrent engineering is a process that must be reviewed and adjusted for continuous improvements of engineering and business operations.

The Concurrent Engineering Approach

Concurrent engineering is a business strategy which replaces the traditional product development process with one in which tasks are done in parallel and there is an early consideration for ever y aspect of a product's development process. This strategy focuses on the optimization and distribution of a firm's resources in the design and development process to ensure an effective and efficient product development process. It mandates major changes within the organizations and firms that use it, due to the people and process integration requirements. Collaboration is a must for individuals, groups, departments, and separate organizations within the firm. Therefore, it cannot be applied at leisure. A firm must be dedicated to the long term implementation, appraisal, and continuous revision of a concurrent engineering process.

Basic Principles

- Get a strong commitment to from senior management.
- Establish unified project goals and a clear business mission.
- Develop a detailed plan early in the process.
- Continually review your progress and revise your plan.
- Develop project leaders that have an overall vision of the project and goals.
- Analyze your market and know your customers.
- Suppress individualism and foster a team concept.
- Establish and cultivate cross-functional integration and collaboration.
- Transfer technology between individuals and departments.
- Break project into its natural phases.
- Develop metrics.
- Set milestones throughout the development process.
- Collectively work on all parts of project.
- Reduce costs and time to market.
- Complete tasks in parallel.

When is it used?

The majority of a product's costs are committed very early in the design and development process. Therefore, companies must apply concurrent engineering at the onset of a project. This makes concurrent engineering a powerful development tool that can be implemented early in the conceptual design phase where the majority of the products costs are committed. There are several applications in which concurrent engineering may be used. Some primary applications include product research, design, development, re-engineering, manufacturing, and redesigning of existing and new products. In these applications, concurrent engineering is applied throughout the design and development process to enable the firm to reap the full benefits of this process.

REASONS FOR USING CONCURRENT ENGINEERING

a. Competitive Advantage

The reasons that companies choose to use concurrent engineering is for the clear cut benefits and competitive advantage that concurrent engineering can give them. Concurrent engineering can benefit companies of any size, large or small. While there are several obstacles to initially implementing concurrent engineering, these obstacles are minimal when compared to the long term benefits that concurrent engineering offers.

b. Increased Performance

Companies recognize that concurrent engineering is a key factor in improving the quality, development cycle, production cost, and delivery time of their products. It enables the early discovery of design problems, thereby enabling them to be addressed up front rather than later in the development process. Concurrent engineering can eliminate multiple design revisions, prototypes, and re-engineering efforts and create an environment for designing right the first time

c. Reduced Design and Development Times

Companies that use concurrent engineering are able to transfer technology to their markets and customers more effectively, rapidly and predictably. They will be able to respond to customer’s needs and desires, to produce quality products that meet or exceed the consumer's expectations. They will also be able to introduce more products and bring quicker upgrades to their existing products through concurrent engineering practices. Therefore companies use concurrent engineering to produce better quality products, developed in less time, at lower cost, that meets the customer's needs.

POTENTIAL ADVANTAGES OF USING CONCURRENT ENGINEERING

- Faster time to market which results in increased market share.
- Lower manufacturing and production costs.
- Improved quality of resulting end products.
- Increased positioning in a highly competitive world market.
- Increased accuracy in predicting and meeting project plans, schedules, timelines, and budgets.
- Increased efficiency and performance.
- Higher reliability in the product development process.
- Reduced defect rates.
- Increased effectiveness in transferring technology.
- Increased customer satisfaction.
- Ability to execute high level and complex projects while minimizing the difficulties.
- Shorter design and development process with accelerated project execution.
- Higher return on investments.
- Reduction or elimination of the number of design changes and re-engineering efforts at later phases in the development process.
- Reduced labor and resource requirements.
- Ability to recognize necessary design changes early in the development process.
- Increased innovation by having all players participate in the concept development phase.
- Ability to design right the first time out / first time capabilities.
- Overlapping capabilities and the ability to work in parallel.
- Increased cohesiveness within the firm.
- Improved communication between individuals and departments within the firm.
- Lower implementation risks.
- Faster reaction time in responding to the rapidly changing market.
- Lower product and process design and development costs.
- Improved inventory control, scheduling and customer relations.

MASS CUSTOMIZATION

Mass customization is the low-cost, high-quality, large volume delivery of individually customized products. It is the ability to quickly design and produce customized products on a large scale at a cost comparable to non-customized products. Customization, cost effectiveness is the ability to produce highly differentiated products without increasing costs, significantly. Consumers expect to receive customized products at close to mass-production prices. Customization volume effectiveness is the ability to increase product variety without diminishing production volume. As markets become more and more segmented and aggregate demand remains constant or increases, firms must continue to design and produce high volumes across the same fixed asset base. Customization responsiveness is the ability to reduce the time required to deliver customized products and to reorganize design and production processes quickly in response to customer requests. It would be counter-productive to pursue mass customization if a customized product takes too long to produce. Speed in product design and production is an indispensable criterion for evaluating an organization's mass customization capability.

DESIGN THINKING APPROACH

Design thinking incorporates the user experience into the design process, moving beyond the simple look and feel part of product design. Design thinking was popularized by IDEO founder Tim Brown, who describes it as “a human-centered approach to innovation that draws from the designer’s toolkit to integrate the needs of people, the possibilities of technology, and the requirements for business success.”

One of the aspects of design thinking that makes it so successful is the prototyping phase. Designers can help lower the risk of launching a new product by testing the product design with small groups of users throughout the development process. A prototype helps validate that the product is something a customer can understand, will use, and that the design is appealing before the product goes to mass production.

LEAN UX APPROACH

The Lean Start-up and Lean UX approaches take design thinking a step further, putting the prototyping process front and center. Lean Start-up is an approach to starting a business venture that takes an idea, translates it into a product or service, measures how customers respond, and then takes the learnings to pivot or iterate. Lean UX takes that same approach and applies it specifically to design.

Lean UX focuses on the human experience behind the design. The deliverables of the entire product development strategy are less important than the learnings the design process delivers. The goal of Lean UX is to get feedback quickly and use it to continuously improve. It's an approach that is particularly collaborative – as if the customer is designing the product alongside the company. The drawback is that this approach to design can ignore other factors related to development; Lean UX can lead to somewhat of a product design bubble.

DESIGN SPRINT APPROACH

The design sprint is a subset of the design thinking approach. There are five phases to the design sprint process that takes place on five separate days:

1. Map
2. Sketch
3. Decide
4. Prototype
5. Test

Design sprints focus on a small part of the problem, or one aspect of the design, rather than building a completely new product. The process allows designers to work with their customers in the prototyping and testing phases, and to learn quickly to continue to design a winning product. Obviously, design sprints integrate elements from the other approaches, but with a more focused, disciplined aspect to product design.

Discussion Forum

Short Questions

1. Define Product Planning.
2. Define Product Design.
3. Mention the unique characteristics of services.
4. Define Product Planning.
5. Mention the objectives of product design.
6. Give any four characteristics of product design.
7. What is Product Life Cycle?
8. What do you mean by Robust Design?
9. Mention any four advantages of concurrent engineering.

Essay Type Questions

1. Differentiate between products and services.
2. Discuss the various categories of new products and services.
3. What are the objectives of product planning?
4. Explain the steps involved in product planning.
5. Discuss the importance of product design in the product development process.
6. Explain the various stages involved in product design process.
7. What are the different modern approaches to modern design? Explain.

CHAPTER -8

PROCESS PLANNING

INTRODUCTION

The objective of the manufacturing process is to transform an idea into a saleable product. The common methodology used to accomplish this goal is to divide the manufacturing method into a number of activities, organized serially. Usually, every activity handles a unique stage of the process, each stage representing a unique self-discipline and training.

Process planning is the systematic determination of methods through which a product is manufactured economically and competitively. Process Planning is a process that converts designs into workable guidelines for manufacture or deliver. It determines how a product will be produced or a provider will be provided. Process planning consists of selecting the appropriate machines, determining the sequence of operations, specifying the inspection stages, tools, jigs and fixtures and so forth in order to manufacture the products in accordance to the required specifications. It additionally decides, which factors will be made in house and which will be purchased from a supplier. It this section, we discuss make or buy decisions, process selection and process plans.

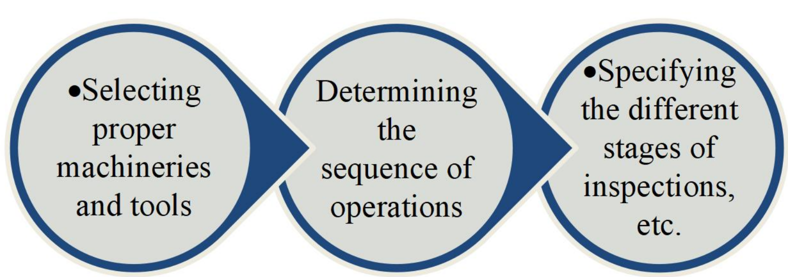
It is an intermediate stage between designing the product and manufacturing it. The following factors are considered while preparing the process plan:

(a) The functional requirements of the product.
(b) Time phased volume of output.
(c) The necessary operations and their sequence.
(d) Necessary tools and equipment.
(e) Estimated manufacturing cost for producing the product.
(f) Requirements of tools, labour and other resources.

The process planning is mainly concerned with, determining the manufacturing processes, sequence of operations, equipments, tools and labour required for the production of a component or a product, coordinating the efforts of all factors in manufacturing the product and to furnish a guide to use the existing or the proposed facilities.

It consists of the following activities:

Fig- 8.1 Process Planning



Process Planning- Definition

Process planning can be defined as "the function, which establishes the sequence of the manufacturing processes to be used in order to convert a part from an initial to a final form, where the process sequence incorporates process description, the parameters for the process and possibly equipment and/or machine tool selection"

- Niebel, B., A. Draper, and R. Wysk

Process planning consists of two parts:

1. Process Design
2. Operations Design

1. Process Design: Process design is concerned with the overall sequences of operation required to achieve the product specifications. The complete description of specific steps in the production process and the linkages among the steps that will enable the production system to produce products of the desired quality, in the required quantity, at the time, the customer wants them and at the budgeted cost.

2. Operations Design: Operations design is concerned with the design of the individual manufacturing operation. It consists of examining the man-machine relationship in the manufacturing process for converting the raw materials into finished product.

Process Plans

Process plans are a set pf documents that detail manufacturing and service deliver specifications. They begin with detailed drawing of product design (Usually from AD system).

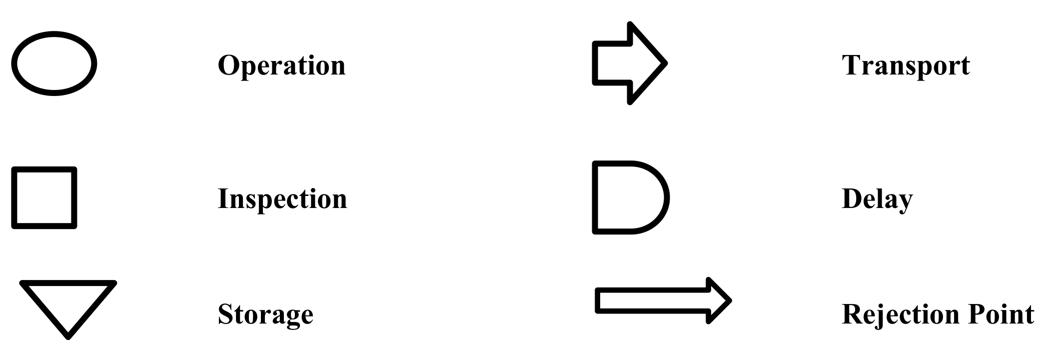
- *Assembly charts or bill of materials* – show the parts and material needed and how they are to be assemble together
- *Operations shut or routing sheets* – listing the operations to be performed with details on equipment, tools, skills, etc.
- *Quality control chick sheets* – specify standards and quality date to be recorded.

Process Analysis

Process analysis is the systematic examination of all aspects of a process to improve its operation. The basic tools of process analysis are process flow charts, diagrams and maps.

Process flow charts:

This chart uses 6 standard symbols to describe the process



Flow charts incorporates both productive activities both productive activities (including operations) as well as nonproductive activities (Inspection, Transportation, delay, Storage etc.) flow charts are used to analyze the efficiency of a series of processes and to suggest improvements.

Provide a standardized method for documenting the steps in the process.

- To identify bottle necks in the layout plans both in manufacturing and service operations.
- Basic tools for process innovation as well as for job
- Flow charts can take many forms, from forehand drawing to animated simulations.
- Process map: it maps out the activities performed by various people in the process. Sometimes process maps also include a time scale.

Process Strategy

Process Strategy is an organization overall approach for physically producing goods and providing services.

Process innovations

Processes are planned with respect to new facilities, new products, new technologies, new markets or new customers. Process should be analyzed on a continuous basis for improvement. When the process does not reach the performance expectations even after continuous improvements efforts, then we can decide that it is the time for complete process redesign or innovation.

Process Selection

A process is a group of related tasks with specific inputs and outputs. Processes exist to create value for the customer, the shareholder, or society. Process selection is a strategic level of decision of selecting the right kind of production process to have in the plant. Process selection is a higher-level decision as it affects the costs, quality and flexibility of operations.

GOAL OF PROCESS PLANNING

The goal of process planning is to improve and streamline the business methods of a company. This would have results like:

- Lower costs, due to fewer staff needed to complete the same process
- Higher efficiency, by eliminating problematic process steps like loops and bottlenecks
- Higher accuracy, by including checkpoints and success measures to make sure process steps are completed accurately
- Greater understanding by all staff of what they need to do to meet their department objectives

PRINCIPLES OF PROCESS PLANNING

Here are some general principles to keep in mind when evaluating or improving processes:

First, define the outputs, and then look toward the inputs needed to achieve those outputs.

- Define the goals of the process and evaluate them regularly to make sure they are still appropriate. This would include specific measures like quality scores and turnaround times.
- When mapped, the process should appear as a logical flow, without loops back to earlier steps or departments.
- Any step performed needs to be included in the documentation. If not, it should be eliminated or documented, depending on whether or not it's necessary to the process.
- People involved in the process should be consulted because they often have the most current information on what works and what does not.

STEPS INVOLVED IN PROCESS PLANNING

The following are the various steps followed in process planning:

1) Study of part drawings and its specifications.

2) To decide about make or buy about the part under planning.

3) Selection of most appropriate process which is competitive and economical.

4) Deciding the sequence of operations which comprises the selected process. Operations are combined wherever possible.

5) Determination of blank size of raw material and list of material is prepared.

6) As per the capacity and capability, the suitable machines with accessories are selected.

7) Determination of inspection points or stages on product manufacturing line.

8) Selection of labour, tools, measuring and inspection devices.

9) Estimation of process and manufacturing cost of product.

10) Preparation of route and operation sheet which is also called process sheet.

SYSTEMS APPROACH TO PROCESS PLANNING AND DESIGN

Inputs

The following are the inputs for the process planning and design.

- Product/service information such as product service demand, price per volumes, competitive environment, customer needs and wants, desired product characteristics, etc.
- Production system information such as resource availability, production economies, available technologies that can be acquired by the firm.
- Operation strategy such as positioning strategy, focus of factory and service facilities and allocation of resources.

Conversion Process

First activity we have to perform before exactly starting the conversion process is the selection of the type of appropriate type of process. Vertical integration studies are done which include study of vendor capabilities, acquisition decision, make-or-buy decisions. Process/product studies are also done which consist of technological steps, product simplification and standardization and product design for producibility.

Equipment studies regarding the level of automation, linkages of machines, equipment selection and training is also performed. Production procedure studies are carried out that include production sequence, material specifications and personnel requirements. Finally facilities studies are done regarding building designs and layout of facilities.

Outputs

- Technological processes include design of specific processes and linkage among process.
- Facilities include building design, layout of facilities and selection of equipments.
- Personnel estimates include skill level requirements, number of employees, training and retraining requirements and supervision requirements.

KEY DECISIONS IN PROCESS DESIGN

New products are not realities until they are manufactured. Process design is necessary to manufacture new products. Process design means the complete delineation and description of specific steps in the production process and the linkages among the steps that will enable the production system to produce the desired quality, in the required quantity, at the time, customers want them and at the budgeted cost.

Key decisions relating to process design relate to organizing the process flows, relating process design to process flow and evaluating the process.

1. Organizing the Process Flows
2. Relating process design to process flow
3. Evaluating the process

LINKAGE BETWEEN PRODUCT PLANNING AND PROCESS PLANNING

Product planning serves as an input to process design. Responsibility for product planning and development rests with marketing department and research and development (R&D) department. The perceived needs of the customers are identified and they are incorporated in the product proposed quality, cost, function, reliability and appearances.

Basic process planning must begin during the product design stages where selection of materials and initial form such as casting, forging, die castings and plastic moldings take place. The minimum possible cost of producing a part or a product is established by the design of the part or the product. Hence, process planning must start at the product design stage itself. The effort to design for low manufacturing cost is referred to as production design as distinct from product design, which consists of functional design and form design.

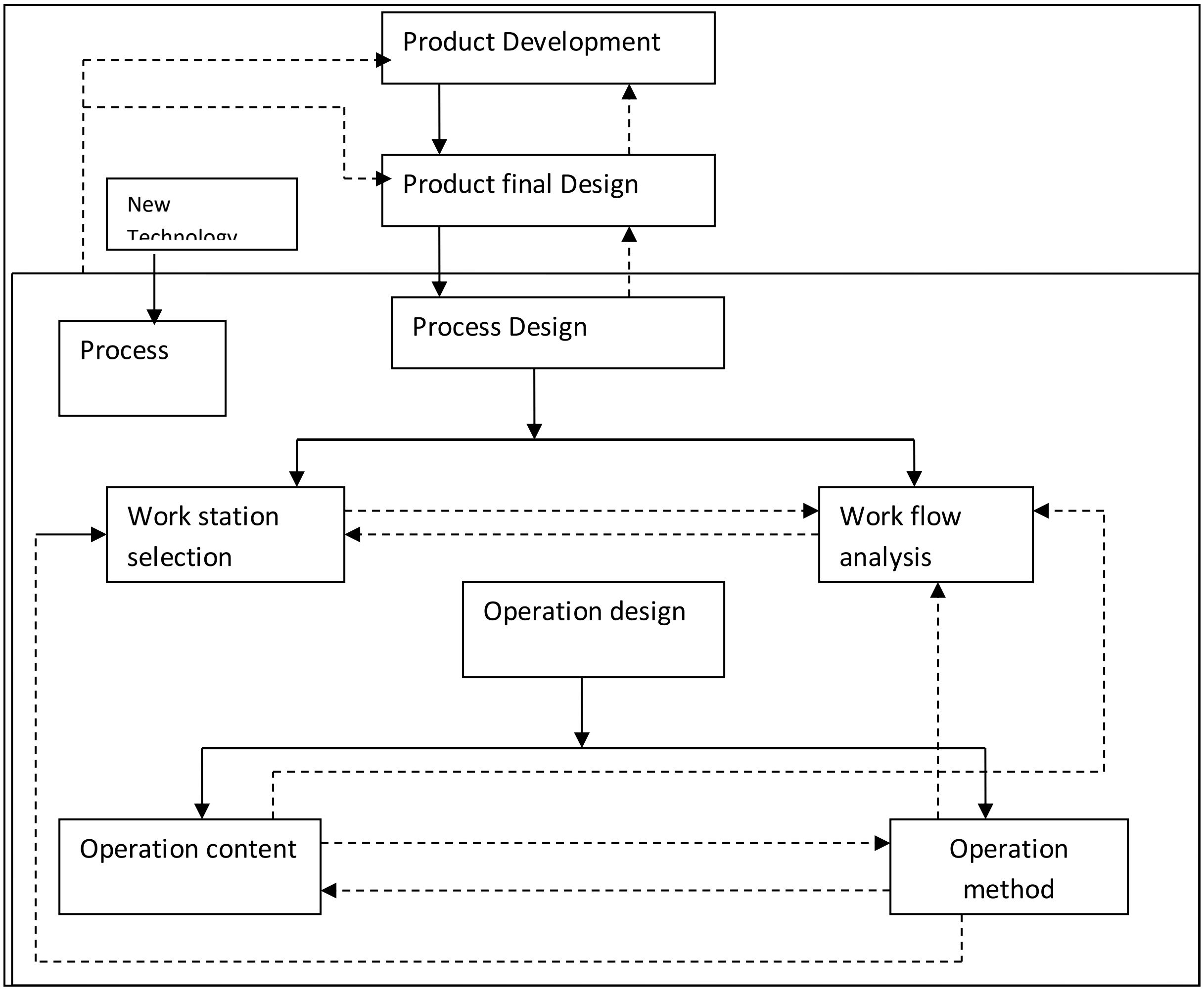
Given the product design, the process planning for manufacture, must be carried out to specify in detail the processes required and their sequence. Production design first sets the minimum possible cost that can be achieved through the specification of materials, tolerances, basic configurations and methods of joining parts. Process planning is responsible to minimize the costs of the manufacturing process and the sequence to meet the required design specifications.

The end of production design is manifested by the release of drawings which summarizes the exact specifications of what is to be made. Process planning takes over from this point and develops the broad plan of manufacture for the part or product including the basic selection of processes necessitated in the design stage.

Relationship between Process Planning and other Operations Management Activities Process planning also affects quality control, human resources requirement, job design and capacity of the plant. Process design determines the details of how products or service will be produced.

Process planning and process design describe the specific steps in the production process and the linkages among the steps that will enable the production system to produce products / services of the desired quality in the required quantity, at the time customers want them and at the budgeted cost. Intense process planning may be required for new products / services. Process re planning may also occur as capacity needs change, business or market conditions change and technological improvements take place in materials and machinery.

Fig- 8.2 Linkage between Product Planning and Process Planning



Sequence

Feedback

MAJOR FACTORS AFFECTING PROCESS DESIGN DECISIONS

Nature of product/service demand

The operations management needs to produce the right kind of products and services according to the expectations of the customers. The forecasting methods can be used to predict the demand of the products and services in the market.

Degree of vertical integration

Vertical integration is the production and distribution chain that is bought under the ownership of the company. This determines the number of production processes to be planned and designed. Decisions regarding the vertical integration are made on the basis of cost, availability of the capital, quality, technological capability, strategic outsourcing etc. lower degree of integration is the outsourcing of process in order to react quicker to changes in customer needs, competitor actions and technology.

Product/service and volume flexibility

Product flexibility is the ability of the production of delivery system to quickly change from one product/ service to other. Volume flexibility is the ability of the production or delivery system to quickly increase or reduce the volume of the product/ service. When the demand pattern is suddenly changed, the volume flexibility is needed and hence the production process is designed such that it can be expanded of reduced according the proposed change in the output.

Degree of automation

Automation is the use of control systems such as computers to control machineries and processes by replacing human operators. If the degree of automation is more, then it may increase the product quality, product flexibility, reduce labour, and related cost. But the setting up cost for automation is very high when comparing to traditional processes.

Level of product/service quality

Quality products/ services can be generated only from a process which is having a good design. The high degree of automation increases the quality of the products and services by reducing the inspection.

Degree of customer contact

The good process design results in customer satisfaction. Process can be design to produce standardized of diversified products according to the expectations of the customers. The companies trying to satisfy their customers with diversified products follow flexible manufacturing systems through which they achieve high customer satisfaction. The company ensuring customer contact can effectively plan their process

TYPES OF PROCESS DESIGN

Product-focused production system

It is arranged on the basis of sequence of operations required to produce the product or service. Production departments are organized according to the type of product/service being produced. The two forms of production line are discrete unit and continuous process.

Process- focused production system

Production departments are grouped according to the type of process. product/ process moves from one process group to another based on that particular job's processing requirements since all the technological processes are grouped together.

Group-Technology (GT)/ Cellular Manufacturing systems

The products or components to be manufactured are placed in families or groups and separate manufacturing cells are used to manufacture these groups.

PROCESS TECHNOLOGY

Manufacturing process technology refers to the equipment, people and systems used to produce a firm's products and services.

Key process technology decisions relate to

- Organizing the process flows
- Choosing the appropriate product-process mix
- Adapting the process to meet strategic requirements
- Evaluating automation and high technology process

Types

1. Job shop Technology
2. Batch Technology
3. Assembly line Technology

4. Continuous flow Technology
5. Project Technology

CAPITAL REQUIREMENTS FOR PROCESS DESIGNS

- Depends on the type of processing organization
- High for product focused, dedicated system, medium for product focused batch system and cellular manufacturing system and least for process focused job shop production system.

ECONOMIC ANALYSIS OF PROCESSES PLANNING

Important aspects:

1. Cost function of processing alternatives
2. Concept of Operating Leverage
3. Break-even Analysis
4. Financial analysis

1. Cost function of processing alternatives

The amount of capital requirement is different for different process designs. Two types of cost involved are fixed costs and Variable costs. Fixed costs act as the annual cost when the production volume is zero. It includes the cost of land, buildings, equipments and other fixed cost. Variable costs are costs that vary according to the production volumes. It includes cost of labour, material and overheads. Automated assembly line has the highest fixed cost and lowest variable costs and for job shop fixed costs are low and variable costs are very high. Finally cellular manufacturing has intermediate fixed and variable costs.

Illustration

ABC Company finds 3 alternative processes automation (A), job shop (B), and cellular manufacturing (C). The details of cost are as given below in the table.

Process	Fixed cost/ year (Rs)	Variable cost/ year (Rs)
A	190000	5.00
B	100000	9.00
C	120000	6.00

What is the most economical process for a volume of 10000 units per year?

Solution:

Total cost (TC) = Fixed cost (FC) + variable cost (VC) × quantity (Q)

TC for process A = 190000 + 5 × 10000 = Rs 240000

TC for process B = 100000 + 9 × 10000 = Rs 190000

TC for process C = 120000 + 6 × 10000 = Rs 180000

Since the total cost for process C is less, the most economical process at 10000 units is process C.

2. Concept of operating leverage

Operating leverage is a measure of the relationship between firm's annual costs and its annual sales. If a high percentage of a firm's total costs are fixed, then the firm is said to have a high degree of operating leverage. A high degree of operating leverage implies that a relatively small percentage change in sales will result in a large percentage change in the operating income.

3. Break-even analysis

- It is used to choose between processing alternatives**.**
- Break-even-analysis states that profits arise from the excess of Total Revenues (TR) Total Costs (TC).

Total cost= Fixed Costs (FC) + Variable Costs (VC)

Profit = TR – TC

= TR – (FC+VC)

Break-even point is the level of output (Volume of output) for which total cost (TC) equals total revenue (TR).

Break Even Analysis (B.E.P)

1. Contribution (C) = Sales (S) – Variable Cost (V.C)
   (or)
   = Profit (P) + Fixed Cost (F.C)
2. Profit Volume (P/V) Ratio $= \frac{C}{S} \times 100$
   (or)
   $$= \frac{Changes\ in\ Profit}{Changes\ in\ Sales} \times 100$$

Note: When two subsequent period profit and sales is given in the problem the second formula only can be used to find out P/V ratio

3. B.E.P (in Rs.) $= \frac{F.C}{P/V\ Ratio}$
   (in Units) $= \frac{F.C}{C}$
4. Margin of Safety (MOS) = Actual Sales – Break Even Sales
   (or)
   (in Rs.) $= \frac{P}{P/V\ Ratio}$
   in Units) $= \frac{P}{C}$
5. Required Sales $= \frac{Required\ Profit + F.C}{P/V\ Ratio}$
6. Profit from given Sales:

New Contribution = Given Sales × P/V Ratio

Profit = New Contribution – F.C

Illustration 1:

Sales Per Unit	3
Variable Cost Per Unit	1.5
Fixed Cost	18000

Contribution (S-V.C)	1.5
P/V Ratio (C/S*100)	50%
B.E.P (in Rs.) (F.C/PV Ratio)	**36000**
B.E.P (in Units) (F.C/C)	**12000**

Illustration 2:

Calculate the following from the record of Sivagangai Paper Mills,

(i) The amount of fixed expenses

(ii) The number of units to break even

(iii) The amount of sales to earn a profit of Rs.5,00,000

(iv) The profit with sales of Rs.10,00,000

The company's sales turnover and profit during two periods were as follows:

	Sales(Rs.)	Profits(Rs)
Period I	20,00,000	2,00,000
Period II	30,00,000	4,00,000

Solution:

i) Calculation of Fixed Assets:

$$= \frac{Changes\ in\ Profit}{Changes\ in\ Sales} \times 100$$

$$= \frac{4,00,000 - 2,00,000}{30,00,000 - 20,00,000} \times 100$$

P/V Ratio = 20%

$$\textbf{P/V Ratio} = \frac{\boldsymbol{Contribution}}{\boldsymbol{Sales}} \times \mathbf{100}$$

$$\mathbf{20\%} = \frac{\boldsymbol{Contribution}}{\mathbf{30,00,000}}$$

30,00,000×20% = Contribution

∴ Contribution = 6,00,000

Contribution = Profit + Fixed Cost

6,00,000 = 4,00,000 + Fixed Cost

∴ Fixed Cost = 6,00,000 – 4,00,000 = 2,00,000

ii) The Break Even Point

(in Rs.) $= \frac{Fixed\ Cost}{P.V\ Ratio}$

$$= \frac{2,00,000}{20\%}$$

B.E.P = Rs. 10,00,000

Note: Per unit information of sales and variable cost is not given. So, the BEP calculation in unit is not easy and the marks can be awarded if the students arrived the answer in rupees.

iii) Required Sales

$$= \frac{Required\ Profit+Fixed\ Cost}{P.V\ Ratio}$$

$$= \frac{5,00,000+2,00,000}{20\%}$$

Required Sales = Rs. 35,00,000

iv) Profit from given sales

New Contribution = Given Sales × P/V Ratio

= 10,00,000 × 20% **= 2,00,000**

Profit = New Contribution – Fixed Cost

= 2,00,000 – 2,00,000 **= 0**

4. Financial Analysis

The planning phase of a firm's capital budgeting process is concerned with the articulation of its broad strategy and the generation and preliminary screening of project proposals. This provides the framework which shapes, guides and circumscribes the identification of individual project opportunities. The focus of this phase of capital budgeting is on gathering, preparing and summarizing relevant information about various project proposals which are being considered for inclusion in the capital budget. A detailed analysis of the aspects such as marketing, technical, economic, and ecological in done for successfully completing the financial analysis.

The Process planning and design of a project would be selected in the order in which they are ranked and cut off point would be reached when the cumulative total cost of the projects become equal to the size of the plan funds. A wide range of appraisal criteria have been suggested for selection of a project. They are divided into two categories such as non-discounting criteria and discounting criteria.

BROAD CRITERIA OF CAPITAL BUDGETING

1. Non discounting criteria

The method of capital budgeting are the techniques which are used to make comparative evaluation of profitability of investment. The non-discounting methods of capital are as follows:

- Pay-back period method (PBP)
- Accounting rate of return method (ARR)

2. Discounting Criteria

- Net Present Value Method (NPV)
- Internal rate of Return Method (IRR)
- Profitability Index Method (PVI)

NON-DISCOUNTING CRITERIA

Payback period method

Under this method the payback period of each project investment proposal is calculated. The investment proposal which has the least payback period is considered profitable. Actual pay back is compared with the standard one if actual payback period is less than the standard the project will be accepted and in case, actual payback period is more than the standard payback period, the project will be rejected. So, payback period is the number of years required for the original investment to be recouped.

For example, if the investment required for a project is Rs. 20,000 and it is likely to generate cash flow of Rs. 10,000 for 5 years. Payback Period will be 2 years. It means that investment will be recovered in first 2 years of the project. Method of calculating payback period is

$$Pay - back\ Period = \frac{Investment}{Annual\ Cash\ inflow}$$

Accounting Rate of Return

This method is also called average rate of return method. This method is based on accounting information rather than cash flows. It can be calculated as

$$Accounting\ Rate\ of\ Return = \frac{\text{Average annual profit after taxes}}{\text{Average Investment}} \times 100$$

Where,

$$\text{Average Investment} = \frac{\text{Original Investment } + \text{ Salvage value}}{2}$$

DISCOUNTED CRITERIA

Under these methods the projected future cash flows are discounted by a certain rate called cost of capital. The second main feature of these methods is that they take into account all the benefits and costs accruing during the life time of the project. Discounted cash flow method is briefly described as follow,

Net Present Value Method (NPV)

In this method present value of cash flow is calculated for which cash flows are discounted. The rate of discount is called cost of capital and is equal to the minimum rate of return which must accrue from the project. NPV is the difference between present value of cash inflows and present value of cash outflows. NPV can be calculated as under.

$$NPV = \frac{CF_1}{(1+\text{K})^1} + \frac{CF_2}{(1+\text{K})^2} + \frac{CF_3}{(1+\text{K})^3} + \ldots + \frac{CF_n}{(1+\text{K})^n} - C$$

OR

$$\sum_{t-1}^{n} = \frac{CF_1}{(1-K)^1} - C$$

Where CF_1, CF_2.. represent cash inflows, k is the firm's cost of capital, C is cost outlay of the investment proposal and n, is the expected life of the proposal. If the project has salvage value also it should be added in the cash inflow of the last year. Similarly, if some working capital is also needed it will be added to the initial cost of the project and to the cash flows of the last year. If the NPV of a project is more than zero, the project should be accepted and if NPV is less than zero it should be rejected. When NPV of two more projects under consideration is more than zero, the project whose NPV is the highest should be accepted.

Internal Rate of Return Method (IRR)

Under this method initial cost and annual cash inflows are given. The unknown rate of return is ascertained. In other words, "The internal rate of return is that rate which equates the present value of cash inflows with the present value of cash outflows of an investment project." At the internal rate of return NPV of a project is zero. Like NPV method IRR method also considers time value of money. In IRR method, the discount rate (r) depends upon initial investment expenditure and the future cash inflows. IRR is calculated as follows:

$$C = \frac{A_1}{(1+\mathrm{r})^1} + \frac{A_2}{(1+\mathrm{r})^2} + \frac{A_3}{(1+\mathrm{r})^3} + \ldots + \frac{A_n}{(1+\mathrm{r})^n}$$

C = initial cash outflow

n = number of years

r = rate of return which is to be calculated.

A_1 A_2 A_3............................A_n = cash inflows in various years

Profitability index/ Benefit-cost Ratio

It is the ratio of value of future cash benefits discounted at some required rate of return to the initial cash outflows of the investment PI method should be adopted when the initial costs of projects are different. NPV method is considered good when the initial cost of different projects is the same. PI can be calculated as under,

$$PI = \frac{\text{Present value of Cash inflows}}{\text{Present value of Cash outflows}}$$

If PI>1 the project will be accepted. If PI<1 the project will be rejected. When PI>1, NPV will be positive, when PI<1 NPV will be negative. In case, more than one project has PI>1 then the project whose PI is the highest will be given first preference and the project with minimum PI will be given last preference.

COMPUTER AIDED PROCESS PLANNING (CAPP)

Manufacturers have been following an evolutionary step to improve and computerize

Process planning in the following five stages:

Stage I - Manual classification; standardized process plans

Stage II - Computer maintained process plans

Stage III - Variant CAPP

Stage IV - Generative CAPP

Stage V - Dynamic, generative CAPP

Earlier to CAPP, producers attempted to triumph over the issues of manual process planning by basic categorization of parts into families and developing standardized process plans for parts families that is called

Stage I. When a new part is initiated, the process plan for that family would be manually recovered, marked-up and retyped. While this improved output but it did not enhance the quality of the planning of processes.

Computer-aided process planning originally developed as a device to electronically store a process plan once it was shaped, recover it, amend it for a new part and print the plan. It is called

Stage II. Other ability of this stage is table-driven cost and standard estimating systems.

Stage III: Computer-aided approach of variant CAPP is based on a Group Technology coding and classification approach to recognize huge number of part attributes or parameters. These attributes permit the system to choose a baseline process plan for the part family and achieve about ninety percent of the planning work. The schemer will add the remaining ten percent of the effort modifying or fine-tuning the process plan. The baseline process plans stored in the computer are manually entered using a super planner concept that is, developing standardized plans based on the accumulated experience and knowledge of multiple planners and manufacturing engineers.

Stage IV: It is generative CAPP. In this stage, process planning decision rules are developed into the system. These decision rules will work based on a part's group technology or features technology coding to produce a process plan that will require minimal manual interaction and modification.

While CAPP systems move towards being generative, a pure generative system that can create a complete process plan from part classification and other design data is a goal of the future. These types of generative system will utilize artificial intelligence type capabilities to produce process plans as well as be fully integrated in a CIM environment. An additional step in this stage is dynamic, generative CAPP which would consider plant and machine capacities, tooling availability, work center and equipment loads, and equipment status in developing process plans.

The process plan developed with a CAPP system at Stage V would differ in due course depending on the resources and workload in the factory. Dynamic, generative CAPP also entails the need for online display of the process plan on a work order oriented basis to cover that the appropriate process plan was provided to the floor.

There are numerous advantages of this type of process planning.

- It can decrease the skill required of a planner.
- It can reduce the process planning time.
- It can reduce both process planning and manufacturing cost.
- It can create more consistent plans. It can produce more accurate plans.
- It can increase productivity. Automated process planning is done for shortening the lead-time, manufacturability feedback, lowering the production cost and consistent process plans.

Discussion Forum

1. Define production planning, process planning and operations planning.
2. What is the goal of process planning?
3. What do you mean by process design?
4. Describe the principles of process planning.
5. Explain with neat sketch various methods of process planning.
6. Explain the use of computers in process planning and cost estimation.
7. Discuss the various stages involved in computer aided process planning process.
8. Explain production planning system with a neat sketch.
9. Explain the processing sequence required to fabricate a single part on multiple machines.
10. Discuss the important aspects of economic analysis of process planning.
11. From the following information calculate:

1. P/V Ratio
2. Break-even Point
3. Margin of safety

Total Sales	Rs. 3, 60,000
Selling price per unit	Rs. 100
Variable cost per unit	Rs. 50
Fixed cost	Rs. 1, 00, 000

If the selling price is reduced to Rs. 90 by how much is the margin of safety reduced?

12. ABC wishes to know it's (a) Break –even Point of production and (b) margin of safety during the July to December, from the following information.

	January to June (Rs.)	July to December (Rs.)
Sales	2,00,000	2,50,000
Net profit	20,000	30,000

CHAPTER -9

WORK STUDY

INTRODUCTION

Managing human within operations involves actual job design, methods, relationships between jobs and machines, and systems of control and communication. Work design highly involves complex "people" relationships between operative staff, supervisors and specialists e.g. engineering managers and staff who direct new machines and maintain them. Other specialists may co-ordinate with health and safety systems or monitor performance and plan maintenance. People are not mere extensions to machines to be switched on and off. A worker's performance may be better than a machine's capability, but still a machine may outperform the human in many tasks.

Human can be sometimes hurt or injured physically by operating environments or trapped socially and psychologically in them/by them. The design of operational systems and the relationship between jobs and performance are of great operational, economic and social significance.

Work study is a generic term for those techniques, method study and work measurement which are used in the examination of human work in all its contexts and which lead systematically to the investigation of all factors which affect the efficiency and economy of the situation being reviewed, in order to ensure improvement. Considerable diplomacy and sensitivity is needed by the industrial engineer or operations manager who becomes involved in work study investigations.

CONCEPT OF WORK STUDY

Generally work study is used to describe a complete set of techniques with the help of which work can be simplified, standardized and measured. When there is a possibility to simplify or modify the existing work or new methods, they are designed and introduced such that the task or activity becomes simpler to ensure the following advantages:

- More production with less effort and hence goods/products are available at cheaper rates.
- Better equipment utilization shall lead to marked increase in the total production without addition of new resources. Thus productivity may improve.

These advantages are possible through the willing cooperation of the human resources engaged in production. Work study has become an important tool of management in view of the above disused benefits. Thus, work study is the investigation by means of a consistent system of work done in an organization in order to achieve the best possible utilization of resources such as men, machines and materials available. Every organization tries to achieve best quality production of various products in the minimum possible time.

The time required in manufacturing a product or item depends on the design of manufacturing procedure. One component of work study known as 'Method Study' aims at determining the best possible manufacturing procedure which involves least time and cause minimum fatigue to workers employed in the work. In short, method study is concerned with determination of the best way of doing a job.

Method study may be defined as "the systematic investigation of the existing method of doing a job in order to develop and install an easy, quick, effective, efficient and comparatively less tiring method or procedure for doing the same job at cheaper rates." This is generally achieved by eliminating unnecessary movements or motions involved in a certain procedure or by changing the sequence of operation of the process itself.

The role of time study or work measurement starts with the determination of time required to complete the job by developed improved procedure for doing that job. Thus, work measurement may be defined as "the application of different techniques to measure and establish the time required to complete the job by a qualified worker at a defined level of performance."

Definitions of Work Study

British Standard Institution defines work study as" a generic term for those techniques particularly 'Method study' and 'Work Measurement' which are used in the examination of work in all its contexts and which leads systematically to the investigation of all the factors which affect the efficiency and economy of the situation being reviewed in order to incorporate improvements at various levels."

Work study may be defined as "The systematic critical, objective and imaginative examination of all factors governing the operational efficiency of any specific activity in order to achieve/ effect improvement."

"Work study is also defined as that body of knowledge concerned with the analysis of the work methods and the equipment used in performing a job, the design of an optimum work method and the standardization of proposed work methods."

OBJECTIVES OF WORK STUDY

Work study is one of the basic techniques of improving productivity. Hence work study aims:

- To analyse the work in order to achieve work simplification and thereby improving productivity of the system.
- To have optimum utilization of resources in the firm.
- To evaluate the work content through work measurement.
- To set time standards for various jobs.

In nutshell, work study is mainly concerned with the examination of human work. In fact planning is not possible unless one knows how long it will take to do a particular job. Thus, time is very important to the manufacturer who must keep to promise, to estimate quantities and to other industrial and business organizations.

NEED FOR WORK STUDY

Principles of work study have been used since long to identify the improvements to be incorporated, when industrial set up was simple and involved lesser problems. The modern industries with increased complexities greatly demand a more systematic approach like work study in its present form for solution of various problems.

Work study is most valuable tool of management for the following reasons:

- It is a direct means of improving productivity of the system involving very less or no cost.
- The approach is simple, systematic, consistent and based on handling of facts. Thus the part played by opinions in taking decisions is minimized.
- No factor affecting the efficiency of operation is overlooked in this approach.
- It provides most accurate means of setting standards of performance which are helpful in the process of production planning and control.
- Application of work study results in immediate savings.
- It is a universal tool for management.
- It is a most penetrating tool of investigation available to management of the industrial unit.

ADVANTAGES OF WORK STUDY

The advantages of work study are summarized as follows:

- It is direct means of improving productivity.
- It results in uniform and improved production flow.
- It reduces the manufacturing cost.
- Fast and accurate delivery dates are possible.
- It provides better service and consumer satisfaction.

- It improves the employee-employer relations.
- It provides job satisfaction and job security to workers.
- Better working conditions are possible for workers.
- It is most important tool of analysis and can help in providing better wages to workers on scientific basis.
- Most accurate method and yet provides a sound basis for production planning, control and incentives for man power.
- Everyone concerned with industries such as worker, consumer and management of the unit is benefited.

TECHNIQUES OF WORK STUDY

Work study consists of two techniques. They are:

i. Method study

ii. Work measurement

Work study is the term used to embrace the techniques of Method Study and Work Measurement which are used to ensure the best utilization of manpower and material resources in carrying out specified activity.

METHOD STUDY

Meaning

Method Study is a technique which analyzes each operation of a given piece of work very closely in order to eliminate unnecessary operations and to approach the quickest and easiest method of performing each necessary operation. It includes the standardization of equipment, method and working conditions, and training of operator to follow the standard method. The philosophy of method study is that 'there is always a better way of doing a job' and the tools of method study are designed to systematically arrive at this better way of doing a job. Method study is essentially used for finding better ways of doing work and is a technique for cost reduction.

Method study is also known as methods engineering. "The technique that subjects each operation of a given piece of work to close analysis to eliminate every unnecessary element or operation and to approach the quickest and best method of performing each necessary element or operation. It includes the improvement and standardization of methods, equipment, and working conditions: operator training; the determination of standard time; and occasionally devising and administering various incentive plans."

Definition

According to British Standards Institution(BS 3138): "Method study is the systematic study is the systematic recording and critical examination or existing and proposed ways or doing work as a means or developing and applying easier and more effective methods and reducing cost."

Method Study may also be defined as "the systematic investigation of the existing method of doing a job in order to develop and install an easy, rapid, efficient and effective and less fatiguing procedure for doing the same and at lower costs. This is generally achieved by eliminating unnecessary motions involved in a certain procedure or by changing the sequence of operations or the process itself."

Objectives of Method Study

Following are the objectives of Method Study:

- Improvement of manufacturing processes and methods.
- Improvement of working conditions.
- Improvement to plant layout and work place layout.
- Reducing the human effort and fatigue.
- Reduced health hazards.
- Reducing material handling.

- Improvement of plant and equipment design.
- Improvement in the utility of materials, machines and man power.
- Ensuring safety.

Some more important objectives of method study are discussed as follows:

- Better design of plant equipment and buildings.
- Less fatigue or workers by avoiding unnecessary movements of manpower.
- Better working conditions and environment for workers/employees.
- To have more effective utilization of materials, machines and manpower and money.
- Better product quality.
- Efficient and fast material handling equipment.
- Leads to standardization, rationalization, simplification and specialization.
- Efficient planning of the section.
- Streamlined working procedures.

METHOD STUDY PROCEDURE

The procedures and steps in Method Study are as follows:

1. Select the work worth studying and define the objectives to be achieved. The objective may be to reduce the manufacturing cost, bottleneck, and fatigue incurred by the workers in order to increase their efficiency.

2. Record all the relevant information pertaining to the existing method in detail and in the form of a chart to obtain a clear picture about the same. Recording can be done with the help of the following tools such as Process Charts, Diagrams, Motion and Film Analysis, and Models.

3. Examine the recorded events critically and in sequence. It involves answering a number of questions. An activity can be eliminated, simplified or combined with another. The likely questions to be asked are:

- Purpose – What is done?
- Person – Who does it?
- Place – Where it is done?
- Means – How is it done?
- Sequence – When is it done?

4. Develop the best method as resulted from critical examination and record it. The developed method should be practical, safe effective and economical.

5. Installation of the (best) developed method or the improved method. It involves the stages such as planning, arranging and implementing. During planning and arranging, necessary arrangements of resources, equipment, tools and instruction to workers overtime are made. The actual installation involves the introduction of developed method as standard practice.

6. Maintain the new method. We should ensure the proper functioning of the installed method by periodic checks and verifications. If there are any deviations, the reasons for deviation should be explored and corrected. Views of the workers, supervisors and other person related with the authorized method can be of immense help in exploring further improvements.

SCOPE OF METHOD STUDY

The scope of method study is not restricted to only manufacturing industries. Method study techniques can be applied effectively in service sector as well. It can be applied in offices, hospitals, banks and other service organizations. The areas to which method study can be applied successfully in manufacturing are:

(1) To improve work methods and procedures.
(2) To determine the best sequence of doing work.
(3) To smoothen material flow with minimum of back tracking and to improve layout.

(4) To improve the working conditions and hence to improve labor efficiency.
(5) To reduce monotony in the work.
(6) To improve plant utilization and material utilization.
(7) Elimination of waste and unproductive operations.
(8) To reduce the manufacturing costs through reducing cycle time of operations.

The sequential order of the correct procedure to be adopted for having effective or purpose oriented results of method study include the following:

i. Select the work/procedure to be analyzed.

ii. Record all the relevant information related with the existing work system with the help of various recording devices or techniques.

iii. Make critical examination of collected data/facts.

iv. Develop and improve the method which is economical and practical after giving due consideration to the alternative method possible.

v. Install the new selected method with proper instructions.

vi. Maintain the latest standards of methods through periodic verification etc.

TOOLS USED IN METHOD STUDY

Process chart is one of the tools used in the method study to represent graphically the steps involved in a manufacturing or business process. There are different types of process charts and some of them are discussed as below:

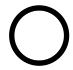
- Operation Process Charts
- Flow Process Charts
- Flow Diagram
- Man Machine Process Charts
- Left-Right Handed Charts
- Simo Chart

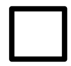
Operation Process Charts

An Operation Process Chart (OPC) is a simple graphical representation of a process. OPC is another form of a “Flow Chart”. It is a standard method of representing processes in the field of Industrial Engineering. It is a chronological sequence of operations, inspection, time allowances and materials used in a manufacturing or business process.

An Operation Process Chart has the following characteristics:

- Shows the chronological sequence of all activities in a process just as a flow chart.
- Shows the relationship between all activities.
- Distinguishes between produced and purchased parts.
- Provides information on the number of employees utilized and the time required performing each activity.
- Primarily used for assembly processes.
- Displays the entrance of all components and subassemblies to the main assembly.
- Use only two symbols: a small circle, which denotes an activity and a small square, which denotes an inspection.

 Activity

 Inspection

The operation process charts contain the following information:

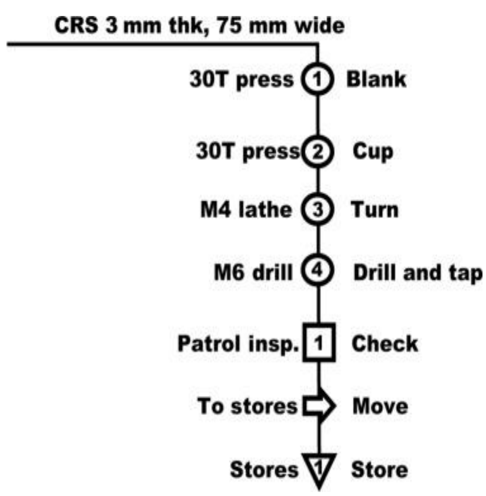
- Part number
- Drawing number
- Process description
- Present and proposed method
- Date and name of the person preparing the chart

The chart is drawn using both horizontal and vertical lines. The horizontal lines denote the introduction of material into the process and the vertical lines denotes the flow of process.

Uses:

- Suggest the possibilities for improvements
- Portrays the effect of change on a given operation on the preceding and subsequent operations
- Helps in the formulation of ideal layout for the plant
- Provides a comparison between two or more competing solutions

Fig- 9.1 Operations Process Chart



The Flow Process Chart

The Flow process Chart is a simple half-text, half-picture method of showing the steps in a process, using symbols to indicate the type of action being taken and text to give details of the action. The chart can selectively be used to show what happens to selected people, materials or equipment.

A Flow Process Chart (FPC) is a detailed representation of a process that combines graphics and text description. It is not usually applied to an entire process, but a small set of activities.

The flow process chart could be of three types namely,

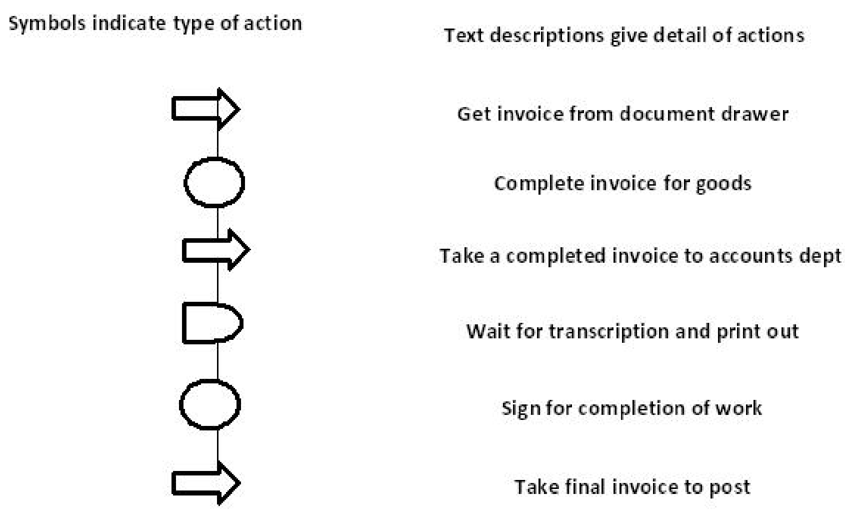
(i) Flow process chart material or product type.

(ii) Flow process chart man type.

(iii) Flow process chart machine type or equipment.

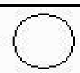
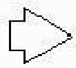
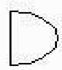
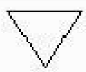
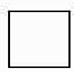
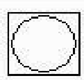
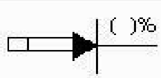
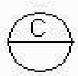
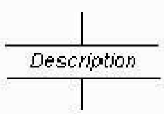
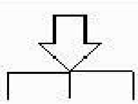
Material or product type flow process chart records what happens to the material or product i.e. the changes the material or product undergoes in location or condition (includes operation and transportation). Man type process chart records the activities of worker or operator i.e. what a worker or operator does, whereas equipment or machine type flow process chart records the manner in which an equipment or machine is used.

Fig. 9.2 Example of Flow Process Chart



The table below shows many of the symbols that may be found in Flow Process Charts.

Table-9.1 Symbols in Flow Process Charts

Symbol	Title	Description
	Operation	A complex action or process often changing something.
	Transport	Movement of people or things. May be accompanied by a distance measurement.
	Delay	Idle time of people or machines, or temporary storage of materials.
	Storage	Permanent storage of materials or other items.
	Inspection	Checking of items to ensure correct quality or quantity.
	Combined operation	Overlay symbols for actions which combine types. Put the main activity outside.
	Reject	Rejection of item. Parentheses show percentage of items rejected. Line to right lead to consequent action.
	Differentiated operation	Letter shows type of operation, e.g. C = clerical, M = machine, etc.
	State change	Description indicates change in state, for example a liquid cooling into a solid.
	Alternating processes	Down-arrow indicates one of several possible actions. This can show alternative or simultaneous processes.

Flow Diagrams

A Flow Diagram (FD) is a pictorial representation of the facility and the process flows within it. It can be used to give a pictorial view of the process in relation to layout of the facility.

Uses of Flow Diagram:

- It provides a mechanism for considering physical boundaries when attempting to improve the process.
- It provides a comparison between the process and facility.
- It is a helpful supplement to the Flow Process Chart since it indicates back tracking and possible traffic congestion areas and facilitates the developing an ideal layout.

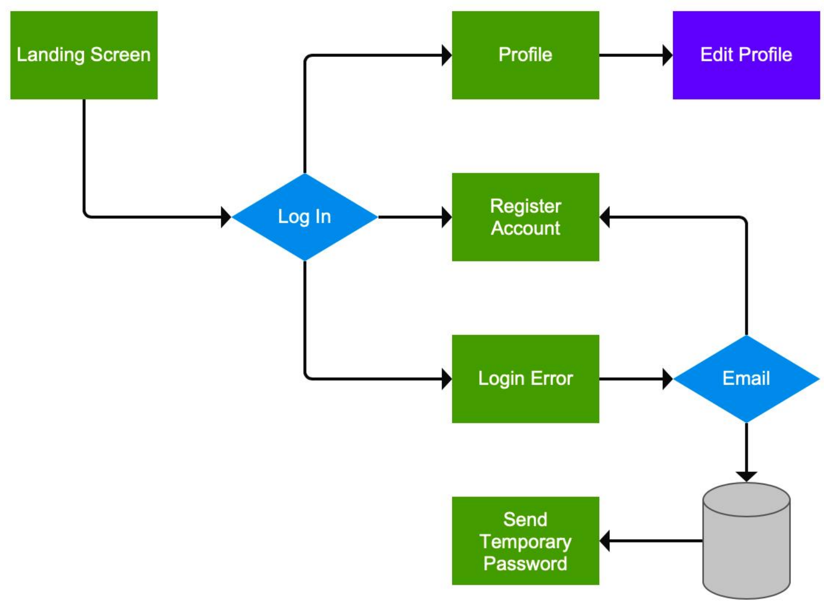
The steps involved in drawing a flow diagram:

i) The plan of the work area is drawn to scale.

ii) The relative positions of various facilities such as machines, stores and area of inspection are marked.

iii) The actual path movements of a worker or material along with the direction of movement are indicated. For better understanding of various movements, different colors and process symbols may be used.

Fig.9.3 Flow Diagram

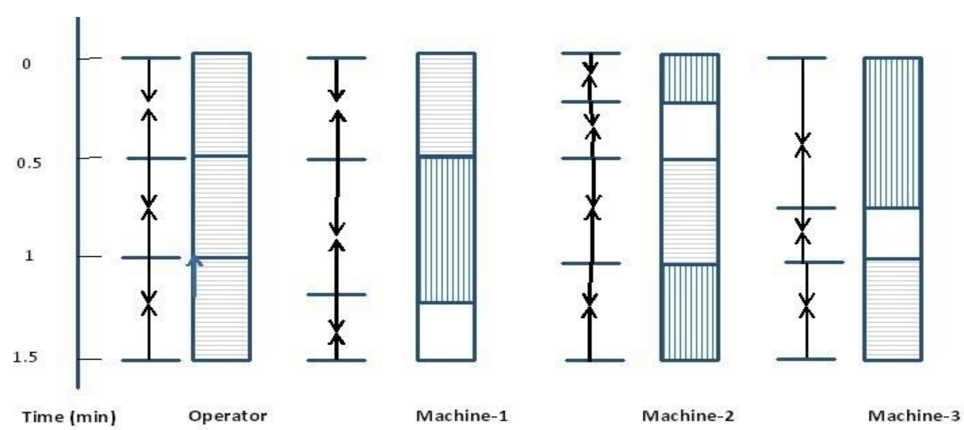


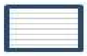
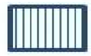
Man - Machine Chart

Man machine chart is useful to record the activities of a worker who is working with a machine with the objective of examining the presence of idle time of the operator and machinery. This chart is useful when the effective working time of the operator is less than the equipment run time. In case, where the worker works on more than one machine simultaneously, the problem is to find the effective combination of man and machine. The optimum point is at which the total cost of the both the idle time of machine and worker is at minimum.

A man- machine chart depicts graphically the coordinated activities of a worker and machine/machines, where the worker working independent or along with the machine or waiting. This chart is drawn against time using some scale.

Fig-9.4 Man Machine Chart



	Set up		Running		Idle

Left-Right Hand Chart

This is also known as two handed process chart. It gives a synchronized and graphical representation of the sequence of manual activities of the worker. This type of chart is used to improve the motion sequence of an operator.

It is called two-handed process chart since it records the activities of the left hand and the right hand of the worker as related to each other in a two column chart by means of symbols aligned representing the simultaneous movements of both hands appear opposite to each other. The chart is used to minimize the unnecessary motions and to arrange the remaining motions in an economical way.

The two handed process chart is given below:

Fig-9.5 Two handed chart

Left Handed Chart		Right Handed Chart	
Description	**Symbol**	**Description**	**Symbol**
Pick the pencil	⇨	D	Delayed/Wait
Hold	▽	⇦	Pick the sharpener
Insert the pencil in the sharper	○	▽	Hold
Rotate the pencil Check the sharpener	○ □	▽ D	Hold Delayed
Place the pencil	⇨	⇦	Place the sharpener

Summary

Symbol	○	⇨	□	▽	D
Frequency (L.H)	2	2	1	1	0
Frequency (R. H)	0	2	0	2	2

Simo-Chart (Simultaneous-Motion Chart)

Simo-Chart is an extremely detailed two hand chart. A Simo-Chart is often based on film analysis. It shows a common scale the Therbling (unit of work) or groups of Therblings performed by different parts of the body of one or more workers. The time scale is represented in winks (1/2000 of a minute).

Simo-Chart is used for micro motion analysis, for example short cycle repetitive jobs like inspection, packing etc., and high order skilled jobs like component assembly. A Simo-Chart shows the relationship between different limbs of a worker with records of duration of micro motions. For example, at an instant it can be found what one hand is doing with respect to another in terms of therblings.

Steps for Constructing Simo-Chart

1. Using a 16 mm movie camera micro motions are filmed as the worker performs the job. A wink counter i.e., a timing device is placed in the field of view.
2. The film thus obtained after a whole cycle, is viewed for analysis.
3. The work study engineer analyses the film, frame by frame concentrating first on the left hand and then on right hand movements.
4. The data noted in step-3 is recorded in the form of therbling chart. The duration of actual movements are also read from the wink counter.
5. A Simo-Chart is prepared at this stage for further study and analysis.
6. This Simo-Chart of the existing method is subjected to a questioning procedure based on the principle of motion economy. The purpose is to develop a better and improved procedure.
7. A new Simo-Chart is now prepared for the new method.
8. The new method is now checked to claim its advantages over the old method.

Simo-Chart contains the following details:

Drawing No. and Name	**Film No.**
Name of the operator	**Chart No.**
Component name	**Sheet No.**
Operation No.	**Date**
	Charted by

Fig –9.5 Simo Chart

LH Description	Symbol (Therblings)	Time (Winks)	Symbol (Therblings)	RH Description

WORK MEASUREMENT (TIME STUDY)

Work measurement also called as "Time Study" involves assessing the time a job should take to do. Time study is defined as "a set of procedures for determining the amount of time required, under certain standard conditions of measurement, for tasks involving some human activity. Such a time is called standard time."

Work measurement is concerned with the determination of the amount of time required to perform a unit of work. Work measurement is very important for promoting productivity of an organization. It enables management to compare alternate methods and also to do initial staffing. It also provides basis for proper planning.

Since it is concerned with the measurement of time, it is also called 'Time Study'. The exact examination of time is very essential for correct pricing. To find the correct manufacturing time for a product, time study is performed. To give competitive quotations, estimation of accurate labor cost is very essential. It becomes a basis for wage and salary administration and devising incentive schemes.

DEFINITIONS OF WORK MEASUREMENT

"Work measurement is defined as the application of techniques designed to establish the work content of a specified task by determining the time required for carrying out the task at a defined standard of performance by a qualified worker".

According to British Standard Institution, Time study is defined as "The application of techniques designed to establish the time for a qualified worker to carry out a specified job at a defined level of performance."

The logical order of correct procedure to be adopted for having effective results of work measurement includes the following:

(i) Divide the selected procedure into small work elements.

(ii) By direct observations record the relevant information regarding the various work elements.

(iii) In the light of relevant information examine the work critically.

(iv) Measure the work content in the terms of time of the work elements involved in method being adopted.

(v) Define and design the new selected method.

(vi) Finally convert the work content time in terms of standard time.

OBJECTIVES OF WORK MEASUREMENT

The objectives of Time study or work measurement are stated as follows:

1. To compare the times of performance by alternative methods.
2. To enable realistic schedule of work to be prepared.
3. To arrive at a realistic and fair incentive scheme.
4. To analyze the activities for doing a job with the view to reduce or eliminate unnecessary jobs.
5. To minimize the human effort.
6. To assist in the organization of labor by daily comparing the actual time with that of target time.

USES OF WORK MEASUREMENT

1. Wok measurement is used in planning work and in drawing out schedules.
2. Wok measurement is used to determine standard costs.
3. Wok measurement is used as an aid in preparing budgets.
4. It is used in balancing production lines for new products.
5. Wok measurement is used in determining machine effectiveness.
6. To determine time standards to be used as a basis for labor cost control.
7. To establish supervisory objectives and to provide a basis for measuring supervisory efficiency.
8. To determine time standards to be used for providing a basis for wage incentive plans.

TECHNIQUES OF WORK MEASUREMENT

For the purpose of work measurement, work can be regarded as:

1. **Repetitive work:** The type of work in which the main operation or group of operations repeat continuously during the time spent at the job. These apply to work cycles of extremely short duration.
2. **Non-repetitive work:** It includes some type of maintenance and construction work, where the work cycle itself is hardly ever repeated identically.

Various Techniques of Work Measurement are as follows:

1. Time study (stop watch technique)
2. Synthesis
3. Work sampling
4. Predetermined motion and time study
5. Analytical estimating

Time study and work sampling involve direct observation and the remaining are data based and analytical in nature.

TIME STUDY

Time study is a work measurement technique for recording the times and rates of working for the elements of a specified job carried out under specified conditions and for analyzing the data so as to determine the time necessary for carrying out the job at the defined level of performance. In other words measuring the time through stop watch is called time study.

Steps followed in Time Study

The industrial engineer observes work and records times (stop watch or synthetic time data) and calculates the basic and standard times. The steps involve:

1. Decide the task(s) to be measured and understand the work/task cycle including the startup, perform and wind-down/put away phases
2. Identify the elements of each task.
3. Observe the task being done (reliable, sufficient, valid observations).
4. Record (stop watch and time sheet) the observed times for each element in the task cycle
5. Calculate basic times for these (average the observed times).
6. Add defined percentage allowances to each element to the basic time
7. Appraise the observed performance and give a rating. Apply an effort/performance rating as an adjustment to each element and then total.

Scope of time study

Work study data contributes to:

- Improved methods to raise output, quality, reduce wastage, enhance reliability and ensure safety.
- Standard time data contributes to capacity planning, scheduling, staff control, asset utilization, and quality improvement. Service and after-sales method improvements may be obtained as well as process improvement and better raw materials usage.
- Implementation planning for product/service and process design requires a detailed understanding of methods and timings.

Work measurement has problems of inaccuracy, subjectivity, variety, human variability and averaging and performance rating is subjective and prone to analyst inaccuracies.

We obtain standard work times from:

- direct observation - time studies and sampling
- from observing similar jobs (pre-determined data)

- reports of those doing the work (trusting their reports)

All involve some form of sampling and generally work measurement requires training for consistency of collection and judgment. People and conditions vary. If performance rating is to be done then subjectivity has to be minimized. Jobs may have short or long cycles of work.

COMPONENTS OF TIME STUDY

Basic time

When a qualified worker is doing a defined job with standard performance, the time taken to do it (use a stop-watch) is the basic time for the job. Operations managers need basic time data for each task so that estimates of completion times can be calculated. The time involved in a large project e.g. build a house can be better estimated if data is available on the time needed to complete each sub-task such as foundations, drainage, walls, floors, roof, plastering, electrics, plumbing, glazing etc.

Standard time

Standard time is a refinement of basic time. The latter reflects performance of a job over a range of conditions. Standard time defines the time required under specific conditions. It incorporates allowances for such factors as rest and relaxation.

A standard time = basic time + relaxation allowance + other allowance.

The standard time is not necessarily the time it will take to actually perform the task but a measured time, normalized to reflect the performance of someone working to a standard. In incorporates observed times, rating of performance and reasonable allowances. It enables units of work to be expressed i.e. as standard minutes or standard hours.

The purpose of Standard Time is as follows:

- To determine labor and equipment requirements
- To assist in developing effective methods
- To determine the number of pieces of equipment a person may run
- To balance the work of teams/crews
- To compare the methods of doing work
- To constrain the use of manpower
- To set schedules
- To set labor standards
- To determine supervisory objectives
- To provide a basis for setting a piece of incentives wages
- To assist in comparing performance with plans with respect to workload and resource usage

Allowances

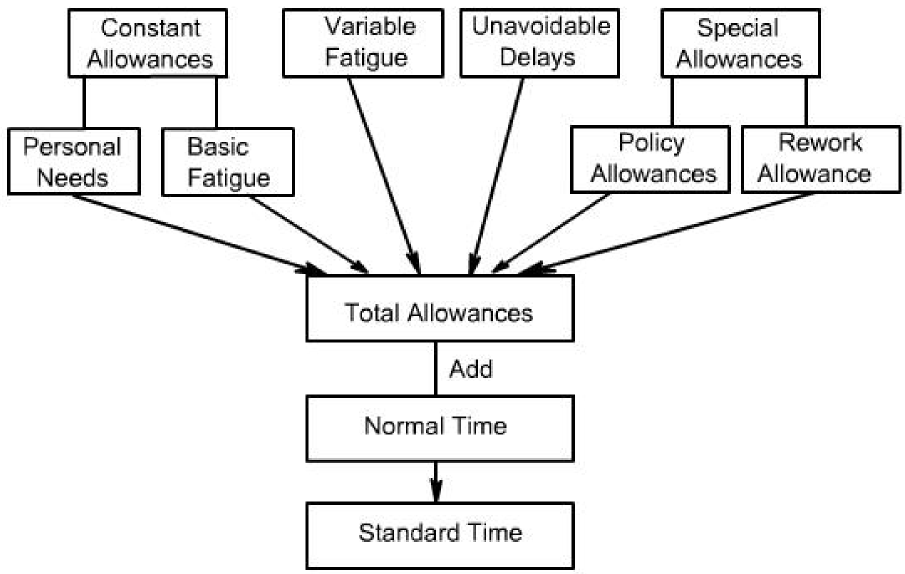
Several allowances may be applied to basic time. A relaxation allowance to account for physiological and psychological effects of tasks in certain circumstances and the worker's personal needs (toilet, washing, etc.) can be defined as a percentage to add to basic time. Other allowances may be agreed to cover contingencies, synchronization problems, idle time etc. Allowance factors can cover attention and effort needed (negligible to very alert, quick, heavy), posture considerations (sitting, standing, crouching, stretching), eye strain and noise, temperature and humidity (hot, ambient, and cold), atmosphere (wet, smelly, dusty, respirator, etc.).

Thus we have identified the elements of each task and have reliable, sufficient, valid observations of the task being done. We have appraised the observed performances and given a rating. Basic times have been calculated by averaging observed time and we have then added a % allowance to each element to the basic time. We can either apply a performance rating as an adjustment to each element and then total or alternatively we can first total these basic + allowance element times and then apply a performance rating % to the whole.

Types of Allowances

The different types of allowances are discussed in this part:

Fig. 9.6 Different types of allowances



Delay Allowance

This time allowance is given to operator for the numerous unavoidable delays and interruptions that he experiences every day during the course of his work. These interruptions include interruptions from the supervisor, inspector, planners, expediters, fellow workers, production personnel and others. This allowance also covers interruptions due to material irregularities, difficulty in maintaining specifications and tolerances, and interference delays where the operator has to attend to more than one machine.

Fatigue Allowance

This allowance can be divided into two parts: (i) basic fatigue allowance and (ii) variable fatigue allowance. The basic fatigue allowance is given to the operator to compensate for the energy expended for carrying out the work and to alleviate monotony. For an operator who is doing light work while seated, under good working conditions and under normal demands on the sensory or motor system, a 4% of normal time is considered adequate. This can be treated as a constant allowance.

The magnitude of variable fatigue allowance given to the operator depends upon the severity of conditions, which cause extra (more than normal) fatigue to him. As we know, fatigue is not homogeneous. It ranges from strictly physical to purely psychological and includes combinations of the two. On some people it has a marked effect while on others; it has apparently little or no effect. Whatever may be the kind of fatigue-physical or mental, the result is same-it reduces the work output of operator.

The major factors that cause more than just the basic fatigue includes severe working conditions, especially with respect to noise, illumination, heat and humidity; the nature of work, especially with respect to posture, muscular exertion and tediousness, and like that. It is true that in modern industry, heavy manual work, and thus muscular fatigue is reducing day by day but mechanization is promoting other fatigue components like monotony and mental stress. Because fatigue in totality cannot be eliminated, proper allowance has to be given for adverse working conditions and repetitiveness of the work.

Personal Allowance

This is allowed to compensate for the time spent by worker in meeting the physical needs, for instance a periodic break in the production routine. The amount of personal time required by operator varies with the individual more than with the kind of work, though it is seen that workers need more personal time when the work is heavy and done under unfavorable conditions. The amount of this allowance can be determined by making all-day time study or work sampling. Mostly, a 5 % allowance for personal time (nearly 24 minutes in 8 hours) is considered appropriate.

Special Allowances

These allowances are given under certain special circumstances. Some of these allowances and the conditions under which they are given are:

- Policy Allowance: Some companies, as a policy, give an allowance to provide a satisfactory level of earnings for a specified level of performance under exceptional circumstance. This may be allowed to new employees, handicap employees, workers on night shift, etc. The value of the allowance is typically decided by management.

- Small Lot Allowance: This allowance is given when the actual production period is too short to allow the worker to come out of the initial learning period. When an operator completes several small-lot jobs on different setups during the day, an allowance as high as 15 percent may be given to allow the operator to make normal earnings.

- Training Allowance: This allowance is provided when work is done by trainee to allow him to make reasonable earnings. It may be a sliding allowance, which progressively decreases to zero over certain length of time. If the effect of learning on the job is known, the rate of decrease of the training allowance can be set accordingly.

- Rework Allowance: This allowance is provided on certain operation when it is known that some percent of parts made are spoiled due to factors beyond the operator's control. The time in which these spoiled parts may be reworked is converted into allowance.

WORK SAMPLING

Work sampling is a statistically based technique utilized for analyzing work performance and machine utilization by direct observation, but without a stop watch. So work sampling is another useful technique of work study. It is a technique in which a large number of observations are made over a period of time of one or group of machines, processes or workers. Each observation records what is happening at that instant and the percentage of observations recorded for a particular activity, or delay, is a measure of the percentage of time during which that activities delay occurs.

This technique is particularly useful to estimate the proportion of delays or idleness’s occurring in an enterprise/plant and attributing the cause for it, such as power failures, input delays, machine cleaning, machine breakdowns and manpower idling or in other words, estimating proportion of time spent by an executive in attending meetings, telephoning or reading etc.

The method of work sampling consists of taking a large number of instantaneous observations randomly, rather than taking observations continuously as is done in various production investigations or studies. This method is a sampling technique and depends upon laws of probability.

A sample taken at random from a large population provides a good estimate of the distribution of the population because it tends to have the same distribution as the population.

Definition of Work Sampling

"Work sampling is a method in which a large number of instantaneous observations are made at random time intervals over a period of time or a group of machines, workers or processes/operations. Each observation records what is happening at that instant and the percentage of observations recorded for a particular activity or delay/idleness is a measure of the percentage of time during which that activity or delay/idleness occurs".

Following formula may be used for finding the requisite number of observation in order to achieve the desired accuracy:

Limit of error = Sp = x √p (1-p)/N

Where x = 1. 2 or 3 for confidence level of 68%, 95% and 99% or one sigma, two sigma three sigma confidence levels respectively

S = Desired relative accuracy.

p = Percentage occurrence of an activity or delay expressed in decimal e.g., 10% = 0.10

N = Sample size or total number of random observations.

Illustration-1:

Assume a Confidence level of 95% and desired relative accuracy of ±5%. Determine the number of observation required for the study. The work sampling method is to be used to determine the utilization of a group of drilling machines. The Preliminary study indicates that the machines are utilized for about 60% of the time.

Solution:

Given

S = Desired Relative

Accuracy = ±5% = .05

p = Percentage occurrence of an activity = 60% = 0.06

X = 2 for 95% confidence level

N = No. of observations =?

$$Sp = \frac{x\sqrt{p(1-p)}}{\sqrt{N}}$$

$$Sp = \frac{2\sqrt{0.60(1-0.60)}}{\sqrt{N}}$$

$$(0.05) \times (0.06) = \frac{2\sqrt{0.60(1-0.60)}}{\sqrt{N}}$$

$$N = \frac{4(0.60)(0.40)}{0.05 \times 0.05 \times 0.6 \times 0.6} = 1067 \text{ Ans.}$$

Illustration-2

A work sampling investigation was conducted to estimate the time for which the workers in plant remain idle. A total of 720 observations were made about the workers. In 45 observations the workers were found idle. If the confidence level is 95%, determine the absolute accuracy of the current estimate of the proportion of time consumed by idleness.

Solution:

Total no. of observations N =120

P = Proportion of idle time = 45/720 = 0.0625

For confidence level 95% X =?

Relative accuracy S =?

$$x = \frac{2\sqrt{1-\mathrm{p}}}{\sqrt{\mathrm{P x N}}} = \frac{2\sqrt{1-0.0625}}{\sqrt{0.0625 \text{ x } 720}} = 0.288 \text{ or } \pm 28.8\%$$

Absolute accuracy = ±Sp = (0.288) x (0.0625) = ± 0.018 Ans.

PREDETERMINED MOTION TIME STUDY (PMTS)

A work measurement technique whereby times established for basic human motions (classified according to the nature of the motion and conditions under which it is made) are used to build up the time for a job at the defined level of performance. The most commonly used PMTS is known as Methods Time Measurement (MTM).

A PMTS may be defined as "a procedure/method which analyses any manual activity/human motion in terms of the basic or fundamental motions required to perform it." Each of these motions is assigned a predetermined or a previously established standard time value in such a manner those times for the individual motions on addition provides a total time for the performance of the activity.

Procedure for PMTS

The steps followed in PMTS are as follows:

(1) Study the complete operation cycle few times.

(2) Observe and record the activities of one hand at a time.

(3) Record only few symbols at a time.

(4) Recording should be started at a point of time that can be easily distinguished.

(5) Care should be taken that no activity is left while recording, as it will affect the method study badly.

(6) Combinations of operations and transport should be avoided, unless they actually occur at the same time.

Objectives of PMTS

The predetermined lime systems have been successfully applied to:

- Determine job time standards.
- Compare the times for alternative, proposed methods so as to determine the economics of the proposals before the production runs or other way round production of equipment to be employed.
- To estimate the manpower, equipment and space requirements before production or prior to setting up of facilities.
- To develop tentative layouts for assembly lines before the work starts so as to minimize the investment on subsequent rearrangement and rebalancing etc.
- For improving and modifying work methods before stating the work on the job.
- To set time standards for various jobs.
- To provide a basis for estimation of labor cost and wage plans.
- To facilitate training of the workers and supervisory staff.
- To utilize for timing of those short and repetitive motion that are difficult to be measured by stop watch.

Advantages of PMTS

Predetermined motion time system possesses the following advantages:

- No timing is required so it eliminates in accuracies associated with stop watch time study.
- The use of PMT eliminates the requirement of troublesome and controversial performance rating. So performance rating is not required.
- The use of PMTS, force the analyst to be method conscious and to take care of method in detail. This sometimes help's to further improve the method.
- Since times can be calculated before starting the work, this procedure is useful in methods design, equipment selection and design and production planning and control.
- They are an excellent training technique.
- Once the analysts of an organization are familiar, they can be quickly applied.
- The basic times determined with the use of PMT system are relatively more consistent.
- Time standard for a job can be arrived at without going to the workplace.
- The time and cost associated with finding the standard time for a job is considerably reduced.

Limitations of PMTS

- PMTS can deal manual motions of an operation only.
- They are not economical for non-repetitive operations.
- They cannot be applied to restricted work (refer to process time studies).
- PMTS's are restrictive in nature because they have been built on data taken from particular operations and thus PMTS provides better results if applied to that type of work/operation only.
- All categories of motions have not been taken into consideration while collecting PMTS data.
- The need of trained personnel. Although PMT System eliminates the utilization of rating quite a bit of judgment is still essentially exercised at various stages.

ANALYTICAL ESTIMATING OF WORK MEASUREMENT

Analytical Estimating is a work measurement technique that enables an estimate of time required to carry out the elements of a job to be produced at a defined level of performance. This level is based on previous knowledge, e.g. standard performance and synthetic standard times, and experience of the elements concerned.

Procedure of Analytical Estimating

The various steps involved are as discussed below:

1. The first step is to find out the job details such as job dimension, standard procedure to do the job, and the job conditions, such as poor illumination, high temperature, hazardous environment, non-availability of jigs, fixture or tools, etc.

2. The second step is to break the job into small elements.

3. In the next step, select time values from the standard data catalogue for as many elements as possible (use synthetic data wherever available).

4. Then estimate the time values for the remaining elements (for which synthetic data is not available) based on past knowledge and experience.

5. Add the time values obtained by steps 3 and 4 to get the total Basic or Normal time (for 100% rating)

6. Add the appropriate blanket relaxation allowance (say 10% to 20% of total normal or basic time) Note that in analytical estimating, the relaxation allowance is not added to time values of individual elements. The blanket relaxation allowances depend on the type of the job and the job conditions.

7. Add any other allowances if applicable, to arrive at the standard time for the given job.

Advantages of Analytical Estimating Technique

- Offers the same advantages enjoyed by synthesis method.
- Helps in planning and scheduling the production
- Provides a basis for fixing the labour rate for non-repetitive jobs.
- Steps to improve labour control.

Disadvantages

Since analytical estimating technique relies upon the judgment of the estimator, the time values obtained may not be as accurate and reliable as that estimated by the stop-watch time study.

Applications of Analytical Estimating Technique

- It may be used for non-repetitive jobs, jobs having long cycle times and jobs having elements of variable nature. For such jobs the stop-watch time study proves to be uneconomical.
- It may also be used for repair and maintenance work, job production, one time large projects, office routines, tool room jobs and engineering construction works.

Discussion Forum

Short Questions

1. Define work study.
2. What is method study?
3. What is Time study?
4. Mention the different techniques of work measurement.
5. List down the objectives of work measurement.
6. Define work sampling.
7. What is PMTS?
8. Give the advantages and disadvantages of method study.

Essay Type Questions

1. Describe the various types of allowances in the estimation of standard time.
2. How is standard time estimated?
3. Explain the different types of Process charts.
4. Discuss the procedure of method study with example.
5. Explain the various techniques of work study.
6. Illustrate the procedure of method study.
9. Discuss the various tools used in method study

CHAPTER -10

PRODUCTION PLANNING AND CONTROL (PPC)

INTRODUCTION

After deciding the type of business, its location, layout, etc., the next step is to apply managerial principles to the production function in an enterprise. Production is a process whereby raw material is converted into finished products and thereby adds to the value of utility of products, which can be measured as the difference between the value of inputs and value of outputs. Production function encompasses the activities of procurement, allocation and utilization of resources. The main objective of the production function is to produce the goods and services according to the customer expectation in the most efficient and economical way. Production management encompasses of many activities starting from identification of potential opportunity for a new product/service to long term planning, aggregate planning, etc. to ensure customer satisfaction. Production planning without production control is like a bank without a bank manager. Planning initiates action while control is an adjusting process, providing corrective measures for planned development.

DEFINITION OF PRODUCTION PLANNING AND CONTROL (PPC)

Some of the definition given by authors is given below:

“Production planning and control is the co-ordination of series of functions according to a plan which will economically utilize the plant facilities and regulate the orderly movement of goods through the entire manufacturing cycle from the procurement of all materials to the shipping of finished goods at a predetermined rate”.

Charles A. Koepke

“Production planning and control involves generally the organization and planning of the manufacturing process. Specifically, it consists of the planning of the manufacturing, routing, scheduling, dispatching and inspection, co-ordination and the control of material, methods, machines, tooling, and operating times. The ultimate objective is the organization of the supply and movement of materials and labor, machine utilization and related activities, in order to bring about the desired manufacturing results in terms of quantity, time and place.”

- Goldon B. Carson

3. “The planning of industrial operations involves four considerations, mainly, what work shall be done, how the work shall be done and lastly, when the work shall be done”.

-Kimball

BENEFITS OF PRODUCTION PLANNING AND CONTROL

Production planning and control can facilitate the manager in the following ways:

- **Optimum Utilization of Capacity**

With the help of Production Planning and Control (PPC), the manager can schedule the tasks and production runs and thereby ensure that the productive capacity does not remain idle and there is no undue queuing up of tasks via proper allocation of tasks to the production facilities. It can be ensured that all the orders can be fulfilled and all machines can be optimally utilized by minimizing the idle time.

- **Inventory control**

Proper PPC will help the manager to choose Just- in- Time (JIT) systems and thereby reduce the overall inventory in firms. It will enable to ensure that the right supplies are available at the right time.

- **Economy in production time**

PPC will help the manager to reduce the cycle time and increase the turnover with the help of proper scheduling.

- **Ensure quality**

A good PPC will provide for adherence to the quality standards so that the quality of output is ensured.

OBJECTIVES OF PRODUCTION PLANNING AND CONTROL

Following are the objectives of production planning and control:

- Systematic planning of production activities to achieve the highest efficiency in production of goods and/or services.
- To organize the production facilities like machines, men, etc., to achieve stated production objectives with respect to quantity and quality time and cost.
- Optimum scheduling of resources.
- Coordinate with other departments relating to production to achieve regular balanced and uninterrupted production flow.
- To conform delivery commitments.
- To enhance materials planning and control.
- To be able to make adjustments due to changes in demand and rush orders.

PHASES OF PRODUCTION PLANNING AND CONTROL

Production planning and control has three phases namely:

a) Planning Phase
b) Action Phase
c) Control Phase

a) PLANNING PHASE

Planning is an exercise of intelligent anticipation in order to establish how an objective can be achieved or a need fulfilled in circumstances, which are invariably restrictive. Production planning determines the optimal schedule and sequence of operations, economic batch quantity, machine assignment and dispatching priorities for sequencing. It has two categories of planning, namely:

1. Prior planning

2. Active planning

Prior Planning

Prior planning means pre-production planning, which includes all the planning efforts, which are taking place before the active planning.

Modules of pre-planning

The modules of prior planning are as follows:

1. ***Product development and design*** is the process of developing a new product with all the features, which are essential for effective use in the field, and designing it accordingly. During the design stage, one has to take several aspects of design like, design for selling, design for manufacturing and design for usage.

2. ***Forecasting*** is an estimate of demand, which will happen in future. Since, it is an estimate based on the past demand, proper care must be taken while estimating it. Given the sales forecast, the factory capacity, the aggregate inventory levels and size of the work force, the manager can decide rate of production to operate the plant over an intermediate planning horizon.

3. ***Aggregate planning*** aims to find out a product wise planning over the intermediate planning horizon.

4. ***Material Requirement Planning (MRP)*** is a technique for determining the quantity and timing for the acquisition of dependent items needed to satisfy the master production schedule.

Active Planning

The modules of active planning are Process planning and routing, Materials planning, Tools planning, Loading, Scheduling, etc.

1. ***Process planning and routing*** is a complete determination of the specific technological process steps and their sequence to produce products according to desired quality, quantity and cost. It determines the method of manufacturing a product, selects the tools and equipment, and analyses how the manufacturing of products will fit into the facilities. Routing recommends the flow of work in the plant and it is related to the considerations of layout, temporary locations for raw materials and components, and materials handling systems.

2. ***Material planning*** is a process which determines the requirements of various raw materials or sub-assemblies by considering the trade-off between various cost components like carrying cost, ordering cost, shortage cost, etc.

3. ***Tools planning*** determine the requirements of various tools by taking process specification (surface finish, length of the job, overall depth of cut etc.), material specifications (type of material used, the hardness of the material, shape and size of the material etc.) and equipment specifications (speed range, feed range, depth of cut range etc.).

4. ***Loading*** is the process of assigning jobs to several machines such that there is a load balance among the machines. This is a relatively complex task, which can be managed with the help of efficient heuristic procedures.

5. ***Scheduling*** is the time phase of loading and determines the best sequence the work to be carried out. This decides the starting and finishing time for each job.

b. ACTION PHASE

The action phase comprises the major step of dispatching. *Dispatching* is the transition from planning phase to action phase where the worker is ordered to start manufacturing of the product. The tasks included in dispatching include, job order, stores issue order, tool order, time ticket, inspection order, move order etc.

The job order number is the key item which is to be mentioned in all other reports or orders. *Stores issue order* gives instruction to stores to issue materials for manufacturing the product as per product specifications. As per tooling requirements for manufacturing the product, the *tool order* instructs the tool room to issue necessary tools. *Time ticket* is nothing but a card which is designed to note down the actual time taken at various processes. This information is used for deciding the costs for future jobs of a similar nature and also for performing variance analysis, which helps to workout control. *Job order* is the official authorization to the shop floor to start the manufacturing of the product. *Inspection order* will be issued to inspection wing for timely testing and inspection so that the amount of rework will be minimized. The process involves moving raw materials and subassembly to the main line is done by a well-designed materials handling system. Hence proper instruction is given to the materials handling facilities for major movements of materials and subassemblies in the form of a *move order*. Movements which involve less distance and fewer loads are managed at the shop floor level based on requests from operators.

c. CONTROL PHASE

The control phase has the following two major modules:

1. Progress reporting

2. Corrective action

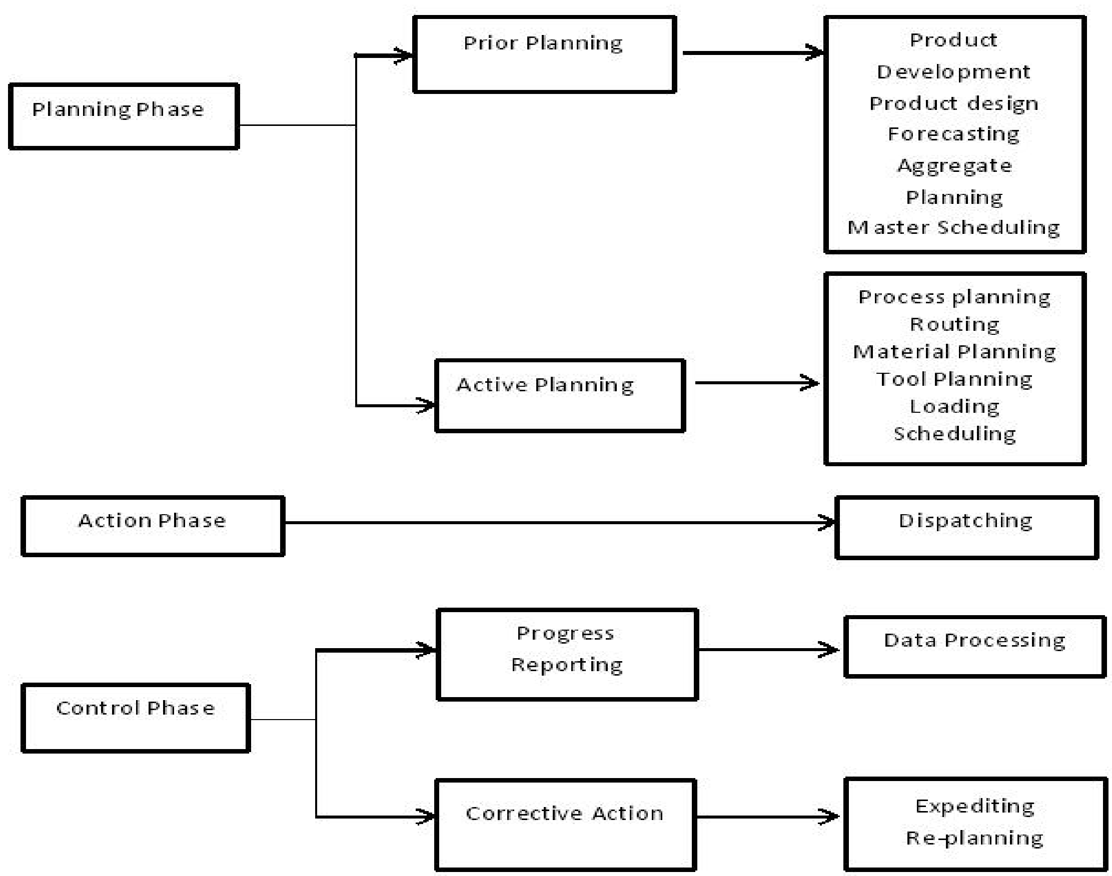
1. Progress Reporting

In progress reporting, the data regarding the progress of job are collected. It helps to make comparison with the present level of performance. The various data pertaining to material rejection, process variations, equipment failures, operator efficiency, operator absenteeism, tool life, etc., are collected and analyzed for the purpose of progress reporting. These data are used for performing variance analysis, which help to identify critical areas that deserve immediate attention for corrective actions.

2. Corrective Action

The tasks under corrective action primarily make provisions for an unexpected event. Some examples of corrective actions are creating schedule flexibility, schedule modifications, capacity modifications, make or buy decisions, expediting the work, pre-planning, etc. Due to unforeseen reasons such as, machine breakdown, labor absenteeism, too much rejection due to poor material quality etc., it may not be possible to realize the schedule as per the plan. Under such condition, it is better to reschedule the whole product mix so that we get a clear picture of the situation to progress further. Hence, it is to be re-examined for selecting appropriate course of action. *Expediting* is the process of taking action if the progress reporting indicates deviations from the originally set target. Pre-planning of the whole affair is done in case the expediting fails to bring the deviated plan to its right path

Fig- 10.1 Phases of Production Planning and Control



Parameters for PPC

The functions of PPC can be explained with the following parameters:

1. Materials: Raw materials, finished parts and components should be made available in the required quantities at the required time to ensure the correct start and end for each operation to ensure uninterrupted production. The function includes the specification of material, delivery dates, variety reduction (standardization), procurement and make or buys decisions.

2. Machines and equipment: This function is related to the detailed analysis of available production facilities, equipment downtime, maintenance policy, procedure and schedules concerned with the economy of jigs and fixtures, equipment availability. Thus, the duties include the analysis of facilities and making their availability with minimum down time due to breakdowns.

3. Methods: This function is concerned with the analysis of alternatives and selection of the best method with due consideration to constraints imposed. Developing specifications for processes is an important aspect of PPC and determination of sequence of operations.

4. Process planning (Routing): It is concerned with the selection of path or route which the raw material should follow to get transformed into finished products. The duties include:

(a) Fixation of path of travel giving due consideration to layout.
(b) Breaking down of operations to define each operation in detail.
(c) Deciding the set up time and process time for each operation.

The routing procedure involves following activities:

(1) An analysis of the article to determine what to make and what to buy.
(2) To determine the quality and type of material
(3) Determining the manufacturing operations and their sequence.
(4) Determination of lot sizes
(5) Determination of scrap factors
(6) An analysis of the cost of the article
(7) Organization of production control forms.

5. Estimating: Once the overall method and sequence of operations is fixed and process sheet for each operation is available, then the operations times are estimated. This function is carried out using extensive analysis of operations along with methods and routing, a standard time for the operation is established using work measurement techniques.

6. Loading and scheduling: Scheduling is concerned with preparation of machine loads and fixation of starting and completion dates for each of the operations. Machines have to be loaded according to their capability of performing the given task and according to their capacity. Thus the duties include:

(a) Loading, the machines as per their capability and capacity.

(b) Determining the start and completion times for each operation.

(c) To coordinate with sales department regarding delivery schedules.

7. Dispatching: This is the execution phase of planning. It is the process of setting production activities in motion through the release of orders and instructions. It authorizes the start of production activities by releasing materials, components, tools, fixtures and instruction sheets to the operator.

The activities involved are:

(a) To assign definite work to definite machines, work centers and men.

(b) To issue required materials from stores.

(c) To issue jigs, fixtures and make them available at the correct point of use.

(d) Release necessary work orders, time tickets, etc., to authorize the timely start of operations.

(e) To record start and finish time of each job on each machine or by each man.

8. Expediting: This is the control tool that keeps a close observation on the progress of the work. It is a logical step after dispatching which is called ‘follow-up’. It coordinates extensively to execute the production plan. Progressing function can be divided into three parts such as:

1. Follow up of materials

2. Follow up of work-in-process

3. Follow up of the assembly

The duties include:

- Identification of bottlenecks and delays and interruptions because of which the production schedule may be disrupted.
- To devise action plans (remedies) for correcting the errors.
- To see that production rate is in line with schedule.

9. Inspection: It is a major control tool which is very much important to PPC both for the execution of the current plans and its scope for future planning. This forms the basis for knowing the limitations with respects to methods, processes, etc., which is very much useful for evaluation phase.

10. Evaluation: This stage though neglected is a crucial to the improvement of productive efficiency. A thorough analysis of all the factors influencing the production planning and control helps to identify the weak spots and the corrective action with respect to pre-planning and planning will be effected by a feedback. The success of this step depends on the communication, data and information gathering and analysis.

AGGREGATE PLANNING

Aggregate planning is an operational activity critical to the organization as it looks to balance long-term strategic planning with short term production success. It is an intermediate term planning decision. It is the process of planning the quantity and timing of output over the intermediate time horizon i.e. three months to one year. Within this range, the physical facilities are assumed to be fixed for the planning period. Therefore, fluctuations in demand must be met by varying labor and inventory schedule. The aggregate plan seeks the best combination to minimize costs.

CHARACTERISTICS OF AGGREGATE PLANNING

- Considers a "planning horizon" from about 3 to 18 months, with periodic updating
- Looks at aggregate product demand, stated in common terms
- Looks at aggregate resource quantities, stated in common terms
- Possible to influence both supply and demand by adjusting production rates, workforce levels, inventory levels, etc., but facilities cannot be expanded.

OBJECTIVES OF AGGREGATE PLANNING

Objective of aggregate planning frequently is to minimize total cost over the planning horizon.

Other objectives should be considered:

- maximize customer service
- minimize inventory investment
- minimize changes in workforce levels
- minimize changes in production rates
- maximize utilization of plant and equipment

AGGREGATE PLANNING STRATEGIES

If a single strategy is used to use the demand, then it is called as a pure strategy. There are two pure planning strategies available to the aggregate planner: a level strategy and a chase strategy. Firms may choose to utilize one of the pure strategies in isolation, or they may opt for a strategy that combines the two.

1. Level Strategy

A level strategy seeks to produce an aggregate plan that maintains a steady production rate and/or a steady employment level. In order to satisfy changes in customer demand, the firm must raise or lower inventory levels in anticipation of increased or decreased levels of forecast demand. The firm maintains a particular level of workforce and a steady rate of output when demand is moderately low. This allows the firm to establish higher inventory levels than are currently needed. As demand increases, the firm is able to continue a steady production rate, steady employment level, while allowing the inventory surplus to absorb the increased demand.

A second alternative would be to use a backorder. A backorder is simply a promise to deliver the product at a later date when it is more readily available, usually when capacity begins to catch up with diminishing demand. The backorder is a device for moving demand from one period to another, preferably one in which demand is lower, thereby smoothing demand requirements over time.

2. Chase strategy

A chase strategy implies matching demand and capacity period by period. This could result in a considerable amount of hiring, firing or laying off of employees; insecure and unhappy employees; increased inventory carrying costs; problems with labor unions; and erratic utilization of plant and equipment. It also implies a great deal of flexibility on the firm's part. The major advantage of a chase strategy is that it allows inventory to be held to the lowest level possible, and for some firms this is a considerable savings. Most firms embracing the just-in-time production concept utilize a chase strategy approach to aggregate planning.

Most firms find it advantageous to utilize a combination of the level and chase strategy. A combination strategy (sometimes called a hybrid or mixed strategy) can be found to better meet organizational goals and policies and achieve lower costs than either of the pure strategies used independently.

The following are the different aggregate planning strategies:

- Building and utilizing through constant work force
- Varying the size of the work force
- Overtime utilization
- Subcontracting

We can use any one of the above strategies or a combination for smoothing fluctuations in demand.

Building and utilizing inventory through constant work force

A constant work force can be used by the companies, which results it constant output during each period in the planning horizon. Sometimes the demand can be fluctuating, and it is very difficult to maintain the right quantity of supply during this period. When the production is higher than the demand, then it can be maintained as inventory and can be used in the near future. This strategy helps to maintain stability in the work force, which in turn results in producing quality products /services due to the expertise gained by the work force.

Varying the work force

The firms can vary the work force, according to the demand patterns by hiring and layoffs of the employees. When the demand is very high, the employees are hired and when the demand of the products reduces, the company can follow some strategies like retrenchment, layoffs, etc. to reduce the workforce. When a company follows these strategies, it will result in the increase of recruitment; training and development cost but the inventory cost become zero.

Subcontracting to other companies

Subcontracting refers to the practice of bringing in an outside company or individual to perform specific parts of a contract or project. This strategy is generally used when the products / services have the maximum demand and when the company is not in a position to generate enough capacity to carry out the production.

MATERIAL REQUIREMENTS PLANNING (MRP)

Material requirements planning (MRP) is a computer-based inventory management system designed to improve productivity for businesses. MRP works backward from a production plan for finished goods, which is converted into a list of requirements for the sub-assemblies, component parts, and raw materials needed to produce the final product within the established schedule.

INPUTS OF MRP

The three basic inputs of an MRP system are as follows:

1. Master Production Schedule (MPS)
2. Inventory Status File (ISF)
3. Bill of Materials (BOM)

The MPS is simply the quantity and timing of all end goods to be produced over a specific time period. MPS is estimated through customer orders and demand forecasts.

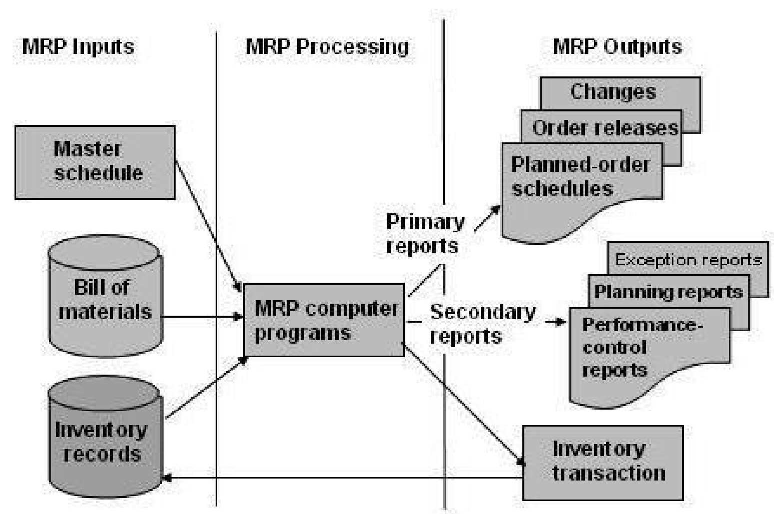
The ISF contains important real-time information on a company's inventory. It lets managers know what they have on hand, where that inventory is, and the overall status of the inventory.

The BOM is a detailed list of raw materials, components, and assemblies required to construct, manufacture or repair a product or service.

MRP PROCESSING

Using information from the bill of materials, master schedule, and inventory records file, an MRP system determines the net requirements for raw materials, component parts, and sub-assemblies for each period on the planning horizon. MRP processing first determines gross material requirements, then subtracts out the inventory on hand and adds back in the safety stock in order to compute the net requirements.

Fig-10.2 Process of Material requirements planning



MRP OUTPUTS

The main outputs from MRP include three primary reports and three secondary reports. The primary reports consist of:

- Planned order schedules, which outline the quantity and timing of future material orders
- Order releases, which authorize orders to be made
- Changes to planned orders, which might include cancellations or revisions of the quantity or time frame

The secondary reports generated by MRP include:

- Performance control reports, which are used to track problems like to miss delivery dates and stock outs in order to evaluate system performance
- Planning reports, which can be used in forecasting future inventory requirements
- Exception reports, which call managers' attention to major problems like late orders or excessive scrap rates

STEPS OF MATERIAL REQUIREMENTS PLANNING (MRP)

The MRP process can be broken down into four basic steps:

1. **Estimating demand and the materials required to meet it**. The initial step of MRP process is determining the customer demand and the requirements to meet it. Utilizing the bill of materials, which is a list of raw materials, assemblies, and components needed to manufacture an end product. MRP breaks down demand into specific raw materials and components.
2. **Check demand against inventory and allocate resources.** This step involves checking demand against inventory possessed by the firm. Then the MRP allocates inventory into the exact areas where it is needed.
3. **Production scheduling.** The next step in the process is simply to calculate the amount of time and labour required to complete manufacturing. A deadline is also provided.
4. **Monitor the process.** The final step of the process is simply to monitor it for any issues. The MRP can automatically alert managers for any delays and even suggest contingency plans in order to meet deadlines.

CAPACITY MANAGEMENT

Capacity management refers to the act of ensuring a business maximizes its potential activities and production output at all times, under all conditions. The capacity of a business measures how much companies can achieve, produce, or sell within a given time period.

Capacity management is concerned with:

- Monitoring the performance of the firm with the existing resources
- Performance analysis of measurement data, including analysis of the impact of new releases on capacity
- Performance tuning of activities to ensure the most efficient use of existing infrastructure
- Understanding the demands of the service and future plans for increased workload
- Capacity planning of material, tools, software, and other resources required over some future period of time.

CAPACITY

The capacity of a production unit is its ability to produce that the customer requires. In production and operations management, three types of capacity are often referred to:

1. Potential Capacity

It denotes the capacity that can be made available to influence the planning of senior management. This is essentially a long-term decision that does not influence day-to-day production management.

2. Immediate Capacity

It means the amount of production capacity that can be made available in the short-term. This is the maximum potential capacity that it is used productively.

3. Effective Capacity

Effective capacity is the maximum amount of work that an organization is capable of completing in a given period due to constraints such as quality problems, delays, material handling, etc.

CAPACITY PLANNING

Capacity planning is the process of determining the production capacity needed by an organization to meet changing demands for its products. It is the process used to determine the increased amount of capacity needed to manufacture existing products or new product(s) according to the market demand. A number of factors can affect capacity, such as the number of workers, the ability of workers, number of machines, waste, scrap, defects, errors, productivity, suppliers, government regulations, and preventive maintenance. Capacity planning is relevant in both the long term and the short term.

Concept of Capacity Planning

Design Capacity: Design capacity is the theoretical maximum output of a system in a given period under ideal conditions. It is the maximum output of a structure, facility, process, machine, tool or component based on its design.

Effective Capacity: Effective capacity rate refers to the amount of product that can be theoretically produced during a period of time. It means the optimum level of output, given the changes in product mix, equipment maintenance, programming and operating issues, labor problems, etc. It usually is less than the total design capacity.

Actual Output: It is the level of output that is achieved actually. It cannot be more than the sufficient capacity because of breakdowns in the machine, labor absenteeism, the inconsistent supply of raw materials, abnormal delay in supply of equipment, power outage, etc.

PROCEDURE FOR CAPACITY PLANNING

1. Assessment of present capacity

The capacity of a department can be measured in terms of their output or inputs. Output is measured in manufacturing and services firms using the following terms provided in the following table:

Table- 10.1 Measure of Capacity in Different types of firms

S. No.	Firms	Measure
Manufacturing Firms (Measured In terms of Output)		
1	Automobile plant	Number of vehicles
2	Iron and Steel plant	Tons of steel
3	Brewery	Barrels of drinks
4	Cannery	Tons of processed foods
5	Power company,	Megawatts of electricity
Service Firms (Measured in terms of Input)		
1	Hospitals	Number of beds
2	Airports	Number of planes
3	Cinema theatres	Number of seats
4	Restaurants	Number of tables and chairs
5	University	Number of students
6	Warehouse	Spaces

2. Estimating future capacity needs

Short term capacity requirements can be estimated by forecasting product demand at different stages of the product life cycle. It is more challenging to anticipate long-term capacity requirements due to the uncertainties of the market and technology.

Capacity forecast helps to determine the gap between the existing capacity and estimated capacity so that necessary adjustments may be made. For example, a company that engages in the manufacturing of two products may find that one product has low demand in summer (e.g., coffee or tea) while another product has low demand in winter (e.g., cool drinks).

3. Identifying alternative ways of modifying capacity

In a situation where the present capacity is not enough to meet the estimated demand capacity, an expansion will be required to meet up with the shortage. Also more shifts or overtime will be required to improve the capacity. The expansion will help in meeting the demand forecast, but it needs extra investment and a danger of falling short of expectations in future demand.

When the present capacity is more than the forecasted, there is a need to cut down excess capacity. Building new products, selling present facilities, lay off workers, or getting more jobs from other companies are all ways to tackle this problem.

4. Evaluation of Alternatives

Different alternatives for capacity improvement or reduction are calculated from economic, technical, and other standpoints. The reactions of staff and locals should be considered during the evaluation to get the correct analysis. Some main evaluation techniques include cost-benefit analysis, queuing theory, decision theory, etc..

5. Choice of Suitable Course of Action

After carrying out the cost-benefit analysis of different alternatives to increase or reduce the capacity, the best alternative is selected.

STRATEGIES OF CAPACITY PLANNING

The primary strategies that an organization can use for capacity planning are as follows:

1. Lead Strategy

This is considered as one of the most aggressive strategies of capacity planning. It is an approach where the company anticipates an increase in demand and thus increases its production capacity beforehand. The management uses lead strategy as an important tool to attract customers towards its products and keep them away from those of rival companies, especially because of inventory shortage during high demands. It also tries to minimize stock out costs.

But one of the disadvantages of lead strategy is that if the demand does not rise, then the organization is stuck with the additional inventory.

2. Lag Strategy

In this type of strategy, the organization responds to the requirement of high demand by boosting its production capacity after the entity has started running at full power. It does not increase production on mere assumptions, as it starts acting only after collecting factual information.

The benefit of Lag Strategy is that the company does not have any additional inventory with it. There is a minimum risk of overproduction and large investments are not done unless it is necessary.

The disadvantage is that the company does not have any additional inventory with it in case of sudden high demand. By the time the company generates additional inventory, either the demand decreases or the customers have already become loyal to some other brand.

3. Match Strategy

This is considered as a moderate strategy since it is an integration of both Lead and Lag strategies. It neither anticipates very high demand and start building accordingly, nor does it stay idle until the high demand arises. Instead, the Match Strategy makes minor modifications depending on changing market conditions. It's a bit hard to accomplish, but the risk is very less comparatively.

4. Adjustment strategy

This strategy involves either reducing or adding to the capacity in small amounts depending upon the prevailing consumer demand. The adjustment strategy can also take place due to some important changes in the product.

CAPACITY REQUIREMENT PLANNING (CRP)

Capacity Requirement Planning (CRP) refers to a planning process that defines the quantity of products or components to be produced and determines whether or not it is possible to meet the demand and thereby achieve performance objectives. Capacity Requirements Planning is a computerized technique for projecting resource requirements for critical workstations.

It applies primarily to medium-range activities. The CRP system receives planned and released orders from MRP system and attempts to develop loads for the firm's work centers that are in good balance with the work-center capacities.

Like MRP, CRP is an iterative process that involves planning, capacity revision (master schedule revision), and re-planning until a reasonably good load profile is developed.

Input of CRP

- *Planned Order Releases:* Information from the MRP provides the information in order to start the order so it can be completed on time.

- *Routing Files:* Information that details the requirements of equipment and labor to complete the order as needed in the required time frame.
- *Open Orders Files:* Information regarding the orders that are currently started and need to be completed.
- *Work centre data:* This data relates to each production work center, including resources, utilization and efficiency standards, and capacity.

CRP processes

- *Calculate work centre capacity:* This is based on human and machine resources, hours of operation, efficiency, and utilization factors.
- *Determine load:* Using a scheduling algorithm, the load imposed on each work center in future time periods is accumulated based on both open and planned factory orders.
- *Balance capacity and load:* Where ever there are imbalances, the capacity or load is adjusted to obtain a balanced schedule. If routine adjustments are not sufficient, rescheduling of the MRP or MPS outputs may be necessary. This is usually a human judgement, and the changes are done iteratively with the work centre load report.

Output of CRP

- *Work centre load report:* It shows the relationship between capacity and load. When this report shows a substantial imbalance, the entire CRP process may be repeated.
- *Revised schedule of planned factory order releases:* It represents the output from MRP adjusted to reflect specific release dates for factory orders that take into account capacity constraints. They are indirect outputs from the CRP process since they are the result of human judgements from the load reports.

USES OF CRP

- To determine the capability of a system or resource to produce a quantity of output in a particular time period.
  - For example:
  - Should the hospital hire more registered nurses to care for the projected patient load?
  - Should the hospital build more rooms for patients?
  - What is the projected finish time for the current projects?
- CRP uses the information to produce a load profile for each machine or work centre. A load profile:
  - Compares released orders and planned orders with the capacity of the work centre.
  - Identifies underloads and overloads.

Discussion Forum

Short Questions

1. What is production planning?
2. Define production control.
3. Define Production Planning Control.
4. Give the benefits of Production Planning Control.
5. Mention any 4 objectives of PPC.
6. What is aggregate planning?
7. Write a short note on capacity planning.
8. Differentiate between design and effective capacity.

Essay Type Questions

1. What is capacity planning? Explain the procedure followed in capacity planning.
2. Explain the concept of Capacity Requirement Planning.
3. Describe the phases of Production Planning Control.
4. Explain the parameters of Production Planning Control
5. Discuss the various strategies of aggregate planning.
6. Explain the process of Materials Requirement Planning.

CHAPTER- 11
SCHEDULING

INTRODUCTION

Scheduling is an important tool for manufacturing, and engineering and it can have a major impact on the productivity of an organization. In manufacturing, the purpose of scheduling is to minimize the production time and costs, by informing a production facility about what to make, when, with which staff, and on which equipment. Production scheduling aims to maximize the efficiency of the operation and reduce costs. Scheduling is establishing the timing of the use of equipment, facilities and human activities in an organization.

It covers the following areas:

1. Assigning job to a particular work center/machine.
2. Timing of job assignment and its completion.
3. Allocating the resources like manpower and materials.
4. Sequence of operations.
5. In order to take care of deviations, feedback and control function.

Production scheduling tools greatly outperform older manual scheduling methods. This provides the production scheduler with powerful graphical interfaces which can be used to visually optimize real-time workloads in various stages of the production, and pattern recognition allows the software to automatically create scheduling opportunities which might not be apparent without this view into the data. For example, an airline might wish to minimize the number of airport gates required for its aircraft, in order to reduce costs, and scheduling software can allow the planners to see how this can be done, by analyzing time tables, aircraft usage, or the flow of passengers.

The benefits of production scheduling include:

- Process changeover reduction
- Inventory reduction, leveling
- Reduced scheduling effort
- Increased production efficiency
- Labor load leveling
- Accurate delivery date quotes
- Real time information

Definition of Scheduling

Operation scheduling is crucial for the success of an organization. It may involve complicated tasks. Effective schedules are needed to meet promised dates or inventory targets.

According to James Lundy, “Operations scheduling consists of the assignment of starting and completion times for the various operations to be performed.”

According to Leon Alford and Henry Beatty, “Production scheduling is defined as fitting specific jobs into a general time-table so that orders may be manufactured in accordance with contractual liability or in mass production so that each component may arrive at and enter into assembly in the order and at the time required.”

PERFORMANCE MEASURES

From the managers’ perspective, it is very important to identify the performance measures to be used in selecting a schedule. In order to meet the organizational goals, the schedules should reflect managerially acceptable performance measures. Some of the common measures used in operation scheduling are as follows:

a. Job Flow Time

The amount of shop time for the job is called as job flow time. Job flow time is the sum total of the moving time between operations waiting time for machines or work orders, process time and delays resulting from machine breakdowns, component unavailability and the like.

b. Make span

Make span is the total time required to complete a group of jobs.

c. Past Due

The measure past due can be expressed as the amount of time by which a job missed its due date or as the percentage of total jobs processed over some period of time that missed their due dates.

d. Work-in-process inventory

Any job in a waiting line, moving from one operation to the next, being delayed for some reason, been processed or residing in component or subassembly inventories is considered to be work-in-process inventory.

e. Total Inventory

Total inventory is the sum of scheduled receipts and on-hand inventories.

f. Utilization

The percent of work time productively spent by a machine or the worker is termed as utilization.

SCHEDULING METHODS

Scheduling methods are mostly classified on the basis on the volume of production and the nature of operations. Mostly the companies use backward and forward scheduling to allocate plant and machinery resources, plan human resources and production processes, and purchase materials.

a. FORWARD SCHEDULING PROCESS

Forward scheduling is planning the tasks from the date resources become available to determine the shipping date or the due date. In other words, it is a method in which actual production start when a job order is received. The start and finish time for each job is determined on the basis earliest start time slots at the work center. The jobs are started at the earliest possible time and finished before the required time. Hence the work-in-process inventory is increased in this type of scheduling method.

b. BACKWARD SCHEDULING PROCESS

Backward scheduling is planning the tasks from the due date or required-by date to determine the start date and/or any changes in capacity required. In other words, the backward scheduling schedules the order according to the due dates of the finished items. In this method the start and finish time for each job is determined according to the latest available completion time at the work center.

FUNCTIONS OF OPERATIONS SCHEDULING

Some of the functions of operations scheduling are discussed as follows:

Resource Allocation

Resource allocation is the process of assigning and managing assets in a manner that supports an organization's strategic goals. Resource allocation includes managing tangible assets such as hardware to make the best use of softer assets such as human capital. Resource allocation involves balancing competing needs and priorities and determining the most effective course of action in order to maximize the effective use of limited resources and gain the best return on investment.

Sequence of Jobs

The next function is to determine the right sequence of jobs that will be performed on each resource. A common technique used is grouping jobs together is to minimize the amount of setup and changeover required. This could be running jobs of similar color or materials one after the other to reduce machine setup.

Start and End Time of Job

When the operations are scheduled in the right order, a specific start and end time will be involved. For the most accurate schedule, we should consider the different machine run rates for various products and various machines. Knowing when operations are supposed to start and finish will help us to notify customers of the status of their order.

Maximum Utilization of Plant

Often, resources are not utilized to their full capacity in the firm. This leaves many resources idle for long periods of time, which can be costly. One method to improve the overall schedule is to focus on the scheduling of operations on resources that are bottlenecks or that cost a lot to run. This will ensure that those resources are always processing items while upstream and downstream operations are adjusted to limit the number of works in progress items.

Information on Machines

Operations scheduling provides up-to-date operations on machines and the products that are being produced. Shop floor feedback on the status of operations offers additional visibility on the status of orders.

Shop Floor Control

Optimized operation schedules ensure that everyone knows what should be started and completed when. This gives additional structure and control over the shop floor operations.

JOB SHOP SCHEDULING

Scheduling problems are common in all businesses and particularly, the job shop face quite a number of problems. A job shop is a process focused production system that employs general purpose processes. In a job shop, large numbers of varieties of products are produced in relatively small volume. Some examples of job shops are machining shops, consulting firms, polyclinics, etc. The production manager uses the results of scheduling in taking some decisions regarding:

- Capacity planning
- Removal of bottlenecks
- Requirement of additional capacities and facilities
- Placement of orders
- Machine utilization
- Customer service
- Delivery of finished goods
- Inventory planning and control
- Maintenance of facilities

SCHEDULING ACTVITIES

The process of scheduling involves three major activities, such as routing, loading and dispatching.

1. Routing

The process of routing explains the sequence of operations and process to be followed in order to produce a particular product. Routing determines what work is to be done, where and how it is to be done. Routing sheets are prepared and it gives a clear picture about the sequence in which a product has to be manufactured.

2. Loading

Loading is defined as assigning specific jobs to each work center for the planning period. It has to be done on the basis of capacity planning. The standard capacity has to be arrived at and then the work load has to be allocated for different work centers. Loading also results in proper sequencing of the activities so that the idle time of machineries is minimized and the jobs are completed with least time possible.

3. Dispatching

Dispatching is the final act of releasing job orders to workers to go ahead with the production process. The production process is controlled to ensure the effective implementation of the schedule in order to achieve the objectives specified in the master production schedule.

Dispatching rules

There are a number of priority rules or heuristics that can be used to select the order of jobs waiting for processing. Some well-known ones are presented in a list adapted from Vollmann, Berry, Whybark, and Jacobs (2005):

- *Random (R):* Any one job in the queue is selected with equal probability. This rule is often used as a benchmark for other rules.
- *First come/first served (FCFS):* Jobs are processed in the order in which they arrive.
- *Shortest processing time (SPT):* The job with the shortest processing time requirement is selected and processed first. This rule tends to reduce work-in-process inventory, average throughput time, and the average job lateness.
- *Earliest due date (EDD):* The job with the earliest due date is done first.
- *Critical ratio (CR):* To use this rule, one must calculate a priority index using the formula (due date–now)/(lead time remaining). This rule is widely used in practice.
- *Least work remaining (LWR):* This is an extension of SPT. This rule dictates that work should be scheduled according to the processing time remaining before the job is considered to be complete. The less work remaining in a job, the earlier it is in the production schedule.
- *Fewest operations remaining (FOR):* This rule is another variant of SPT. It sequences jobs based on the number of successive operations remaining until the job is considered complete. The fewer operations that remain, the earlier the job is scheduled.
- *Slack time (ST).* This rule is a variant of EDD; it utilizes a variable known as slack. Slack is computed by subtracting the sum of setup and processing times from the time remaining until the job's due date. Jobs are run in order of the smallest amount of slack.
- *Slack time per operation (ST/O):* This is a variant of ST. It is calculated by dividing the slack time by the number of operations remaining until the job is complete with the smallest values being scheduled first.

These rules assume that setup time and setup costs are independent of the processing sequence. However, this is not always the case. Jobs that require similar setups can reduce setup times if sequenced back to back. In addition to this assumption, the priority rules also assume that setup time and processing times are deterministic and not variable, there will be no interruptions in processing, the set of jobs is known, no new jobs arrive after processing begins, and no jobs are canceled.

SCHEDULING TECHNIQUES

Some of the scheduling techniques used in operations management are as follows:

- Gantt Charts
- Job sequencing rules
- Queuing theory
- Critical ratio method

GANTT CHART

A Gantt chart is a graphical representation of the duration of tasks against the progression of time. A Gantt chart is a useful tool for planning and scheduling projects. It is helpful when monitoring a project's progress

A Gantt chart is a type of bar chart that illustrates a project schedule. It illustrates the start and finish dates of the terminal elements and summary elements of a project. Terminal elements and summary elements comprise the work breakdown structure of the project. Some Gantt charts also show the dependency (i.e, precedence network) relationships between activities.

When to Use Gantt Charts?

- When scheduling and monitoring tasks within a project.
- When communicating plans or status of a project.
- When the steps of the project or process, their sequence and their duration are known.
- When it’s not necessary to show which tasks depend on completion of previous tasks.

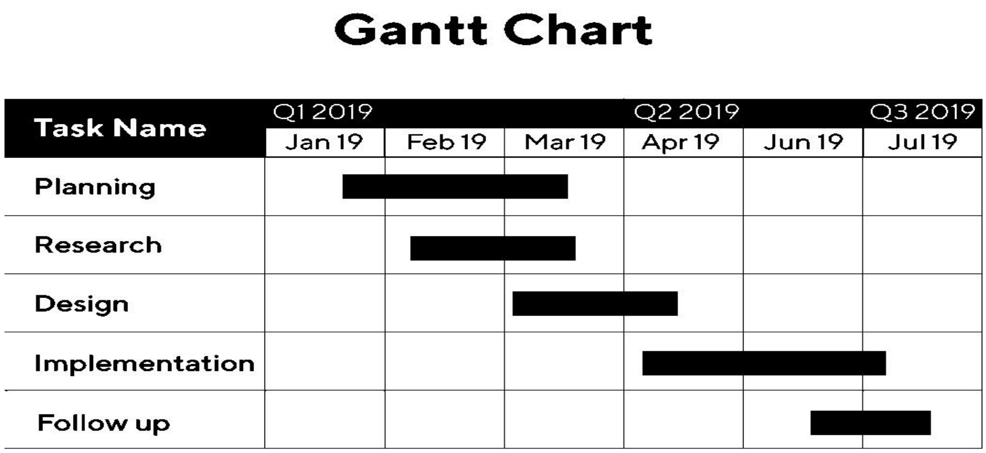
Gantt chart Construction

1. Identify tasks:

- Identify the tasks needed to complete the project.
- Identify key milestones in the project by brainstorming a list, or by drawing a flowchart, storyboard or arrow diagram for the project.
- Identify the time required for each task.
- *Identify the sequence:* Which tasks must be finished before a following task can begin, and which can happen simultaneously? Which tasks must be completed before each milestone?

2. Draw a horizontal time axis along the top or bottom of a page. Mark it off with an appropriate scale for the length of the tasks (days or weeks).
3. Down the left side of the page, write each task and milestone of the project in order. For events that happen at a point in time (such as a presentation), draw a diamond under the time the event must happen. For activities that occur over a period of time (such as developing a plan or holding a series of interviews), draw a bar that spans the appropriate times on the timeline: Align the left end of the bar with the time the activity begins, and align the right end with the time the activity concludes. Draw just the outlines of the bars and diamonds; don’t fill them in.
4. Check that every task of the project is on the chart.

Fig-11.1 Example of Gantt chart



JOB SEQUENCING RULES

Johnson's Rule

In operations research Johnson's Rule is a method of scheduling a number of jobs on two successive work centers. The primary objective of Johnson's Rule is to find an optimal sequence of jobs to reduce makespan (the total amount of time it takes to complete all jobs). It also reduces the amount of idle time between the two work centers.

Before the technique can be applied, several conditions need to be in place:

1. The time for each job must be constant.
2. The job times must be mutually exclusive of the job sequence.
3. All jobs must go through the first work center before going through the second work center.
4. There must be no job priorities.

Objectives of Johnson's Rule

- To minimize the processing time for sequencing a group of jobs through two work centers.
- To minimize the total idle times on the machines
- To minimize the flow time from the beginning of the first job until the end of the last job

Conditions for the Johnson's Rule

In order for the technique to be used, several conditions must be satisfied:

- Job time(including setup and processing) must be known and constant for each job at each work centre
- Job times must be independent of the job sequence.
- All jobs must follow the same two-setup work sequence.
- Job priorities cannot be used.

Johnson's Rule is illustrated as follows:

1. List the jobs and their times at each work center.
2. Select the job with the shortest time. If the job is for the first work center, then schedule the job first. If that job is for the second work center, then schedule the job last. Break ties arbitrarily.

Job Times (hours)		
Job	**Work Center A**	**WorkCenter B**
A	3.20	4.20
B	4.70	1.50
C	2.20	5.00
D	5.80	4.00
E	3.10	2.80

1. The smallest time is located in Job B (1.50 hours). Since the time is in Work Center B, schedule this job last. Eliminate Job B from further consideration.

?	?	?	?	**B**

2. The next smallest time is located in Job C (2.20 hours). Since the time is in Work Center A, schedule this job first. Eliminate Job C from further consideration.

C	?	?	?	B

3. The next smallest time after that is located in Job E (2.80 hours). Since the time is in Work Center B, schedule this job last. Eliminate Job E from further consideration.

C	?	?	**E**	B

4. The next smallest time after is located in Job A (3.20 hours). Since the time is in Work Center A, schedule this job first. Eliminate Job A from further consideration.

C	**A**	?	E	B

5. The only job left to consider is Job D.

C	A	**D**	E	B

Illustration:

There are five jobs at a factory. Each job must be processed through two work centers (drill machine and lathe machine). Please indicate the sequence of the job by using the Johnson's Rule.

The time for processing each job is as follows:

Job	Work Centre 1 (Drill)	Work Centre 2 (Lathe)
A	5	2
B	3	6
C	8	4
D	10	7
E	7	12

Solution:

Set the sequence that will minimize the total processing time for the five jobs:

Step 1: The job with the shortest processing time is A, in work centre 2 (with a time of 2 hours). Because it is at the second centre, schedule **A** last.

				A

Step 2: Job **B** has the next shortest time (3).Because that time is the first work center; we should schedule it first and eliminate it from the consideration.

B				A

Step 3: The next shortest time is Job **C** (4) on the second machine. Therefore, place it at last.

B			C	A

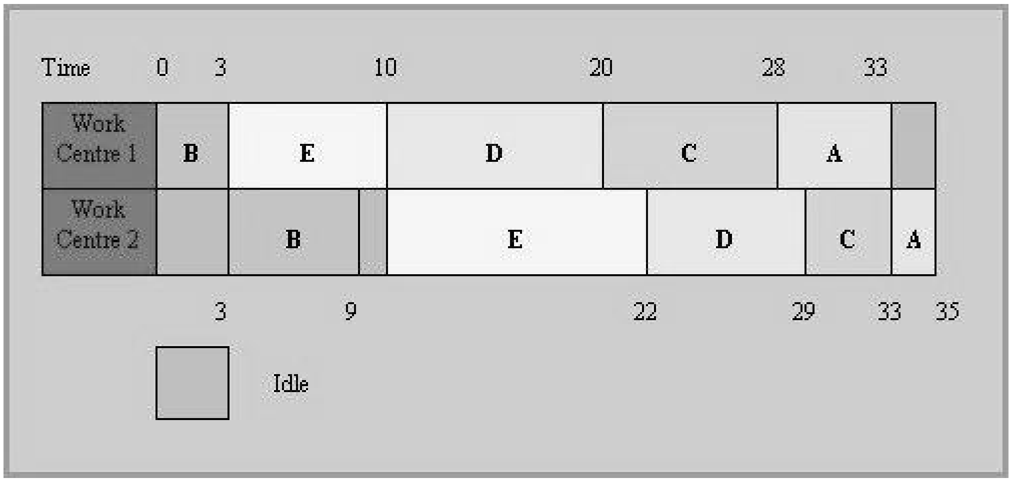
Step 4: There is a tie (at 7) for the shortest remaining job. We can place **E**, which was on the first work center, first. Then **D** is placed in the last sequencing position.

B	F	D	C	A

The sequential times are:

Job	**B**	**E**	**D**	**C**	**A**
Work centre 1	3	7	10	8	5
Work centre 2	6	12	7	4	2

The Time-phased flow of this job sequence is illustrated graphically as below:



QUEUING THEORY

Queuing theory is a branch of mathematics that studies how lines form, how they function, and why they malfunction. Queuing theory examines every component of waiting in line, including the arrival process, service process, number of servers, number of system places, and the number of customers—which might be people, data packets, cars, or anything else.

Real-life applications of queuing theory cover a wide range of businesses. Its findings may be used to provide faster customer service, increase traffic flow, improve order shipments from a warehouse, or design data networks and call centers.

Queuing theory is powerful because the ubiquity of queue situations means there are countless and diverse applications of queuing theory. Queuing theory can be applied in the areas such as telecommunications, transportation, logistics, finance, emergency services, computing, industrial engineering, project management, etc.

Terms used in Queuing Theory

- *Customer:* Customers may either be a person or a machine or other items which are arriving to avail some service.
- *Service Stations:* It is a point where service is provided. It can be one or more service station.
- *Waiting Time:* The time that the customer spends in the queue before being serviced
- *Time Spent by a Customer in the System:* It is equal to the waiting time of the customer plus the service time.
- *Number of customers in the system:* It is equal to the sum of number of customers in queue and the number of customers being served.
- *Queue Length:* Number of customers waiting in the queue comprises the queue length.
- *Jockeying:* Joining the other queue and leaving the first queue.
- *Reneging:* Joining the queue and leaving it afterwards.
- *Balking:* Customers decide not to join the queue.
- *Queueing System:* It is the system consisting of arrival of customers, waiting in queue, picking up for service, according to a certain discipline, being serviced and departure of customers.

ELEMENTS OF QUEUING SYSTEM

The input (arrival pattern):

The input describes the way in which the customers arrive and join the system. We cannot predict the arrival time of customers randomly. It is characterized by its size, arrival time, distribution of customers, mean time between intervals, and attitude of customers. Mean time is often represented by Greek letter **λ** known as LAMBDA. Mean time between arrivals is represented by **1/λ.**

Service Mechanism

- It is understood as the arrangement of service facility to serve the customers. If there are infinite numbers of servers, then all the customers are served instantaneously on arrival, and there will be no queue.
- If the numbers of servers are finite, then the customers are served according to the specific order with service time a constant or a random variable.
- The average number of customers being served in one unit of time at a service station is often denoted by the Greek letter **μ.**
- Average time taken to service a customer is represented by **1/μ.**

Queue Discipline

It is a rule according to which the customers are selected for the service when a queue has been formed. The common disciplines are:

1. First Come First Served (FCFS)
2. First in First out (FIFO)
3. Last in First Out (LIFO)
4. Selection for Service in Random Order (SIRO)

Output of the Queue

- Generally this factor is not important, but in some cases it may influence the service/arrival rate.
- For example, if there is only one door through which people enter and leave after being served, it is possible that people leaving could affect the rate of arrival.

Importance of Queuing Theory

- Waiting in line is a common occurrence in everyday life because it serves various key functions as a process. When there are limited resources, queues are a fair and necessary manner of dealing with the flow of clients. In the absence of a queuing process to deal with overcapacity, bad things happen.
- For example, if a website has too many visitors, it will slow down and fail if it does not include a mechanism to adjust the speed at which requests are processed or a mechanism to queue visitors. Consider planes waiting to land on a runway. When there are too many planes to land at once, the lack of a queue has actual safety issues when jets try to land at the same time.
- Queuing theory is significant because it helps to describe queue characteristics such as average wait time and gives tools for queue optimization.
- Queuing theory influences the design of efficient and cost-effective workflow systems from a commercial standpoint.

CRITICAL RATIO METHOD

In addition to variance analysis and earned value analysis, another tool for project control is the Critical Ratio analysis.

The critical ratio CR= CPI x SPI.

The ideal CR will be 1.0. Ratios greater than 1.0 imply project doing well on both cost and schedule while ratios below 1.0 imply poor performance**.**

Discussion Forum

Short Questions

1. Define Scheduling.
2. Mention ay 4 performance measures used in operations scheduling.
3. Write any two differences between forward and backward scheduling process.
4. What is job shop scheduling?
5. What is Gantt chart?
6. Mention the objectives of Johnson’s rule.
7. Define loading.
8. Define routing.

Essay Type Questions

1. Illustrate Johnson’s rule of sequencing.
2. Discuss the various types of scheduling activities in operations management.
3. When will you use Gantt Charts?
4. What are the various sequencing rules?
5. Explain the elements of queuing system.
6. Illustrate the various rules in dispatching unction.

CHAPTER-12

PURCHASING

INTRODUCTION

Purchasing is the act of buying the goods and services that a company needs to operate and/or manufacture products. Given that the purchasing department of an average company spends an estimated 50 to 70 percent of every revenue dollar on items ranging from raw materials to services, there has been greater focus on purchasing in recent years as firms look at ways to lower their operating costs. Purchasing is now seen as more of a strategic function that can be used to control bottom-line costs. Companies are also seeking to improve purchasing processes as a means of improving customer satisfaction.

Purchasing and procurement are used to denote the function of and the responsibility for procuring materials, supplies, and services. Procurement is the process of finding and agreeing to the terms and acquiring goods, services, or works from an external source, often via a tendering or competitive bidding process. Recently, the term "supply management" has increasingly come to describe this process as it pertains to a professional capacity.

Purchasing is the act of acquiring a good or service and how a procurement manager goes about paying for something. This process involves:

- Spend requests and purchase approvals.
- Creation of a purchase order.
- Receiving and checking goods and services.
- Attaching a packing slip to a purchase.
- Passing the completed purchase to the accounts payable team.

PROCUREMENT

Procurement is the act of obtaining goods or services, typically for business purposes. Procurement is most commonly associated with businesses because companies need to solicit services or purchase goods, usually on a relatively large scale.

Procurement generally refers to the final act of purchasing, but it can also include the procurement process overall which can be critically important for companies leading up to their final purchasing decision. Companies can be on both sides of the procurement process as buyers or sellers, though here we mainly focus on the side of the soliciting company.

Definition of Procurement

According to John, Chandra, Tim defined that, procurement includes sourcing and purchasing and covers all of the activities involved in the product/ service sourcing, purchasing and delivery from the supplier to the customer.

Procurement Vs Purchasing

Procurement and purchasing are two processes that are done during the process of acquiring goods and services for an organization. However, they vastly differ in their method and approach.

Procurement	Purchasing
Activities related to acquiring goods and services	Functions associated with buying goods and services
Steps that happen before, during, and after purchase	The straightforward process of purchasing commodities
Used in a production environment (internal process)	Used in a wholesale environment (external process)
Puts more importance on an item's value than its cost	Tends to focus more on the item's price than its value
Refers to a set of tasks that spot and fulfill needs	Refers to the specific task of committing expenditure
Includes need recognition, sourcing, and contract closure	Includes ordering, expediting, and payment fulfillment
Follows a proactive approach to spot and fulfill needs	Follows a reactive approach to satisfy internal needs

SUPPLY MANAGEMENT

The term supply management refers to the act of identifying, acquiring, and managing resources and suppliers that are essential to the operations of an organization. Supply management includes the purchase of physical goods, information, services, and any other necessary resources that enable a company to continue operating and growing.

Most people consider supply chain management as the way corporations buy raw materials and finished goods. But supply management is more than simply buying products and contracting for services. It is a systematic business process that goes further than procurement to include the coordination of pre-production logistics and inventory management, along with budgeting, employees, and other key information to keep the business running smoothly.

The main goals within supply management are cost control, the efficient allocation of resources, risk management, and the effective gathering of information to be used in strategic business decisions.

PURCHASING

Purchasing is a process in inventory management focused on buying raw materials, goods and services. Purchasing includes supplier research, discussing prices, getting contracts, payments, supplier relationship management and enhancement of existing purchasing systems. The purchasing process is of importance because it is used to identify user requirements, effectively and efficiently and evaluate the need, identify suppliers, ensure the payment occur promptly and drive continuous improvement. Buying of inventory is usually driven by the purchasing department.

Definitions of Purchasing

- According to Lysons**,** "Purchasing is that function responsible for obtaining by purchase, lease or other legal means, equipment, materials, supplies and services required by an undertaking for use in production".

- According to Bailey and Farmer**,** "Purchasing is the procurement of right quality of material, at the right time in the right quantity, from the right source at the right price".

From the above definitions, some key variables or elements are noted:

- Right Quality: To purchase the right quality of materials.
- Right Quantity: To purchase the materials in right quantity.
- Right Time: To make the materials available at the right time.
- Right Price: To purchase the material at the right price.
- Right Source: To purchase the materials from the right source.

Objectives of Purchasing

Following are the objectives of purchasing:

1. To pay reasonably low prices for the best values obtainable, negotiating and executing all company commitments.
2. To keep inventories as low as is consistent with maintaining production.
3. To develop satisfactory sources of supply and maintain good relations with them.
4. To secure better vendor performance, including prompt deliveries and acceptable quality.
5. To locate new materials or products as required.
6. To develop good procedures, together with adequate controls and purchasing policy.
7. To implement such programmes as value analysis, cost analysis, and make-or-buy to reduce cost of purchases.
8. To secure, high caliber personnel and allow each to develop to his maximum ability.
9. To maintain as economical a department as is possible, commensurate with good performance.
10. To keep top management informed of material development which could affect company profit or performance.
11. To achieve a high degree of co-operation and coordination with other departments in the organization.

TYPES OF PURCHASING

Organizations buy many different goods and services. The challenge of purchasing is deciding on the supplier that offers the best opportunity for items an organization must purchase externally.

CENTRALIZED AND DECENTRALIZED PURCHASING

Centralized Purchasing

When all types of purchases are done at one level, it is known as centralized purchasing. A separate department, known as purchase department, is set up for this purpose. All departments send their purchase requirements to purchase department and it arranges procurement of various goods needed.

Decentralized Purchasing

This type of purchasing is suitable for concerns or when there is more than one plant or the plants are situated at different places. Every department or plant, as the case may be, is authorized to make its own purchases. A separate purchasing agent is appointed for every department or plant. To enforce general purchasing policies all the purchasing agents are put under the in-charge of general purchasing agent. He gets periodical reports from all purchasing agents. This helps in exercising control over materials. This system has some advantages as well as disadvantages.

The various types of purchase include the following:

a. Purchasing according to the requirements

This method is appropriate for items which are not used regularly in the production process. These items are generally not stored in inventories. The purchasing department should keep a record of reliable and trustworthy suppliers who were sincere to the organization in the past.

b. Purchasing for some definite future period

This method of purchasing is generally used for those items which are regularly consumed. The consumption of items should be comparatively low and the price changes for these items should be less.

c. Market Purchasing

It is the purchase of goods usually in smaller quantities or in an emergency without contract or negotiations.

d. Speculative Purchasing

When purchasing is done purely from the point of view of taking advantage of a speculated rise in the price of the commodity, it is called speculative purchasing. The intent is not to buy for the internal consumption, but to resell the commodity at a later date when the prices have gone up and to make a profit by selling. The items may be those that are needed for internal consumption, but the quantity shall be much more than the requirement so as to take the advantage of the coming price rise.

e. Contract Purchasing

In this type of purchasing, the purchase department enters into agreement with various suppliers to supply the items at some future period periodically. Here a purchaser agrees to buy goods to be paid for in a series of installments, each comprising a proportion of the capital and an interest element. After the final payment, legal ownership passes to the user.

f. Scheduled Purchasing

In this type of purchasing, the purchasing is scheduled according to the various departments or of the organization.

Table-12.1 Different Types of Purchases

Type of Purchase	Description	Examples
Raw materials	Items with a lack of processing by the supplier into a newly formed product. Often these raw materials are not of equal quality and are purchased by "grade."	Petroleum, coal, lumber, copper, zinc, gold, and silver

Type of Purchase	Description	Examples
Semi-finished products and components	All items purchased from a supplier required to support an organization's final that are production.	Components, subassemblies, assemblies, subsystems, and systems (seat assembly, steering assembly, doors, and posts)
Finished products	Products for internal use or products that require no major processing before resale to the end customer.	Furniture, computers, cars, and carts
Maintenance, repair, and operating items (MRO)	Items that do not go directly into an organization's product but are required to run the business.	Spare parts, office and cleaning supplies
Production support items	Materials required for packaging and shipping.	Tape, bags, inserts, and shrink-wrap
Services	Services are required to support the facility or business.	Customer support, temporary labor, facilities, and legal
Capital equipment	Assets intended to be used for more than one year.	Machinery, computer systems, and material-handling equipment
Transportation and third-party purchasing	A specialized type of service buying to manage inbound and outbound material flows.	Rail, truck, ocean, 3PL, and multimodal

STRATEGIC AND TRANSACTIONAL PURCHASING

Strategic Purchasing

Strategic purchasing is a process that develops supply relationships between manufacturers, suppliers and retail businesses. Fully integrating strategic purchasing activities in the company's business management plan is the best way to ensure that company has the products consumers are looking for. Usually, strategic purchase is crucial to the support of the firm's distinctive competence. This generally includes raw material and components normally used in the production process.

Strategic purchasing enables firms to foster close working relationships with a limited number of suppliers, promotes open communication among supply chain partners, and develops a long-term strategic relationship orientation for the achievement of mutual goals. This implies that strategic purchasing plays a synergistic role in fostering value-enhancing relationships and knowledge exchange between the firm and its suppliers, thereby creating value. In addition, supply managers are heavily involved in cross-functional teams charged with determining supplier qualification and selection, as well ensuring early supplier involvement in product design and specification development.

Transactional Purchasing

Transactional (indirect) buying involves repetitive purchases, from the same vendor, probably through a blanket purchase order. These orders could include products and services not listed on the bill of materials, but are used indirectly in producing the item.

PURCHASING PROCESS

Purchasing process is divided into the following three phases.

1. Strategic purchasing planning
2. Purchasing execution
3. Purchasing implementation & Monitoring

Table 12.1 Purchasing Process and its Functions

PHASE	FUNCTIONS
Strategic Purchasing Planning	Internal Assessment Specification Development External Assessment Category planning Purchasing strategy development
Purchasing Execution	Supplier Search Supplier evaluation Bidding, Negotiation & Supplier Selection Purchasing approval and award contracts development
Purchasing Implementation and Monitoring	Implementation plan development Supplier performance measurement Supplier performance evaluation Implementation evaluation / improvement

STRATEGIC PURCHASE PLANNING

Strategic purchase planning begins with an internal assessment about the firm's core competencies, current product specifications, current supply base and portfolio, as well as further portfolio optimization opportunities. During the specification development phase buyers update what they need to deliver to the market and what they require from the supplier, establish the purchasing team and finally make an agreement on the purchasing specifications. It is followed by external assessment, including supply market analysis and investigation of suppliers' distribution, the total cost of ownership and competitors. After the internal and external assessment is made, the quantity of required items and spent volume can be planned. Thus the firms' market and bargaining position can be assessed and then, an appropriate strategy can be developed.

PURCHASING EXECUTION

The first step in purchasing execution phase is to search for suppliers. The buyers prepare a list of all potential suppliers by developing supplier pre-qualification criteria and Request for Information (REI). It is sent to reference organizations for assessment and finally the candidate supplier list is compiled.

Then supplier evaluation is done, where the buyer develops and releases a Request for Quotation (REQ) to candidate suppliers. The buyers conduct analysis of the offers received from the suppliers and also perform audits or even conduct on-site visits. Suppliers are selected on the basis of decision making tools like bidding and negotiations.

The buyer and supplier make final agreements through the bidding and various rounds of negotiation. Finally the buyer approves the purchasing and awards contracts.

PURCHASING IMPLEMENTATION AND MONITORING

The process begins with the development of the implementation plan which involves the internal communication with internal customers and external communication with suppliers. Subsequently the target performance level and actual performance level are identified for achieving the performance measurement and evaluation. Performance measurement and evaluation performance measurement can result in better communication, both within the buying company and between the buyer and the supplier. Finally, performance feedbacks are reported to internal customers and management level will as to suppliers.

PURCHASE MANAGEMENT

Purchase management defines the acquisition of various goods and services from the outside network. It is a routine function of any organization that also serves as one of the business's strategic avenues. Purchase management brings efficiency and effectiveness to the system of purchases. It is followed by the management and thereby assisting in carrying out the process of manufacturing.

Definitions

"Purchasing management is an activity that goes beyond the simple act of buying. It includes research and development for the proper selection of materials and sources, follow-up to ensure timely delivery, inspection to ensure both quantity and quality, and controlling traffic, receiving, store keeping and accounting operations related to purchases."

– J. H. Westing, L. V. Fine, Gary Joseph Zenz

Objective of Purchase Management

The objectives of purchase management are listed as follows:

- To keep department expenses low
- Development of goods & new vendors (suppliers)
- Development of good relation with the existing suppliers
- Training & development of employees in department
- To maintain proper & up-to-date records of all transactions
- Participating in the development of new material and products
- To contribute in product improvement
- To avoid Stock- out situations
- To develop policies & procedure

FUNCTIONS OF PURCHASE MANAGEMENT

The purchase management has the following functions:

1. Receive Purchase Request

- It is the starting point of procurement activity.
- It is the Statement of requirement of Production.

2. Review and evaluate requisitions

Purchase Department reviews the following:

- Item description
- Quantity
- Estimated purchase price or last purchased price
- Consumption pattern in the last 3 years
- When the material is required

3. Supplier selection

The supplier selection is done in this stage. It involves the following activities:

- Deciding on the mode of procurement
- Invitation to tender is issued

4. Scrutiny of offers

- Reply of a supplier to the invitation to tender is called an Offer.
- An offer is scrutinized for its specifications, price and other terms and conditions.

5. Order placement

- The purchasing department selects the supplier and place order.

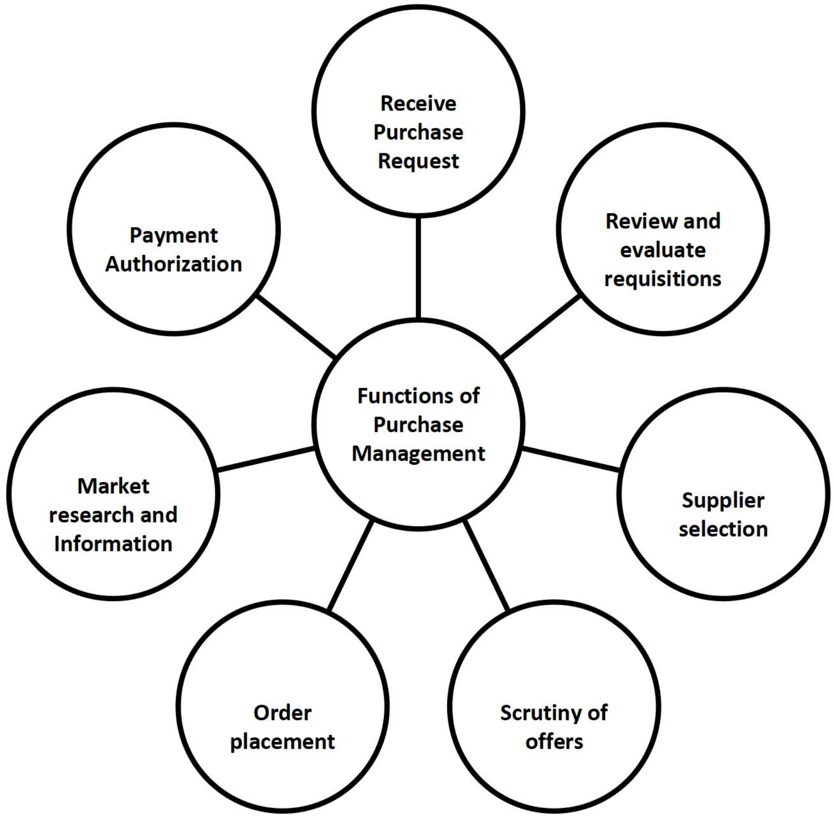
6. Market research and Information

- Discussions and meetings between supplier representatives are conducted to collect the information regarding the requirement.
- Keeps in check, the latest developments with respect to the company and its product
- Studies new developments in production materials and processes

7. Payment Authorization

- Ensuring all goods are delivered before payment is made

Fig- 12.1 Functions of Purchase Management



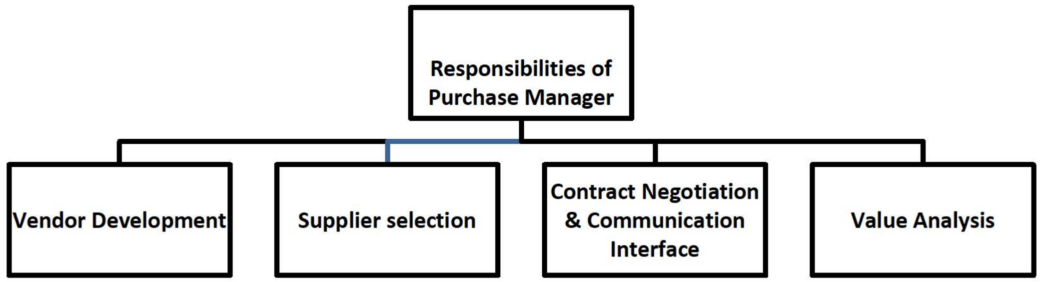
RESPONSIBILITIES OF PURCHASING MANAGER

A purchase manager should not only buy a product at the lowest price but also should be a knowledgeable person who understands design, Engineering, Production, Marketing and other related functions. Hence a purchase manager should know all the information about the internal operations of the information about the external supply market, and to combine these two in procuring materials at the right quantity, quality, time and cost. A purchase manager cannot always be the final decision maker regarding the quality, quantity time or cost of the materials. Purchase manager should serve as a liaison between various departmental managers, and external environment, therefore he acts as an advisor or an informer to various departments and overcome the conflicting opinions / objectives both inside and outside the company.

The purchase manager is responsible for the following activities:

- Vendor Development
- Supplier selection
- Contract negotiation and communication interface
- Value Analysis

Fig- 12.2 Responsibilities of Purchase Manager



VENDOR DEVELOPMENT

A vendor relation is another important objective of purchase management. The management must maintain a good relation with vendors and should not forget that they are the asset for the organization. The purchase manager should ensure the right selection of vendors from the available list of suppliers who are capable of supplying the products according to the firm's expectation. The purchase manager should collect the information regarding the suppliers, products and their services from the available sources such as yellow pages, newspapers, websites, business journals, etc. after creating a database of vendors, the purchase manager select the right vendor for the supplies by assessing the specifications and quality of the products. The manager should also ensure that the sources of supplies are stable, reliable and capable of fulfilling the cost and quantity requirements of the firm time to time.

A good personal and professional relationship has to be maintained by management through the following ways:

- Helping the vendor during their financial & technical problems
- Maintaining a healthy professional relationship with proper negotiations, evaluation & compensations

SUPPLIER SELECTION

The purchase manager selects the appropriate vendor through the following steps.

- The manager develops a list of suitable suppliers and gets the quotation for the materials to be supplies with them.
- After obtaining the quotations from the vendors the manager examines the cost of the products and other aspects such as delivery charges, discount structure and supplementary charges like taxes payable.
- The ability of the vendor to deliver the items in the required quantity and quality is measured by the manager.
- Then finally the vendor is selected and the order is passed to him. The purchasing manager can use the vendor rating methods to select the suppliers.

CONTRACT NEGOTIATION AND COMMUNICATION INTERFACE

After the selection of the vendor, the purchase manager negotiates with the selected vendor and establishes the terms and conditions for formulating the agreement. The terms include issues like the price of the items, quality and other performance standards, technical specifications, deliver schedules, freight payments, etc. the major objectives of negotiation is to make the economical purchases and to establish and maintain a long term relationship with the vendors.

The purchase department acts an interface between the indenting departments and the suppliers. The communication between the various departments and the pure suppliers is channeled through the purchase manager.

VALUE ANALYSIS

Value Analysis can be used by the purchase managers to make decisions regarding the proper substitutes or raw materials used.

- It is systematic method, thinking about substitutes.
- It is basically consists of studying in detail about the 'value' of the material.
- The value of the product /materials can be due to functional characteristics / performance or may be due to 'Esteem' value

The value analysis is an organized effort that studies in detail the value of the item or material. Value analysis review the design changes with the objective of eliminating high-cost materials and the technologies that had become obsolete and also reducing the number of parts.

The purchase managers collect information relating to raw materials and finished products such as cost, manufacturing process, performance characteristics, etc. Then the functions of the products are listed out and classified into primary and secondary. After analyzing the product with the above criteria the purchase manager evaluates the possibility of using alternate material.

Stages of value Analysis

The following are the different stages of value Analysis:

1) Information Stage:

In this stage, all relevant information regarding the raw materials and finished products is gathered. The information includes:

- Cost of materials
- Manufacturing Method / Technology / Process
- Performance Characteristics

2) Functional Analysis:

At this stage, the functions of the materials are explored and listed on basis of basic and secondary functions. Then each of these functions is given value points / weightages on the basis of its importance or desirability. Simultaneously the cost incurred in incorporating the each function in that material /product is also listed. Now the cost included and value points are compared and the area of the product, where much cost is spent for little values is identified. Higher cost-to-worth function is identified and substitute designs are developed. If the valued of a function is very small, in that case the function can be dropped in the substitute product.

3) Brain Storming:

The main idea behind this stage is to increase creativity among the executives to identify the alternative possibilities for the material. All the ideas and suggestions are recorded irrespective of feasible and non-feasible one.

4) Evaluation Phase:

The ideas recorded during the brainstorming session are evaluated in terms of functional analysis. This analysis is carried out till we get a better alternative which might offer similar functional value as the original material, but at reduced cost.

5) Implementation:

This is the last phase of the process and here all the new ideas and identified substitutes are discussed with the respective departments regarding their implement ability. Thus the purchase manager is able to identify the substitutes of equal functional value at the reduced procurement cost.

VENDOR SELECTION AND RATING

Selection of the suitable supplier is both a right as well as a responsibility of the purchase department. It is a continuous process and the decision taken regarding vendor selection is not taken once and is a complex one. We cannot always decide that the supplier bidding the lowest price is the best supplier. Many economic and non-economic factors are considered while evolving the optimum decision.

The selection of supplier of standardized products will differ substantially from that of non – standardized products.

Identification of sources of suppliers:

1. The purchase department should be familiar with all possible sources of supply of various types of material. The stage is also known as ‘survey stage’.
2. Following sources of supply:
3. Specialized trade directors
4. Regional directories of chambers of commerce or such organizations
5. Assistance of professional bodies or consultants
6. The purchases hand book or buyers guide
7. Manufactures and distributors catalogue
8. The advertisement in dailies, mails, etc.
9. The new product and process announcements as published in dailies
10. Trade fair exhibitions
11. Film slide or movie

The survey stage is done by the purchase department, in consultation with other departments to generate more suppliers.

Development of approval list of suppliers:

After survey stage, the inquiry stage is carried and based upon that a short listing is done. The short listing is made out of the given source of suppliers in terms of:

- Production facilities and capacity
- Financial position
- Product quality
- Possibility of timely supply
- Technical competence

- Manufacturing efficiency
- Policies
- Competitive attitude

The objective of the inquiry stage is to locate the suppliers who are capable of supplying the material in the required quality and quantity, at the right time and price and from the right source. For critical items involving huge economic values and high degree of technicality, the evaluation and selection of the prospective supplier will be made in a group decision. The group / supplier survey team should department, engineering department, quality control department R&D department. Finally an approved list of suppliers is prepared and there must be more than our vendor to facilitate competitive advantage.

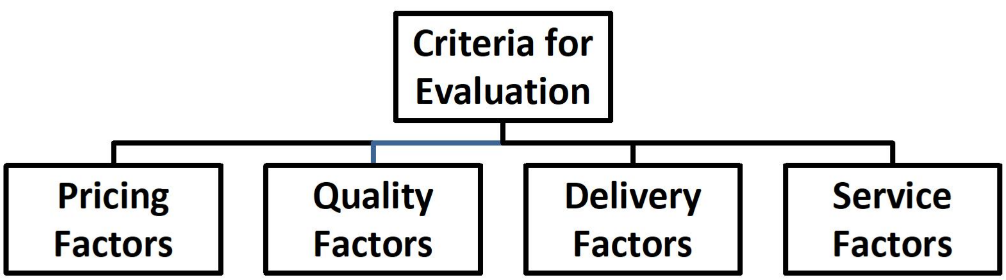
EVALUATION AND SELECTION OF SUPPLIERS

The evaluation and selection of the supplier differ according to the type of material purchased. The bids are invited from the approved suppliers of the material to be purchased along with required time, mode of payment, etc.

CRITERIA FOR EVALUATION

Vendor performance is usually evaluated in the areas of pricing, quality, delivery, and service. Each area has a number of factors that some firms deem critical to successful vendor performance.

Fig- 12.3 Criteria for Evaluation of vendor performance



Pricing Factors

Competitive pricing: The prices paid should be comparable to those of vendors providing similar product and services. Quote requests should compare favorably to other vendors.

Price stability: Prices should be reasonably stable over time.

Price accuracy: There should be a less number of variances from purchase order prices on the invoiced received.

Advance notice of price changes: The vendor should provide adequate advance notice of price changes.

Sensitive to costs: The vendor should demonstrate respect for the customer firm's bottom line and show an understanding of its needs. Possible cost savings could be suggested. The vendor should also exhibit knowledge of the market and share this insight with the buying firm.

Billing: Are vendor invoices are accurate? The average length of time to receive credit memos should be reasonable. Estimates should not vary significantly from the final invoice. Effective vendor bills are timely and easy to read and understand.

Quality factors

Compliance with purchase order: The vendor should comply with the terms and conditions as stated in the purchase order. Does the vendor show an understanding of the customer firm's expectations?

Conformity to specifications: The product or service must conform to the specifications identified in the request for proposal and purchase order. Does the product perform as expected?

Reliability: Is the rate of product failure within reasonable limits?

Reliability of repairs: Is all repair and rework acceptable?

Durability: Is the time until replacement is reasonable?

Support: Is quality support available from the vendor? Immediate response to and resolution of the problem is desirable.

Warranty: The length and provisions of warranty protection offered should be reasonable. Are warranty problems resolved in a timely manner?

State-of-the-art product/service: Does the vendor offer products and services that are consistent with the industry state-of-the-art? The vendor should consistently refresh product life by adding enhancements. It should also work with the buying firm in new product development.

Delivery factors

Time: Does the vendor deliver products and services on time; is the actual receipt date on or close to the promised date? Does the promised date correspond to the vendor's published lead times? Also, are requests for information, proposals, and quotes swiftly answered?

Quantity: Does the vendor delivers the correct items or services in the contracted quantity?

Lead time: Is the average time for delivery comparable to that of other vendors for similar products and services?

Packaging: Packaging should be sturdy, suitable, properly marked, and undamaged. Pallets should be the proper size with no overhang.

Documentation: Does the vendor furnish proper documents (packing slips, invoices, technical manual, etc.) with correct material codes and proper purchase order numbers?

Emergency delivery: Does the vendor demonstrate extra effort to meet requirements when an emergency delivery is requested?

Service factors

Good vendor representatives have a sincere desire to serve: Vendor reps display courteous and professional approach, and handle complaints effectively. The vendor should also provide up-to-date catalogs, price information, and technical information. Does the vendor act as the buying firm's advocate within the supplying firm?

Inside sales: Inside sales should display knowledge of buying firm's needs. It should also be helpful with customer inquiries involving order confirmation, shipping schedules, shipping discrepancies, and invoice errors.

Technical support: Does the vendor provide technical support for maintenance, repair, and installation situations? Does it provide technical instructions, documentation, and general information? Are support personnel courteous, professional, and knowledgeable? The vendor should provide training on the effective use of its products or services.

Emergency support: Does the vendor provide emergency support for repair or replacement of a failed product?

Problem resolution: The vendor should respond in a timely manner to resolve problems. An excellent vendor provides follow-up on status of problem correction.

E-PURCHASING AND E-PROCUREMENT

The Internet and e-commerce are drastically changing the way purchasing is done. Internet use in buying has led to the terms "e-purchasing" or "e-procurement." Certainly, communication needed in competitive bidding, purchase order placement, order tracking, and follow-up are enhanced by the speed and ease afforded by establishing online systems. In addition, negotiation may be enhanced and reverse auctions facilitated. Reverse auctions allow buying firms to specify a requirement and receive bids from suppliers, with the lowest bid winning.

E-procurement is considered one of the characteristics of a world-class purchasing organization. The use of e-procurement technologies in some firms has resulted in reduced prices for goods and services, shortened order-processing and fulfillment cycles, reduced administrative burdens and costs, improved control over off-contract spending, and better inventory control. It allows firms to expand into trading networks and virtual corporations.

Criteria for e-purchasing include:

- Supporting complete requirements of production (direct) and non-production (indirect) purchasing through a single, internet-based, self-service system.
- Delivering a flexible catalog strategy.
- Providing tools for extensive reporting and analysis.
- Supporting strategic sourcing.
- Enhancing supply-chain collaboration and coordination with partners.

Discussion Forum

Short Questions

1. Define Procurement.
2. List down the difference between procurement and purchase.
3. Summarize the importance of purchasing in forms.
4. What is supply management?
5. Differentiate between centralized and decentralized purchasing.
6. Mention the objectives of purchasing.
7. What is purchase management?
8. What is e-procurement?
9. Define Value analysis.

Essay type Questions

1. Explain the different phases of purchase process.
2. Explain the various types of purchasing.
3. What do you mean by strategic and transactional purchasing?
4. Discuss the functions of purchase manager.
5. Illustrate the criteria for evaluating the vendors.
6. Discuss the different stages of Value Analysis.

CHAPTER-13

MATERIAL HANDLING

INTRODUCTION

Material handling refers to the movement, storage, protection and control of the materials as well as the products through the process manufacturing, warehousing, distribution, consumption and disposal. Material handling as a process blends a wide range of manual, semi-automated and automated equipment and systems which provide support to the logistics and make the supply chain function. The focus is on the methods, mechanical equipment, systems and related controls used to achieve these functions. An organization material handling system and processes is incorporated with the aim of improving customer service, reducing Inventory, shortening delivery items, and lowering overall handling costs in manufacturing, distribution and transportation. Their application is helpful for:

1. Forecasting.
2. Resource allocation.
3. Production planning.
4. Flow and process management.
5. Inventory management and control.
6. Customer delivery.
7. After sales support and service.

Definition

1. "Material handling embraces the basic operations in connection with the movement of bulk, packaged and individual products in a semi-solid or solid state by means of gravity manually or power-activated equipment and within the limits of individual producing, fabricating, processing or service establishments."

-Haynes

DIMENSIONS OF MATERIAL HANDLING

Material handling process has four dimensions that impact the efficient product flow through the warehouse: Movement, Time, Quantity, and Space.

1. *Movement:* Moving product from Receiving to Outgoing
2. *Time:* The life of products lives in storage, receipt of inventory-to-shipment time frame
3. *Quantity:* Amount of products that can be stored in the allotted space
4. *Space:* Amount of space that is allotted or available

OBJECTIVES OF MATERIAL HANDING

The common hand shovel and the baskets were the only material handling tools, until some years ago, but now due to increasing demand for sophisticated handling equipment, material handling system has been revolutionized throughout the world.

The main objective of the efficient materials handling is to decrease the costs. Materials handling equipment does not come under the production machinery, but is an auxiliary equipment which can improve the flow of materials which in turn shall reduce the stoppages in production machines and thus increases their production**.** Material handling aims at:

(1) Costs Reduction by:

- Decreasing inventory level.
- Utilising space to better advantage.
- Increasing productivity.

(2) Waste Reduction by:

- Eliminating damage to material during handling.
- Being flexible to meet specific handling requirements of different nature.
- Making proper control over stock during in and out handling.

(3) Improve Productivity by:

- Increasing productivity per man-hour.
- Increase in machine efficiency through the reduction of machine downtime.
- Smoothing out workflow.
- Improving production control.

(4) Improve Working Conditions by:

- Providing safe working conditions.
- Reducing worker's fatigue.
- Improving personal comfort.
- Upgrading employees/workers to productive work.

(5) Improve Distribution by:

- Decreasing damage to the products during handling and shipping.
- Improving routing.
- Improving location of the storage facilities.
- Increasing the efficiency of shipping and receiving.

IMPORTANCE OF MATERIAL HANDLING

The success of a business depends on the efficient and safe transportation of their products from one area of the warehouse to another. This is the reason why many large companies consider their warehouse as the hub of their operations. Good material handling is important for the following reasons:

Avoid work place accidents

Mishandling of the equipment can lead to about 21% of permanent disability and 25% of temporary disability are attributed to workplace accidents. To avoid, it is necessary to have trained staff and correct machinery or equipment. It would be helpful in reducing employee injuries and lost sick days.

Efficiency saves money

Efficient equipment and handling tools in the warehouse generally results in less loss of times. Employees will not waste time in searching for the products. This would lead to reduced expenses thereby results in savings.

Reduces product loss

Product loss or damage is not desirable by any organization as it loads to decrease in the profit margin. Product damage or loss can be prevented by implementing good material handling practices in the warehouse.

Importance of warehouse layout

Smart storage techniques increase the safety of employees. In order to facilitate easy material handling and minimize hazardous conditions, an open plan of warehouse is beneficial and most preferable.

Customer service
It is important to provide qualitative, quantitative and speedy delivery of the products to the users. Appropriate material handling contributes in coordinating the warehouse operations.

ADVANTAGES OF MATERIAL HANDLING

The advantages of material handling are given as below:

1. Cost Reduction:

This achieved by

- Decreasing the inventory costs.
- Utilizing the space to better extent.
- Increasing the overall production of the system.

2. Waste Reduction:

This is achieved by:

- Maintaining proper control over, in and out of stock handling.
- Eliminating damage to material during the handling process.
- Providing flexibility to meet the specific handling requirements of all materials.

3. Increased productive capacity:

It is achieved by:

- Improving productivity per man-hour.
- Improving the efficiency of machines by reducing the machine downtime.
- Smoothing out workflow in the plant.
- Improving the production control.

4. Improved working conditions:

These are achieved by:

- Improving the personal comfort.
- Reducing fatigue of workers.
- Proving safer working conditions.
- Upgrading employees for productive work.

5. Improved distribution:

It is achieved by:

- Improved routing.
- Improve location of storage facilities.
- Improving the efficiency of shipping and receiving.
- Reduction in damages of products during handling.

PRINCIPLES OF MATERIAL HANDLING

A material handling system should be able to move and store the material effectively with minimum effort, maximum safety and in the shortest time.

Following are the principles of material handling:

1. *Planning principle:* All material handling activities should be planned.

2. *Systems principle:* Plan system integration with maximum handling activities and coordinating the full scope of operations (receiving, storage, production, inspection, packing, warehousing, supply and transportation).
3. *Space utilization principle:* Make optimum use of cubic space.
4. *Unit load principle:* Increase the quantity, size, weight of load handled.
5. *Gravity principle:* Utilize the force of gravity to move a material wherever practicable.
6. *Material flow principle:* Plan an operation sequence and equipment arrangement to optimize material flow.
7. *Simplification principle:* Reduce, combine or eliminate unnecessary movement and/or equipment.
8. *Safety principle:* Provide scope for safe handling methods and equipment.
9. *Mechanization principle:* Use mechanical or automated material handling equipment.
10. *Standardization principle:* Standardize method, types, and size of material handling equipment.
11. *Flexibility principle:* Use methods and equipment that can perform a variety of task and applications.
12. *Equipment selection principle:* Consider all aspects of material, movements and method to be utilized.
13. *Dead weight principle:* Reduce the ratio of dead weight to payload in mobile equipment.
14. *Motion principle:* Equipment designed to transport material should be kept in motion.
15. *Idle time principle:* Reduce idle time of both material handling equipment and manpower.
16. *Maintenance principle:* Plan for preventive maintenance or scheduled repair of all handling equipment.
17. *Obsolescence principle:* Replace obsolete handling methods or equipment when more efficient method/equipment is required to improve operation.
18. *Capacity principle:* Use handling equipment to help achieve its full capacity.
19. *Control principle:* Use material handling equipment to improve production control, inventory control and other handling.
20. *Performance principle:* Determine efficiency of handling performance in terms of cost per unit handled which is the primary criterion.

SCOPE OF MATERIAL HANDLING

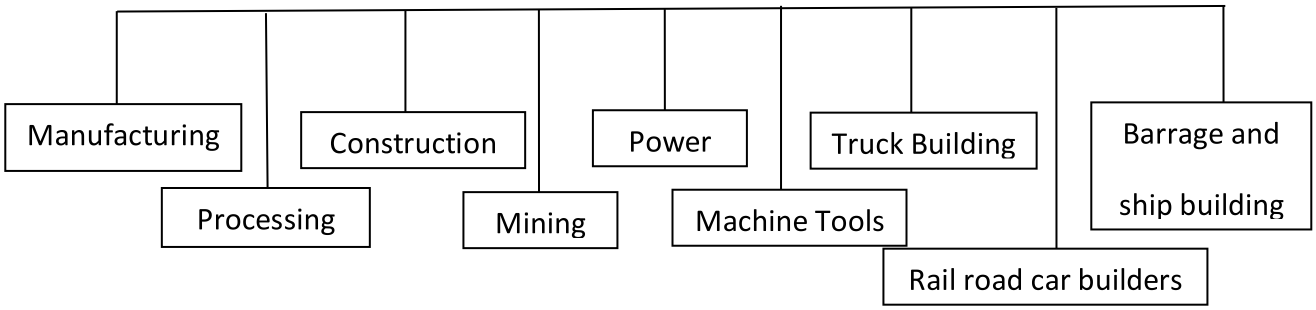
1. Manufacturing

(i). Manufacturing is the largest single field where a wide range of material handling equipment is utilized.
(ii). Material handling problems involve surveys, equipment and plant layouts, routing, packaging of materials and shortage of materials.

2. Processing

(i). The processing requires the handling of bulk materials like-solids, liquid, gases and semi- liquids.
(ii). Plant design can be affected by the special handling problems.

Fig- 13.1 Scope of Material Handling



3. Construction

(i). Construction requires appropriate receiving, sorting, storing and moving materials.

(ii). In case of heavy construction projects, now it is possible to choose special methods and equipment for material handling.

(iii). Civil engineers are influenced by it in project planning.

4. **Mining**

(i). Wide variety of equipment is now available for both underground mines and open pit operations for the task of extraction, handling and transportation of coal and ore.

(ii). The cost of extracting the material has been reduced to the minimum.

5. Power

Material handling equipment is needed for handling fuel and ash in the power generation industry.

6. Machine tools

Now the design of many processing machines is influenced by the need of integrating different material handling features to modern machine mechanisms.

7. Truck building

The automotive engineer develops trucks and trailer as efficient material handling vehicles. These are designed to ensure

- Speedy loading and unloading operations
- Cargo is properly secured
- Safer transportation of a variety of materials

8. Railroad car builders

These are involved in the development of terminal equipment, improved rail road cars, improved material handling process for loading and securing freight and transferring or unloading it at the terminals.

9. **Barrage and ship building**

New handling devices and improved types of marine carriers are manufactured in this industry.

10. Aircraft

Better cargo and storage method for airways where material handling is concerned.

MATERIAL HANDLING EQUIPMENT

Material handling equipment is used for the movement, storage, protection consumption and disposal of materials within a facility or at a site. It surrounds a wide range of tools, vehicles, storage units, appliances and accessories used for transporting, storing, controlling, enumerating and protecting the products at any stage of consumption or disposal.

CATEGORIES OF MATERIAL HANDLING EQUIPMENT

Material handling equipment can be classified into two major categories, namely:

1. Fixed path equipment

Fixed path equipment is equipment which moves in a fixed path. Conveyors, monorail devices, chutes, and pulley drive equipment belong to this category. A slight variation in this category is provided by the overhead crane, which, though restricted, can move materials in any manner within a restricted area by virtue of its design. Overhead cranes have a very good range in terms of hauling tonnage and are used for handling bulk raw materials, stacking and at times palletizing

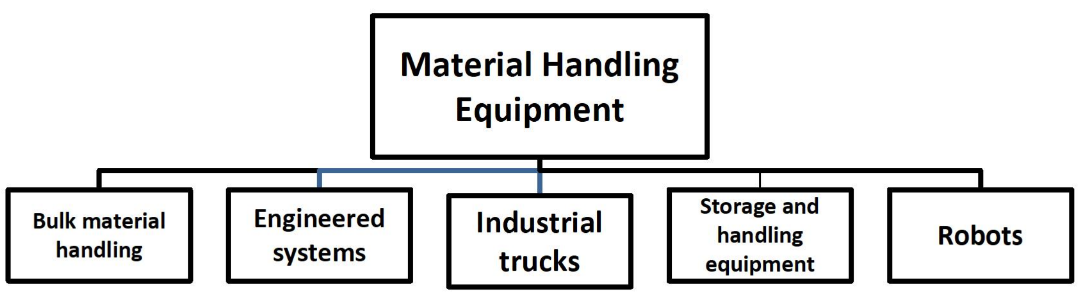
2. Variable Path equipment

Variable path equipment has no restrictions in the direction of movement although their size is a factor to be given due consideration trucks, forklifts mobile cranes and industrial tractors belong to this category. Forklifts are available in many ranges, they are maneuverable and various attachments are provided to increase their versatility.

Material handling equipment is further classified into five main categories such as:

1. Bulk material handling
2. Engineered systems
3. Industrial trucks
4. Storage and handling equipment
5. Robots

Fig- 13.2 Classification of Material Handling Equipment



1. Bulk Handling Material Equipment

The term 'bulk handling equipment' refers to the storage, control and transportation of materials by bulk, and in loose form. There are plenty of examples of this application such as the handling of food, beverages, liquids, metal items (such as screws and nails) and minerals. In general terms, these pieces of equipment primarily handle these items when they are loose. One example is a conveyor belt that is used to move items from one part of the production process to another. Drums and hoppers may be used as well, to 'funnel' these loose items into a stage where they can be more easily manipulated, or packaged.

Conveyor belts are used for horizontal transportation. For vertical transportation, elevators are most commonly used.

Types of bulk handling material equipment

- Bucket and grain elevators
- Conveyor belts
- Hoppers and silos

- Reclaimers
- Stackers

2. Engineered Systems

An engineered system is one that is typically automated. Such systems are also usually created from a variety of units. When combined, they work to enable both storage and transportation. An 'Automated Storage and Retrieval System (AS/RS)' are one example of a system that is engineered. This is a large, automated device that comes complete with racks, shelves and aisles. These storage solutions are accessed by a 'shuttle' i.e. a mechanized device that is similar to a cherry picker. This device can be used by the system operator to manually select the items as needed, or the entire system can be computerized and automated.

An AS/RS can be integrated with a production facility's existing computer network to keep on top of stock control, plus other logistical systems. It can also be integrated with other stages of the production process, so that as much automation can be offered as possible.

Types of engineered systems

- Automated guided vehicles (AGVs)
- Conveyor systems
- Robotic delivery systems

3. Industrial Trucks

Industrial trucks are carriers designed to transport materials within a factory area with maximum flexibility in making moves. Most industrial trucks permit mechanized pickup and deposit of the loads, eliminating manual work in lifting as well as transporting. Depending on their means of locomotion, industrial trucks may be classified as hand trucks or power trucks.

Hand Trucks

Hand trucks with two wheels permit most of the load to be carried on the wheels, but some of the load must be assumed by the operator to balance the truck during movement. Common two wheel hand trucks include the barrel, box, drum, hopper, refrigerator, paper-roll, and tote-box trucks. Four-wheel hand trucks are found in many more varieties, including dollies, high- and low-bed flat trucks, carts, rack carriers, wagons, and various hand-lift trucks having mechanical or hydraulic lifting mechanisms for raising and lowering a load.

Power Trucks

Power trucks are propelled by batteries and an electric-motor drive or by an internal combustion engine, with either a mechanical drive or a generator and electric-motor drive. Diesel engines are used in place of gasoline engines on some types.

- The non-lift platform truck is used simply for hauling, but other power trucks are provided with hydraulic mechanisms for lifting the loads.
- Forklift trucks are equipped with a fork like mechanism on the front end designed to pick up loads on specially designed platforms, called pallets, elevate the load to the desired height, transport it, and deposit it at the desired location and height.
- Ram trucks have a single protruding ram for handling coiled material.
- The crane truck is a portable boom crane mounted on an industrial truck. It may be used with hooks, grabs, and slings for bundled or coiled material.
- The straddle truck resembles a gantry crane on four pneumatic-tired wheels. The operator rides above the inverted U-frame, within which the load is carried on elevating bolsters.

Other types of industrial trucks include:

- Automated guided vehicles (AGVs)

- Hand, platform and pallet trucks
- Order pickers
- Pallet jacks
- Side-loaders
- Walking stackers

4. Storage and Handling Equipment

Equipment that is used for storage usually only encompasses items that are not automated. Storage and handling equipment that is automated falls under the term 'engineered systems'. Storage equipment is used to hold products and materials when they are not being used, or when they are waiting to enter or leave the production process. These periods could be long-term or short-term in order to allow a suitable build-up of stock or finished items.

Storage and handling equipment refers to pallets, racking or shelves. Materials are stored in a neat and convenient manner to await transportation, or their entry into the production process if necessary. Having suitable storage equipment will add to any company's production efficiency. The efficiency of any production system is maximized by the ease at which each stage of the entire system operates. Any inefficient section creates a bottleneck that will have an effect on all other sections of the system further down the production line.

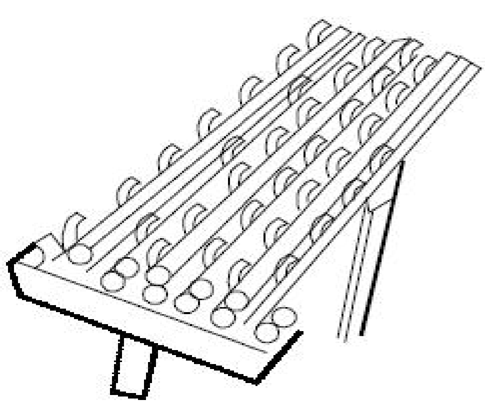
Types of storage and handling equipment

- Drive-through or drive-in racks
- Pallet racks
- Push-back racks
- Shelving
- Sliding racks
- Stacking frames

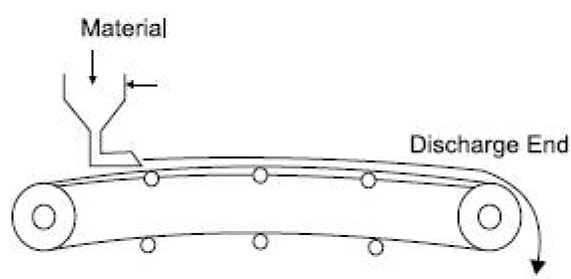
5. Robots

Many types of robots exist in the market. They vary in size, functionality, and maneuverability. While many robots are used for handling and transporting material, others are used to perform operations such as welding or spray painting. An advantage of robots is that they can perform in a hostile environment such as unhealthy conditions or carry on arduous tasks such as the repetitive movement of heavy materials.

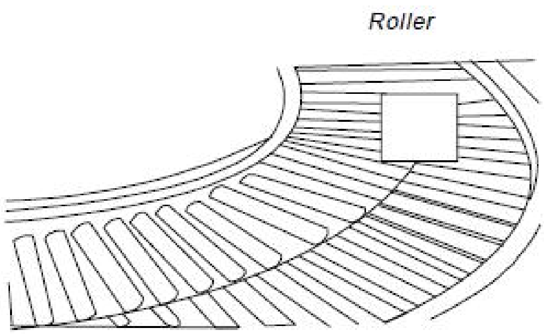
Fig- 13.2 Material Handling Equipment



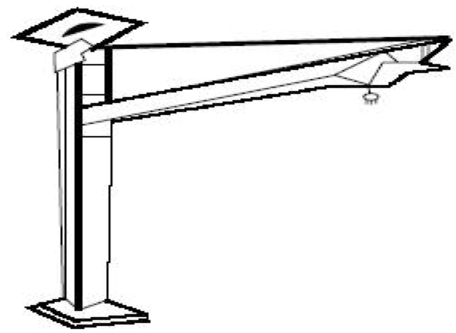
Wheel Conveyor



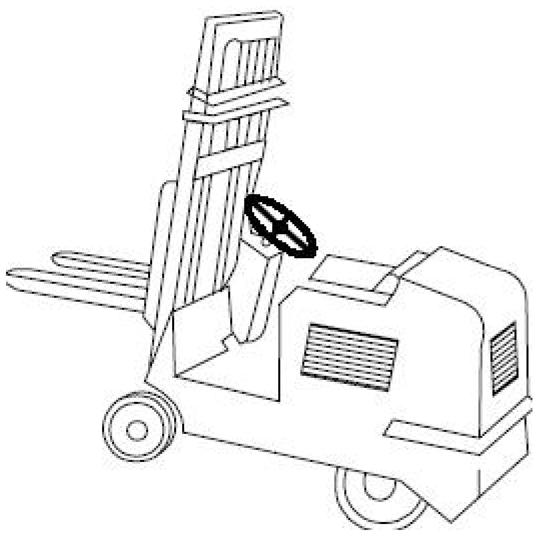
Belt Conveyor



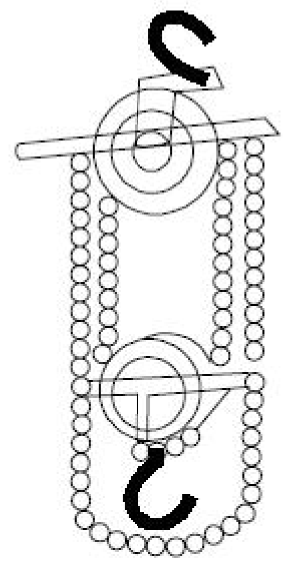
Roller Conveyor



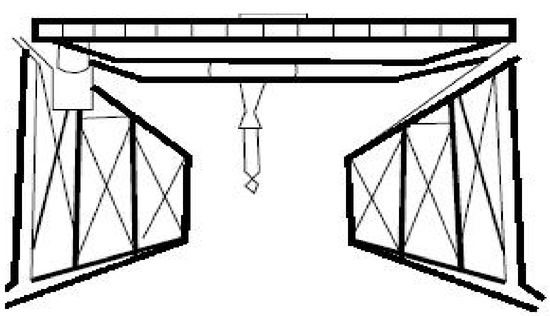
Jib Crane



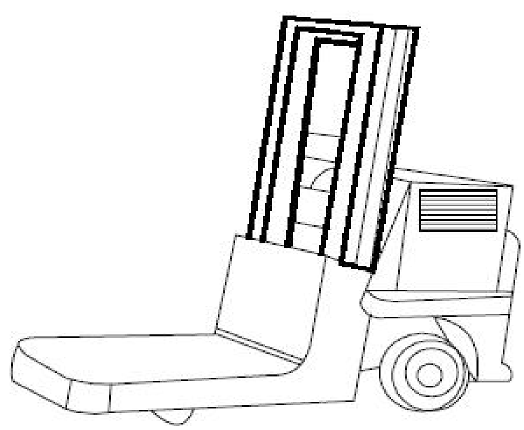
Fork Truck



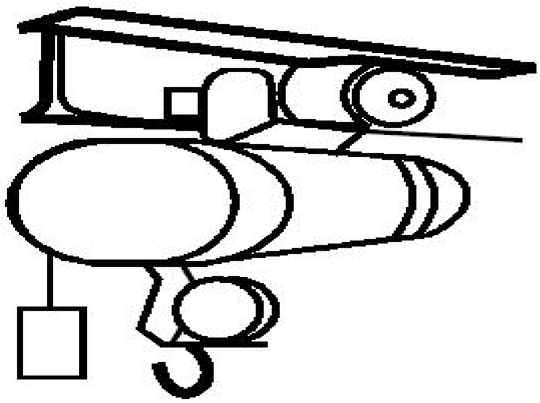
Chain Hoist



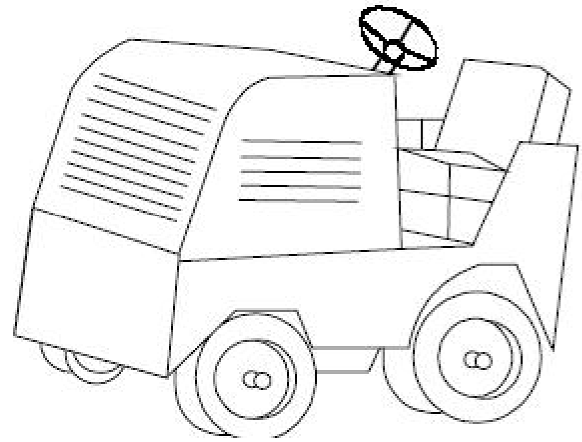
Bridge Crane



Platform Truck



Electric Hoist



Industrial Tractor

FACTORS AFFECTING THE SELECTION OF MATERIAL HANDLING EQUIPMENT

The selection of materials handling equipment requires the attainments of appropriate equilibrium between the production problem, the capabilities of the available equipment as well as the human element involved. The ultimate motive is to arrive at the lowest cost per unit of material handled.

The following factors are to be taken into account while selecting material handling equipment.

Properties of the material

Nature of material (i.e. solid, liquid or gas, and size, shape) and weight of material to be moved are important considerations which may lead to a preliminary elimination from the range of available equipment under review. When the material is fragile, corrosive or toxic will imply that certain handling methods and containers will be preferable to others.

Layout and characteristics of the building

Another restricting factor is the availability of space for handling. A low-level ceiling may impact the use of hoists or cranes. The presence of the supporting columns in odd places can limit the size of the material handling equipment. If the building is multi-storied, chutes or ramps for industrial trucks may be used. The layout itself will indicate the type of production operation (continuous, intermittent, fixed position or group) and can indicate some items of equipment that will be more suitable than others. Floor capacity also helps in selecting the best material handling equipment.

Production flow

If the flow is fairly constant between two fixed positions that are not likely to change, fixed equipment such as conveyors or chutes can be successfully used. If the flow is not constant and the direction changes occasionally from one point to another because several products are being produced simultaneously, moving equipment such as trucks would be preferable.

Cost considerations

This is one of the most important considerations. The above factors can help to narrow the range of suitable equipment, while costing can help in making a final decision. Several cost elements need to be taken into consideration when comparisons are made between various items of equipment that are all capable of handling the same load.

Initial investment, operating and maintenance costs are the major cost to be considered. By calculating and comparing the total cost for each of the items of equipment under consideration, a more rational decision can be reached on the most appropriate choice.

Nature of operations

The selection of equipment also depends on the nature of operations:

- handling is temporary or permanent
- the flow is continuous or intermittent
- material flow pattern-vertical or horizontal

Engineering factors

The selection of equipment also depends on engineering factors like door and ceiling dimensions, floor space, floor conditions, and structural strength.

Equipment reliability

The reliability of the equipment and supplier reputation and the after-sale service also plays an important role in selecting material handling equipment.

EVALUATION OF MATERIAL HANDLING SYSTEM

The cost factors include investment cost, labor cost, and anticipated service hours per year, utilization, and unit load carrying ability, loading and unloading characteristics, operating costs and the size requirements are the various factors considered for evaluation of material handling equipment.

Other factors to be considered are sources of power, conditions where the equipment has to operate and such other technical aspects. Therefore, choices of equipment in the organization will improve the material handling system through work study techniques. They usually result in improving the ratio of operating time to loading time through palletizing, avoiding duplicative movements, etc. Obsolete handling systems can be replaced with more efficient equipment.

The effectiveness of the material handling system can be measured in terms of the ratio of the time spent in the handling to the total time spent in production. This will cover the time element. The cost effectiveness can be measured by the expenses incurred per unit weight handled. It can be safely said that very few organizations try to collate the expenses and time in this manner so as to objectively view the performance and to take remedial measures. Some of the other indices which can be used for evaluating the performance of handling systems are listed below:

Equipment Utilization Ratio

Equipment utilization ratio is an important indicator for judging the materials handling system. This ratio can be computed and compared with similar firms or in the same over a period of time.

In order to know the total effort needed for moving materials, it may be necessary to compute Materials Handling Labor (MHL) ratio. This ratio is calculated as under:

MHL = Personnel assigned to materials handling/ Total operating work force

In order to ascertain whether is the handling system delivers materials work centers with maximum efficiency; it is desirable to compute direct labor handling loss ratio. The ratio is:

DLHL = Materials handling time loss of labor / Total direct labor time

The movement's operations ratio which is calculated after dividing total number of moves by total number of productive operations indicates whether the workers are going through too many motions because of poor routing.

It should, however, be emphasized that the efficiency of materials handling mainly depends on the following factors:

i. efficiency of handling methods employed for handling a unit weight through a unit distance
ii. efficiency of the layout which determines the distance through which the materials have to be handled
iii. utilization of the handling facilities
iv. efficiency of the speed of handling

GUIDELINES FOR EFFECTIVE UTILISATION OF MATERIAL HANDLING EQUIPMENT

The following guidelines are vital in the design and cost reduction of the materials handling system:

1. As the material handling adds no value but increases the production cycle time. Eliminate material handling wherever possible. Ideally, there should not be any handling.

2. Sequence the operations in a logical manner so that handling is unidirectional and smooth.

3. Use gravity wherever possible as it results in conservation of power and fuel.

4. Standardize the handling equipment to the extent possible as it means interchangeable usage, better utilization of handling equipment, and lesser spares holding.

5. Install a regular preventive maintenance for material handling equipment so that downtime is reduced.

6. In selection of handling equipment, criteria of versatility and adaptability must be the governing factor. This will ensure that investments in special purpose handling equipment are kept at a minimum.

7. Weight of unit load must be high, so that each 'handling trip' is productive.

8. Work study aspects, such an elimination of unnecessary movements and combination of processes should be considered while installing a material handling system.

9. Non-productive operations in handling, such as slinging, loading, etc., should be kept at a minimum through appropriate design of handling equipment. Magnetic cranes for scrap movement and loading in furnaces combination of excavators and tippers for loading and unloading ores in mines are examples in this respect.

10. Location of stores should be as close as possible to the plant which uses the materials. This avoids handling and minimizing investment in material handling system.

11. Application of OR techniques such as queueing can be very effective in optimal utilization of materials handling equipment.

12. A very important aspect in the design of a material handling system is the safety aspect. The system designed should be simple and safe to operate.

13. Avoid any wasteful movements and method study can be conducted for this purpose.

14. Ensure proper coordination through judicious selection of equipment and training of workmen.

Discussion Forum

Short Questions

1. Define material handling
2. What are the various dimensions of material handling?
3. Give any four objectives of material handling.
4. Mention any four principles of material handling.
5. What do you mean by "Equipment Utilization Ratio"?
6. Mention some of the fixed path equipment.
7. Mention some of the variable path equipment.

Essay Type Questions

1. Explain the objectives of material handling.
2. Explain the principles of material handling.
3. Differentiate fixed path and variable path equipment.
4. How do you evaluate the material handling system?
5. Discuss the factors to be considered while selecting material handling equipment.
6. Explain the different types of material handling equipment.
7. Discuss the guidelines for effective utilization of material handling equipment.

Mini Case- Paint Company

ABC Paint Company stores all its metal compressed gas containers in a warehouse. These long cylindrical metal tanks contain various gases used in manufacturing cans of spray paint. The gas tanks are delivered to the warehouse by truck. Two receiving dock workers unload the containers from the delivery trucks and place them on four wheel trucks. Two materials handlers are responsible for pushing the loaded trucks into the warehouse, unloading the tanks and setting them up on end. The two materials handlers spend a major portion of their day moving loads of the gas tanks into the warehouse and placing them into the proper storage locations. In total, there are five different types of gases that in equal proportion make up 98% of all gas handled.

Question:

If the management would like to identify a better way to handle these gas tanks, how can it improve the material handling operation?

For your Understanding

Toyota Material Handling's Latest Solutions Bring Improved Warehouse Efficiency Within Reach

Toyota Material Handling (TMH) is introducing two new electric products to the company's growing lineup of warehouse solutions, designed to take the operational efficiency of customer warehouses to new heights. TMH strives to offer customers the pinnacle of quality, durability and reliability with the release of the all-new Toyota Multidirectional Reach Truck and Toyota Furniture Order Picker.

The Toyota Multidirectional Reach Truck is an innovative alternative to traditional material handling – specially designed to handle wide, bulky loads – while offering the flexibility to maneuver in narrow aisles thanks to articulating load wheels that allow for horizontal travel.

The Multidirectional Reach Truck is engineered with features that enable increased throughput and exceptional maneuverability. With the capability to handle loads up to 22 feet wide and a capacity of up to 4,500 lbs., the Multidirectional Reach Truck offers improved storage density and operational efficiency for customers looking to optimize their warehouse space.

This reach truck is best suited for pallet-less load handling, long load handling and specialty racking, making it ideal for moving materials such as lumber, pipe, carpet and other building supplies.

“This model is just the latest example of our ongoing efforts to meet all of our customers’ unique needs,” said Tony Miller, TMH Senior Vice President of Operations & Engineering. “The Toyota Multidirectional Reach Truck will save customers time and space while increasing productivity because of its ability to travel both parallel and perpendicular to racking. It’s a perfect solution for moving and lifting wide loads in narrow aisles.”

The new Toyota Furniture Order Picker is also an ideal solution for handling bulky loads, including items such as couches, dining room tables and steel panels. It’s capable of lifting large items as high as 366 inches on carts or furniture platforms with ease, speed and stability.

The Furniture Order Picker – available in 24v and 36v models – has a lift capacity of 1,600 lbs. and is available with custom options that – combined with its excellent ergonomics and intuitive functionality – empowers customers to increase overall productivity.

Notable features, including a glance and go display, tight turn radius and upgraded lift/lower speeds, make the new Furniture Order Picker an ideal solution for furniture warehouses and distribution centers.

“Like our customers, Toyota is not one-dimensional. We are dynamic and responsive to the challenges of our business and our industry, and we understand the importance of versatility in the solutions we use to stay ahead,” said Bill Finerty, TMH Senior Vice President of Sales. “Our new Toyota Multidirectional Reach Truck and Furniture Order Picker reflect that appreciation for versatility and are manufactured to help customers rise to the occasion at a time when consumers are demanding greater efficiency and productivity from the supply chain than ever before.”

The all new Toyota Multidirectional Reach Truck and Furniture Order Picker are both powered by AC motors; come standard with the unparalleled reputation and quality inherent in products manufactured with the world-renown Toyota Production System (TPS), and are backed by the hallmark Toyota 360 Support promise

Source: https://www.dcvelocity.com/articles/53017-toyota-material-handling-s-latest-solutions-bring-improved-warehouse-efficiency-within-reach

CHAPTER- 14

INVENTORY MANAGEMENT AND CONTROL

INTRODUCTION

Inventories occupy the most strategic position in the structure of working capital of most business enterprises. It constitutes the largest component of current asset in most business enterprises. In the sphere of working capital, the efficient control of inventory has passed the most serious problem to the cement mills because about two-third of the current assets of mills are blocked in inventories. The turnover of working capital is largely governed by the turnover of inventory. It is therefore quite natural that inventory which helps in maximize profit occupies the most significant place among current assets**.** The term 'inventory' refers to the stockpile of production a firm is offering for sale and the components that make up the production.

The inventory means aggregate of those items of tangible personal property which are:

- held for sale in ordinary course of business
- in process of production for such sales
- to be currently consumed in the production of goods or services to be available for sale

Inventories are expandable physical articles held for resale for use in manufacturing a production or for consumption in carrying on business activity such as merchandise, goods purchased by the business which are ready for sale.

In short, inventory may be defined as the materials, which are either saleable in the market or usable directly or indirectly in the manufacturing process. It also includes the items which are ready for making finished goods in some other process or by comparing them either by the concern itself and/or by outside parties. In other words, the term inventory means the material having any one of the following characteristics. It may be:

- saleable in the market
- directly saleable in the manufacturing process of the business
- usable directly in the manufacturing process of the undertaking
- ready to send to the outside parties for making usable and saleable productions out of it

Generally raw materials, stores and spare parts, finished goods and work-in-process have been included inventories. Firm also manufactures inventory to supplies. Supplies included office and plant cleaning materials (soap, brooms etc. oil, fuel, light bulbs and the likes). These materials do not directly enter into the production process, but are necessary for production process. Inventory constitutes the most significant part of current assets of a large majority of companies in India. For example, on an average inventory are more than 57 per cent of current assets in public limited companies and about 60.5 percent in government companies in India. Therefore, it is absolutely imperative to manage inventories efficiently and effectively in order to avoid unnecessary investment in them. An undertaking neglecting the management of inventories will be jeopardizing its long

Definitions

Inventory is defined as a list of goods and materials which are available in stock for business (Sharma, 2016)

Inventory is defined as "any item of property held in stock by a firm, including finished goods ready for sale, goods in the process of production, raw materials, and goods that will be consumed in the process of producing goods to be sold."

Inventory is also defined as "a quantity of goods owned and stored by a business that is intended either for resale or as raw materials and components used in producing goods that the business sells."

CLASSIFICATION OF INVENTORY

The Inventory can be classified into the following categories-

1. Raw Materials Inventory
2. Stores and Spares
3. Work-in-progress Inventory
4. Finished goods Inventory

1. Raw Material Inventory:

This comprises of the raw materials purchased from firms for using the production operations. The objective of maintaining raw material inventory is to detach the production function from the purchasing function. This detachment is necessary to avoid production delays because of the delays in the shipments of raw materials.

2. Stores and Spare:

These include the products which are accessories to the main products produced for the purpose of sale. Example- Screws, nuts, bolts, cramps, etc.

3. Work-in-process inventory:

These include the materials committed for the production process but not completed. Investment in work-in-process inventory increases when the production process is lengthy and complex.

4. Finished goods inventory:

These include the finished products awaiting sale. The motive of finished goods inventory is to separate the production function and sale function so that it is no longer required to produce the goods before a sale can occur.

Also the inventory can be classified on the basis of function and nature of goods.

Classification of Inventory on the Basis of Function

1. Lot-size Inventories:

Some firms prefer purchasing materials in bulk in order to avail discount on bulk purchases. Practically it is not possible to produce the goods in exact amount of the firms demand. Some inventories gather. The inventories accumulated or gathered as known as lot-as inventories.

2. Fluctuation Inventories:

Due to demand and supply factors, the market for some raw materials or commodities fluctuates. This fluctuation is marked in respect of agro -based products. Demand fluctuates overtime and accurate estimate is not possible so some reserve stocks are maintained. Those reserves (safety) stocks are fluctuation inventories.

3. Transportation Inventories:

Raw materials are transported from production place to the business firms needing it. Since, the goods and raw materials in transit cannot serve for whom these have been sent, these resources in transit represent the transportation inventories.

4. Anticipation Inventories:

A business firm need to accumulate inventories while anticipating price rise or introducing the business promotion tools. These inventories are known as anticipation inventories.

Classification on the Basis of Nature of Inventory

1. Safety Inventory:

Safety inventory provides for failures in supplies, unexpected increase in demand, i.e. an insurance cover.

2. Excessive Inventory:

Management is constrained for keeping excessive inventory for the reasons beyond its control as a measure of government price support of commodity as in the case of strategic import.

3. Normal Inventory:

Normal inventory is based on the production plan and the time of supplies and economic ordering quantity levels.

4. Flabby Inventory:

It comprises of finished goods, raw materials and stores maintained because of poor working capital management and ineffective distribution.

5. Profit making inventory:

It includes stock of raw materials and finished goods held for realizing stock profit.

INVENTORY MANAGEMENT

Inventory management is the branch of business management that covers the planning and control of the inventory. Inventory management refers to the process of ordering, storing, using, and selling a company's inventory. This includes the management of raw materials, components, and finished products, as well as warehousing and processing of such items.

Inventory management is the process of reducing inventory management costs and optimizing the firm's ability to meet customer demand. This can be done using a variety of inventory management methods like reducing dead stock or calculating an optimal reorder point using the reorder point formula. Inventory management in business refers to managing order processing, manufacturing, storage, and selling raw materials and finished goods. It ensures the right type of goods reach the right place in the right quantity at the right time and at the right price. Thus, it maintains the product availability at warehouses, retailers, and distributors. It ensures that the right inventory is available as per the demand at low costs. It also makes sure that the core processes of a business keep running efficiently by optimizing the availability of inventory.

Inventory Management includes managing and controlling raw materials, stocks, finished goods, warehousing, storage and other aspects which help reach the product from production to distributor or retailer. Each organization regularly strives on efficient inventory management to uphold optimum inventory to be able to meet its necessities and avoid over or under inventory that can impact the monetary statistics of the firm.

Inventory management is all about striking the balance between overstocking and understocking. Overstocking will lead to cash flow blockage and additional cost for managing excess stock. On the flip side, understocking leads to loss of sale due to non-availability of stock at the right time. It is all about maintaining the right level inventories at the right time and keeping the inventory handling cost at low.

Definitions

Inventory management can be defined as a whole lot of activities done to maintain an optimum number of inventories to ensure uninterrupted production, sales, high customer satisfaction, reduced inventory handling cost, and so on.

According to Inventory Management is defined as a framework employed in firms in controlling its interest in inventory. It includes the recording and observing of stock level, estimating future request, and settling on when and how to arrange.

- William Stevenson

Inventory management is a method that companies use to organize, store, and replace inventory, to keep an adequate supply of goods at the same time minimizing cost.

- Deveshwar and Dhawal

OBJECTIVES OF INVENTORY MANAGEMENT

The primary objectives of inventory management are:

(i) To minimize the possibility of disruption in the production schedule of a firm for want of raw material, stock and spares.

(ii) To keep down capital investment in inventories. So, it is essential to have necessary inventories. Excessive inventory is an idle resource of a concern. The concern should always avoid this situation. The investment in inventories should be just sufficient in the optimum level. The major dangers of excessive inventories are:

- The unnecessary tie up of the firm's funds and loss of profit
- Excessive carrying cost
- The risk of liquidity

The excessive level of inventories consumes the funds of business, which cannot be used for any other purpose and thus involves an opportunity cost. The carrying cost, such as the cost of shortage, handling insurance, recording and inspection, are also increased in proportion to the volume of inventories. This cost will impair the concern profitability further.

On the other hand, a low level of inventories may result in frequent interruptions in the production schedule resulting in under-utilization of capacity and lower sales. The aim of inventory management thus should be to avoid excessive inventory and inadequate inventory and to maintain adequate inventory for smooth running of the business operations. Efforts should be made to place orders at the right time with the right source to purchase the right quantity at the right price and quality. The effective inventory management should:

- Maintain sufficient stock of raw material in the period of short supply and anticipate price changes.
- Ensure a continuous supply of material to production department facilitating uninterrupted production.
- Minimize the carrying cost and time.
- Maintain sufficient stock of finished goods for smooth sales operations.
- Ensure that materials are available for use in production and production services as and when required.
- Ensure that finished goods are available for delivery to customers to fulfil orders, smooth sales operation and efficient customer service.
- Minimize investment in inventories and minimize the carrying cost and time.
- Protect the inventory against deterioration, obsolescence and unauthorized use.
- Maintain sufficient stock of raw material in period of short supply and anticipate price changes.
- Control investment in inventories and keep it at an optimum level.

Problems faced by management

- To maintain a large size inventories for efficient and smooth production and sales operation.
- To maintain only a minimum possible inventory because of inventory holding cost and opportunity cost of funds invested in inventory.
- Control investment in inventories and keep it at the optimum level. Inventory management, therefore, should strike a balance between too much inventory and too little inventory. The efficient management and effective control of inventories help in achieving better operational results and reducing investment in working capital. It has a significant influence on the profitability of a concern.

ADVANTAGES OF INVENTORY MANAGEMENT

Accurate inventory management is key to running a successful product business. Tracking stock regularly can help avoid stock errors and other problems. The following are the benefits of strong inventory management:

Better Inventory Accuracy: With solid inventory management, the firm knows what is in stock and orders only the amount of inventory you need to meet demand.

Reduced risk of overselling: Inventory management helps track what is in stock and what is on backorder, so that the firms do not oversell products.

Cost Savings: Stock costs money until it sells. Carrying costs include storage handling and transportation fees, insurance and employee salaries. Inventory is also at risk of theft, loss from natural disasters or obsolescence.

Avoiding stock out and excess stock: Better planning and management helps a business minimize the number of days, if any, that an item is out of stock and avoid carrying too much inventory.

Greater insights: With inventory tracking and stock control, the firms can also easily spot sales trends or track recalled products or expiry dates.

Better terms with Vendors and Suppliers: Inventory management also provides insights about which products sell and in what volume. Use that knowledge as leverage to negotiate better prices and terms with suppliers.

Increased productivity: Good inventory management solutions save time that could be spent on other activities.

Increased profits: A better understanding of both availability and demand leads to higher inventory turnover, which leads to greater profits.

A more organized warehouse: An efficient warehouse with items organized based on demand, which items are often sold together and other factors reduces labor costs and speeds order fulfillment.

Better customer experience: Customers that receive what they order on time are more loyal.

FACTORS AFFECTING THE LEVEL OF INVENTORY

The level of inventory should be appropriate. The appropriateness of the amount of inventory depends upon a number of factors. Some significant factors affecting the level of inventory are explained as follows:

1. Nature of business: The level of inventory will depend upon the nature of business whether it is a retail business, wholesale business, manufacturing business or trading business.

2. Inventory turnover: Inventory turnover refers to the amount of inventory which gets sold and the frequency of its sale. It has a direct impact on the amount of inventory held by a business concern.

3. Nature of type of product: The product sold by the business may be a perishable product or a durable product. Accordingly, the inventory has to be maintained.

4. Economies of production: The scale on which the production is done also affects the amount of inventory held. A business may work on large scale in order to get the economies of production.

5. Inventory costs: More the amount of inventory is held by the business, more will be the operating cost of holding inventory. There has to be a trade-off between the inventory held and the total cost of inventory which comprises of purchase cost, ordering cost and holding cost.

6. Financial position: Sometimes, the credit terms of the supplier are rigid and credit period is very short. Then, according the financial situation of the business the inventory has to be held.

7. Period of operating cycle: If the operating cycle period is long, then the money realization from the sale of inventory will also take a long duration. Thus, the inventory managed should be in line with the working capital requirement and the period of operating cycle.

8. Attitude of management: The attitude and philosophy of top management may support zero inventory concepts or believe in maintaining huge inventory level. Accordingly, the inventory policy will be designed for the business.

INVENTORY SYSTEM

An inventory system facilitates the organizational structure and the operating policies for maintaining and controlling materials to be inventoried. This system is responsible for ordering and receipt of materials, timing the order placement and keeping record of what has been ordered, how much ordered and from whom the order placement has been done.

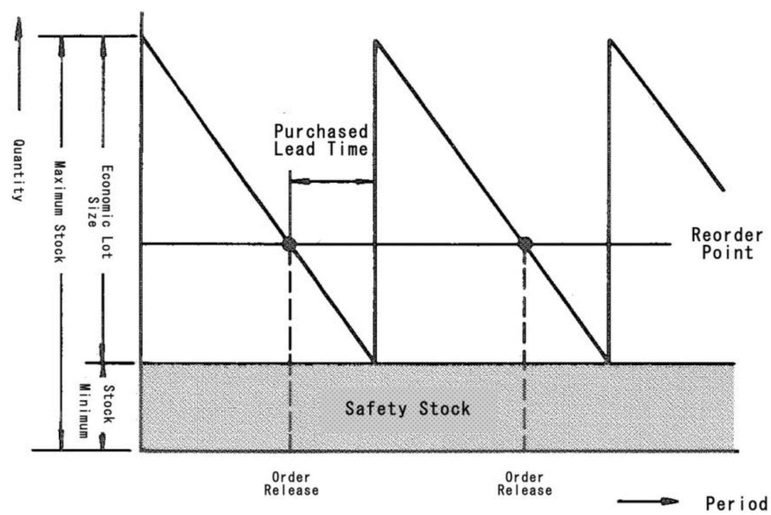
There are two models of inventory system:-

1. The fixed order quantity system
2. The fixed order periodic system

1. FIXED ORDER QUANTITY SYSTEM (Q SYSTEM)

The fixed order quantity system is also known as the Q system. In this system, whenever the stock on hand reaches the reorder point, a fixed quantity of materials is ordered. The fixed quantity of material ordered each time is actually the economic order quantity. Whenever a new consignment arrives, the total stock is maintained within the maximum and the minimum limits. The fixed order quantity method is a method that facilitates for a predetermined amount of a given material to be ordered at a particular period of time. This method helps to limit reorder mistakes, conserve space for the storage of the finished goods, and block those unnecessary expenditures that would tie up funds that could be better utilized elsewhere. The fixed order quantity may be bridged to an automatic reorder point where a particular quantity of a good is ordered when stock at hand reaches a level which is already determined.

Fig- 14.1 Q System



Advantages of fixed order quantity system:

- Each material can be procured in the most economical quantity.
- Purchasing and inventory control people automatically gives their attention to those items which are required only when are needed.
- Positive control can easily be handled to maintain the inventory investment at the desired level only by calculating the predetermined maximum and minimum values.

Disadvantages of fixed order quantity system:

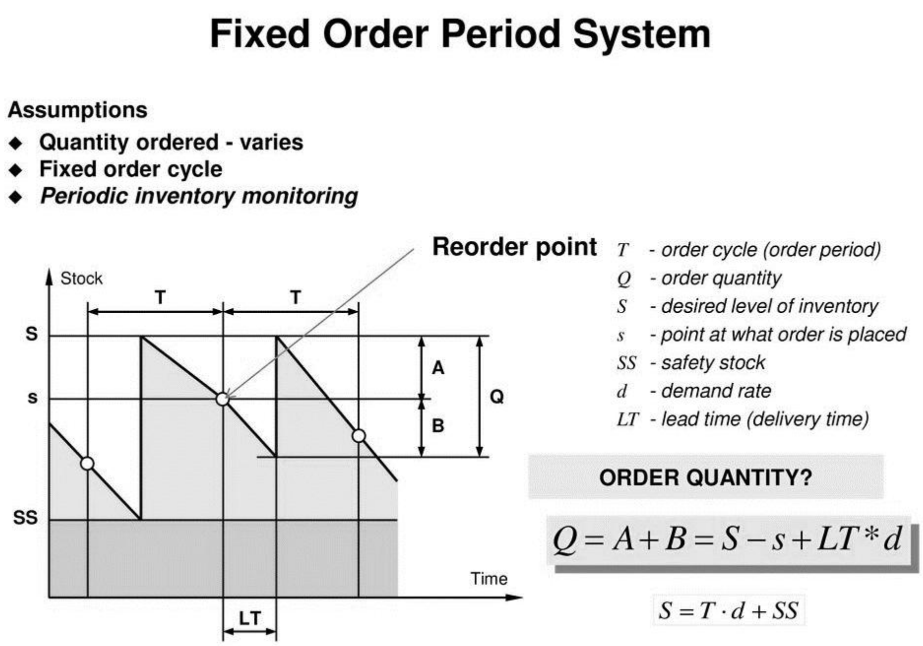
- Sometimes, the orders are placed at the irregular time periods which may not be convenient to the producers or the suppliers of the materials.
- The items cannot be grouped and ordered at a time since the reorder points occur irregularly.

- If there is a case when the order placement time is very high, there would be two to three orders pending with the supplier each time and there is likelihood that he may supply all orders at a time.
- EOQ may give an order quantity which is much lower than the supplier minimum and there is always a probability that the order placement level for a material has been reached but not noticed in which case a stock out may occur.
- The system assumes stable usage and definite lead time. When these change significantly, a new order quantity and a new order point should be fixed, which is quite cumbersome.

2. FIXED ORDER PERIOD SYSTEM (P SYSTEM)

In this system, the stock position of each material of a product is checked at regular intervals of time period. When the stock level of a given product is not sufficient to sustain the operation of production until the next scheduled tested, an order is placed destroying the supply. The frequency of reviews varies from organization to organization. It also varies among products within the same organization, depending upon the importance of the product, predetermined production schedules, market conditions and so forth. The order quantities vary for different materials.

Fig-14.2 P System



Advantages of fixed period quantity system

- The ordering and inventory costs are low. The ordering cost is considerably reduced though follow up work for each delivery may be necessary.
- The suppliers will also offer attractive discounts as sales are guaranteed.
- The system works well for those products which exhibit an irregular or seasonal usage and whose purchases must be planned in advance on the basis of sales estimates.

Disadvantages of fixed period quantity system

- The periodic testing system tends to peak the purchasing work around the review dates.
- The system demands the establishment of rather inflexible order quantities in the interest of administrative efficiency.
- It compels a periodic review of all items; this itself makes the system somewhat inefficient.

Table- 14.1 Distinction between Q System and P System

Difference	Q system	P system
Initiation of order	Stock on hand reaches to reorder point	Based on fixed review period and not stock level
Period of order	Any time when stock level reaches to reorder point	Only after the predetermined period
Record keeping	Continuously each time a withdrawal or addition is made	Only at the review period
Order quantity	Constant the same quantity ordered each time	Quantity of order varies each time order is placed
Size of inventory	less than the P system	Larger than the Q system
Time to maintain	Higher due to perpetual record keeping	Less than due to only at the review period

INVENTORY PLANNING

Inventory planning refers to the process that any organization adopts to determine the optimal quantity as well as timing, with the sole aim of aligning such plans with the organization's capacity to produce and make sales. Inventory planning usually affects the company in numerous ways. For example, it directly determines the cash flow of any organization and its profits margins with reference to those that have an over reliance on fast turnovers of materials and goods. Evidently, inventory planning is an important aspect of any business's success. Good inventory planning supports several vital business objectives including:

- Customer service and satisfaction
- Supply chain efficiency
- Control of costs
- Accurate sales and demand forecasting

How to develop an inventory plan

The following questions are to be answered in order to develop an inventory plan.

What is the volume of the product?

Business forecasting comes in handy while developing an inventory plan. Once you understand the demand for your product in the market, it will be much easier to devise a methodology to plan and maintain your inventory levels.

What factors impact inventory?

Factors that affect demand include well-considered advertising, your competition's price cuts and offerings, the income and context of your target market, seasonal demand, trends and customer preferences.

Is the warehouse efficient?

To maintain an optimum level of inventory, it is crucial to manage a well-organized storage space for your goods. Your staff should be able to identify, track, and, place orders easily, for any new deliverables and also keep a constant tab on when the product is running out. This way you can have a balance of your demand and supply, thus reducing unnecessary overhead costs of transferring goods from one place to another.

Is the order process streamlined?

Look for ways to improve the connection between inventory and order management.

What can you automate?

Automation of different processes in a business will be of great help while devising an inventory plan, as there will be reduced errors and more accuracy in reports.

Earlier, the conventional way to track inventory was to use pen and paper. Over a period of time, businesses switched to spreadsheets, and most small businesses still manage their inventory in the same manner. However, as the business grows, it becomes next to impossible to continue using manual methods or spreadsheets, since a business owner will end up spending more time managing inventory rather than focus on the overall business. Also, inherently entering data by hand, is time consuming and error prone, and tends to be a repetitive task, which can easily be automated. Most importantly, an efficient inventory management in today's day and age demands a centralized database that is accessible to multiple resources in your business, across multiple locations and updates on a real-time basis.

It needs to be noted here that inventory management software isn't the only technology that can help a business manage its inventory and stock efficiently. It also includes mobile scanners, POS machines, barcode machines and a host of other equipment which can automate your inventory processes.

INVENTORY CONTROL

Inventory control is concerned with the acquisition, storage, handling and use of inventories so as to ensure the availability of inventory whenever needed, providing adequate provision for contingencies, deriving maximum economy and minimizing wastage and losses. Hence Inventory control refers to a system, which ensures the supply of required quantity and quality of inventory at the required time and at the same time prevent unnecessary investment in inventories.

It is one of the most vital phases of material management. Reducing inventories without impairing operating efficiency frees working capital that can be effectively employed elsewhere. Inventory control can make or break a company. This explains the usual saying that "inventories" are the graveyard of a business. Designing a sound inventory control system is in a large measure for balancing operations. It is the focal point of many seemingly conflicting interests and considerations both short range and long range.

The aim of a sound inventory control system is to secure the best balance between "too much and too little." Too much inventory carries financial rises and too little reacts adversely on continuity of productions and competitive dynamics. The real problem is not the reduction of the size of the inventory as a whole but to secure a scientifically determined balance between several items that make up the inventory.

The efficiency of inventory control affects the flexibility of the firm. Insufficient procedures may result in an unbalanced inventory. Some items out of stock, other overstocked, necessitating excessive investment. These inefficiencies ultimately will have adverse effects upon profits. Turning the situation round, difference in the efficiency of the inventory control for a given level of flexibility affects the level of investment required in inventory. The less efficient is the inventory control, the greater is the investment required. Excessive investment in inventories increase cost and reduce profits, thus, the effects of inventory control of flexibility and on level of investment required in inventories represent two sides of the same coin.

Maintaining an inventory is necessary because of the following reasons:

i. It helps in smooth and efficient running of an enterprise.

ii. It provides service to the customer at short notice. Timely delivery can fetch more goodwill and orders.

iii. In the absence of the inventory, an enterprise may have to pay high prices because of piecemeal purchasing. Maintaining an inventory may earn price discounts because of bulk purchasing. Such purchases entail less order and, therefore, less clerical costs.

iv. It also takes advantage of favorable market.

v. It acts as a buffer stock when raw materials are received late and shop rejections are too many.

vi. Process and movement inventories (also called pipeline stocks) are quite necessary in big enterprises wherein a significant amount of time is required to ship items from one location to another.

Though inventories are essential, their maintenance also costs money by way of expenses on stores, equipment, personnel, insurance, etc. Thus, excess inventories are undesirable. So, only that quantity should be kept in stock, which balances the costs of holding too much stock vis-à-vis the costs of ordering in small quantities. This calls for controlling the inventories in the most profitable way and that is why we need inventory analysis. We now discuss various factors involved in inventory analysis.

1. **Inventory related costs:** Various costs associated with inventory control are often classified as follows:

i) Set-up cost: This is the cost associated with the setting up of machinery before starting production. The set-up cost is generally assumed to be independent of the quantity ordered for.

ii) Ordering cost: This is the cost incurred each time an order is placed. This cost includes the administrative costs (paper work, telephone calls, and postage), transportation, receiving and inspection of goods, etc.

iii) Purchase (or production) cost: It is the actual price at which an item is purchased (or produced). It may be constant or variable. It becomes variable when quantity discounts are allowed for purchases above a certain quantity.

iv) Carrying (or holding) cost: The cost includes the following costs for maintaining the inventory: i) Rent for the space; ii) cost of equipment or any other special arrangement for storage; iii) interest of the money blocked; iv) the expenses on stationery; v) wages of the staff required for the purpose; vi) insurance and depreciation; and vii) deterioration and obsolescence, etc.

v) Shortage (or Stock-out) cost: This is the penalty cost for running out of stock, i.e., when an item cannot be supplied on the customer's demand. These costs include the loss of potential profit through sales of items demanded and loss of goodwill in terms of permanent loss of the customer.

2. Demand: Demand is the number of units required per period and may either be known exactly or known in terms of probabilities. Problems in which demand is known and fixed are called deterministic problems whereas problems in which demand is known in terms of probabilities are called probabilistic problems.

3. Selling Price: The amount which one gets on selling an item is called its selling price. The unit selling price may be constant or variable, depending upon whether quantity discount is allowed or not.

4. Order Cycle: The period between placements of two successive orders is referred to as an order cycle. The order may be placed on the basis of either of the following two types of inventory review systems:

a) The record of the inventory level is checked continuously until a specified point is reached where a new order is placed. This is called continuous review.
b) The inventory levels are reviewed at equal intervals of time and orders are placed accordingly at such levels. This is called periodic review.

5. Time Horizon: The period over which the time cost will be minimized and inventory level will be controlled is termed as time horizon. This can be finite or infinite depending on the nature of demand.

6. Stock Replenishment: The rate at which items are added to the inventory is called the rate of replenishment. The actual replenishment of items may occur at a uniform rate or be instantaneous over time. Usually, uniform replacement occurs in cases when the item is manufactured within the factory while instantaneous replacement occurs in cases when the items are purchased from outside sources.

7. Lead Time: The time gap between placing an order for an item and actually receiving the item into the inventory is referred to as lead time.

8. Reorder Level: The lower limit for the stock is fixed at which the purchasing activities must be started for replenishment. With this replenishment, the stock reached at a level is known as maximum stock. The level between maximum and minimum stock is known as the reorder level.

9. Economic Order Quantity (EOQ): The order in quantity that balances the costs of holding too much stock vis-à-vis the costs of ordering in small quantities too frequently is called Economic Order Quantity (or Economic lot size).

10. Reorder Quantity: The quantity ordered at the level of minimum stock is known as the reorder quantity. In certain cases, it is the 'Economic Order Quantity'.

INVENTORY ANALYSIS TECHNIQUES

(I) Modern Techniques

(a) Economic Order Quantity (EOQ)

(b) Re-Order Point (ROP)

(c) Fixing Stock Levels

(d) Selective Inventory Control

(i) ABC Analysis

(ii) VED Analysis

(iii) SDE Analysis

(iv) FSN Analysis

(II) Traditional Techniques

(a) Inventory Control Ratios

(b) Two Bin System

(c) Perpetual Inventory System

(d) Periodic Order System

MODERN TECHNIQUES

Modern techniques of inventory control refer to those techniques which are evolved through a scientific process. These techniques involve the use of a formula or a method which is logically derived to keep control on the inventory levels. These techniques are explained as below:

(a) ECONOMIC ORDER QUANTITY (EOQ)

The optimal size of an order for replenishment of inventory is called economic order quantity. Economic order quantity (EOQ) or optimum order quantity is that size of the order where total inventory costs (ordering costs + carrying costs) are minimized. Economic order quantity can be calculated from any of the following two methods:

- Formula Method
- Graphic Method

Formula Method: It is also known as 'SQUARE ROOT FORMULA' or 'WILSON FORMULA' as given below:

$$EOQ = \sqrt{\frac{2AB}{CS}}$$

Where, EOQ = Economic Order Quantity

A = Annual Demand or Consumption in Units

B = Buying Cost per order

C = Carrying Cost Per Unit Per Year

S = Storage Cost

No. of orders = R/EOQ

Time gap between two orders = No. of days in a year/No. of orders

Total Cost = Purchase Cost + Carrying Cost + Order Cost

= (D × Unit Price) + (EOQ/2 × C) + (D/EOQ × B)

Illustration

Calculate the Economic Order Quantity from the following particulars:

Annual requirement =4,000 units

Cost of materials per unit =Rs. 40

Cost of placing and receiving one order= Rs. 80

Annual carrying cost of inventory, 40% of inventory value.

Solution:

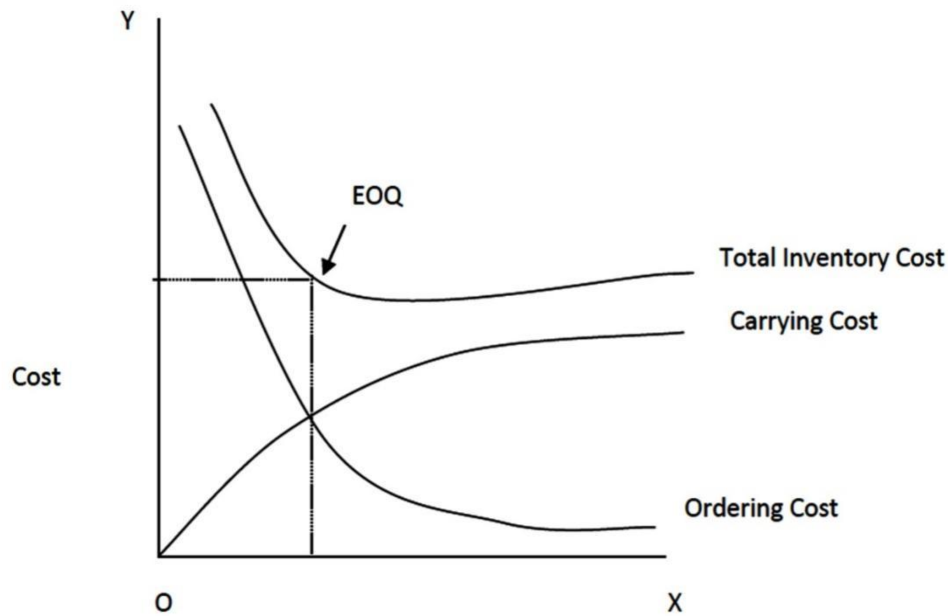
Here, A = 4,000 B = 80 Unit Price = 40

C = 40% of Unit Price = 40% of 40 = 16

$$EOQ = \sqrt{\frac{2AB}{CS}}$$

$$= \sqrt{\frac{2(4{,}000\, units \times Rs. 80)}{16}} = 200\, units$$

Graphic Method: The economic order quantity can also be determined with the help of graph. Under this method, ordering costs, carrying costs and total inventory costs according to different lot sizes are plotted on the graph. The intersection points at which the inventory carrying cost and the ordering cost meet, is the economic order quantity. At this point the total cost line is also minimum.



Assumptions: The following assumptions are made:

- The rate of consumption of inventory is assumed to be constant.
- Costs will not change over time.
- Lead time is assumed to be known and constant.
- Per order cost, carrying cost and unit price are constant.
- Carrying or holding costs are proportionate to the value of stock held.
- Ordering cost varies proportionately with the price.

Deterministic Inventory Models

The following symbols are used in connection with the inventory models:

c = purchase (or manufacturing) cost of an item

c_1 = holding cost per quantity unit per unit time

c_2 = shortage cost per quantity unit per unit item

c_3 = ordering (set up) cost per order (set up)

R = demand rate

P = production rate

t = scheduling period which is variable

t_p = prescribe scheduling period

D = total demand or annual demand

q = lot (order) size

L = lead time

x = random demand

$f(x)$ = probability density function for demand x.

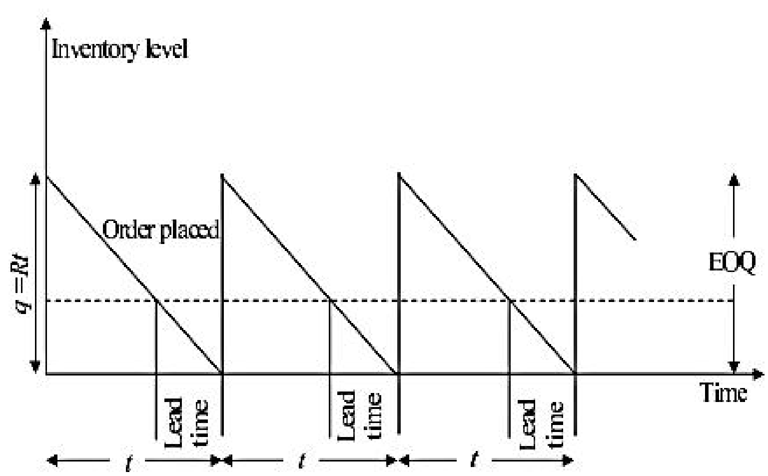
z = order level

Model I (a): EOQ model without shortage

The basic assumptions of the model are as follows:

- Demand rate R is known and uniform.
- Lead time is zero or a known constant.
- Replenishment rate is infinite, i.e., replenishments are instantaneous.
- Shortages are not permitted.
- Inventory holding cost is c_1 per unit per unit time.
- Ordering cost is c_3 per order

Our objective is to determine the economic order quantity q∗ which minimizes the average total cost of the inventory system. An inventory-time diagram with inventory level on the vertical axis and time on the horizontal axis is shown in Fig. 1.2. Since the actual consumption of inventory varies constantly, the concept of average inventory is applicable here. *Average Inventory = 1/2[maximum level + minimum level] = (q +0)/2 = q/2.*



Inventory-time diagram when lead time is a known constant

Thus, the average inventory carrying cost is $= average\ inventory \times holding\ cost = \frac{1}{2}qc_1$. The average ordering cost is $(R/q)c_3$. Therefore, the average total cost of the inventory system is given by

$$C(q) = \frac{1}{2}c1q + \frac{c_3R}{q}$$

Since the minimum average total cost occurs at a point when average ordering cost and average inventory carrying cost are equal, therefore, we have $\frac{1}{2}c_1q = \frac{c_3R}{q}$ which gives the optimal order quantity

$$q^* = \sqrt{\frac{2c_3R}{c_1}}$$

This result was derived independently by F.W. Harris and R.H. Wilson in the year 1915. That's why the model is called Harris-Wilson model.

Characteristics of Model I(a)

(i) Optimal ordering interval $t^* = \frac{q^*}{R} = \sqrt{\frac{2c_3R}{c_1R}}$

(ii) Minimum average total cost $C_{min} = C(q^*) = \sqrt{2c_1c_3R}$

If in Model I(a), the ordering cost is taken as $(c_3 + kq)$ where k is the ordering cost per unit item ordered then there will be no change in the optimal order quantity q^*. In this case, the average total cost is

$$C(q) = \frac{1}{2}c1q + \frac{c_3R}{q} + kR$$

Example: A manufacturing company purchases 9000 parts of a machine for its annual requirements, ordering one month usage at a time. Each part costs Rs.20.

The ordering cost per order is Rs. 15 and the carrying charges are 15% of the average inventory per year. Suggest a more economic purchasing policy for the company. How much would it save the company per year?

Solution: Given that R = 9000 parts/year, c_1 = (15/100)×20 = *Rs.3* per part/year, c_3 = Rs.15 per order. Using Harris-Wilson formula,

$$q^* = \sqrt{2c_3R/c_1} = 300\ units$$

$$t^* = \frac{q}{R} = \frac{1}{30year} = 12days\ (approx.)$$

$$C_{min} = \sqrt{2c_1c_3R} = \text{Rs.}900$$

If the company follows the policy of ordering every month, then

lot size of inventory each month q = 9000/12 = 750 parts,

annual storage cost = c1(q/2) = Rs. 1125,

annual ordering cost = 15 × 12 = Rs. 180.

The total cost per year = 1125 + 180 = Rs. 1305.

Therefore, the company should purchase 300 parts at time interval of 12 days instead of ordering 750 parts each month. Then there will be a net saving of Rs. 405.

Lot Size in Discrete Units

Let the lot size q be constrained to values *u,2u,3u,...* Then the necessary conditions for optimal q, *i.e.,* $q*$ are

$$C(q*) \leq C(q* + u)$$

$$C(q*) \leq C(q* - u)$$

From equations (1.4) and (1.5), we get by simplifying

$$q*(q* - u) \leq \frac{2Rc_3}{C_1} \leq q*(q* + u)$$

Example: Demand in an inventory system is at a constant and uniform rate of 2400 kg. per year. The carrying cost is Rs.5 per kg. per year. No shortage is allowed. The replenishment cost is Rs.22 per order. The lot size can only be in 100 kg. unit. What is the optimal lot size of the system?

Solution: Given that R = 2400kg/year, c_1 = Rs.5/kg/year, c_3 = Rs.22 per order, u = 100 kg. The optimal lot size $q*$ has to satisfy the inequality

$$q*\ (q* - u) \leq \frac{2c_3R}{C_1} \leq q*\ (q* + u)$$

$$i.e.,\ q*(q* - 100) \leq 21120 \leq q*\ (q* + 100)$$

By trial and error, we find the optimal lot size q $*$ = 200 kg.

Sensitivity of Lot Size System

The average cost *C(q)* of the lot size system is a function of the controllable variable *q* where $C(q) = \frac{1}{2}c_1q + \frac{c_3R}{q}$.

The optimal results are $q^* = \sqrt{\frac{c_3R}{q}}$ and C* = C(q*) $= \sqrt{2c_1c_3R}$.

Suppose that instead of the optimal lot size q*, the decision maker uses another lot size q' which is related to q^* by the relation $q' = bq^*,\ b > 0$.

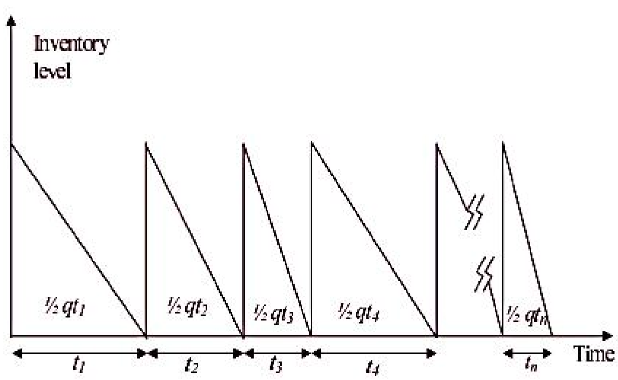
Let C′ designate the average total cost of the system then. We use the ratio C′ /C* as a measure of sensitivity. It can be shown that $C'/C^* = (1+ b^2)/\ (2b)$.

So, the measure of sensitivity is a function of b and is independent of the other parameters c_1, c_3 and *R*.

Model I (b): EOQ Model with Different Rates of Demand

This inventory system operates on the assumptions of Model I(a) except that the demand rates are different in different cycles but order quantity is fixed in each cycle. The objective is to determine the order size in each reorder cycle that will minimize the total inventory cost. Suppose that the total demand D is specified over the planning period T. If $t_1,\ t_2, \ldots,\ t_n$ denote the lengths of successive n inventory cycles and $D_1, D_2, \ldots, D_n$ are the demand rates in these cycles, respectively, then the total period *T* is given by $T = t_1+t_2+\ldots+t_n$. the following figure depicts the inventory system under consideration.

Fig-14.3 EOQ Model with Different Rates of Demand



Inventory-time diagram for different cycles

Suppose that each time a fixed quantity *q* is ordered. Then the number of orders in the time period *T* is $n = D/q$. Thus, the inventory carrying for the time period *T* is

$$\frac{1}{2}qt_1c_1 + \frac{1}{2}qt_2c_1 + \ldots + \frac{1}{2}qt_nc_1 = \frac{1}{2}qc_1(t_1 + t_2 + \ldots + t_n) = \frac{1}{2}qc_1T$$

Total ordering cost = (Number of orders) × $c_3 = \frac{D}{q}c_3$

Hence, the total inventory cost is $C(q) = \frac{1}{2}c_1qT + \frac{C_3D}{q}$

The optimal ordering quantity (q*) is then determined by the first order condition as

$$q^* = \sqrt{\frac{2c_3(D/T)}{c_1}}$$

The minimum total inventory cost is obtained by substituting the value of $q*$ in the cost equation, i.e.,

$$C_{min} = \sqrt{2c_1c_3(D/T)}$$

Here we observe from the optimal results that the fixed demand rate *R* in Model I(a) is replaced by the average demand rate *(D/T)* in this model.

II. QUANTITY DISCOUNT MODELS

A quantity discount is an incentive offered to a buyer that results in a decreased cost per unit of goods or materials when purchased in greater numbers. A quantity discount is often offered by sellers to entice customers to purchase in larger quantities. The seller is able to move more goods or materials, and the buyer receives a more favorable price for them. At the consumer level, a quantity discount can appear as a BOGO (buy one, get one discount) or other incentives, such as buy two, get one free. Quantity discounting can be fruitful. The principal benefit is to increase total sales volume in order to realize economies of scale. Quantity discounts boost units per transaction (UPT). The resulting increased sales volume can lead to economies of scale in the form of purchasing goods and materials in bulk at a quantity discount from suppliers, and the ability to combine incidental per-order costs, such as shipping and packaging, into one sale. These economies of scale have the potential to reduce per-unit costs to the seller.

II.(a) Inventory Model with Single Discount

The purchase inventory model with single discount may be expressed as follows:

Order Quantity	Unit Price (Rs.)
$1 \le Q_1 < b$	P_1
$b \le Q_2$	P_2

Following are the steps to summarize the approach.

1. Compute the optimal order quantity for the lowest price (highest discount), i.e.,

$$Q_2^* = \sqrt{\frac{2DC_o}{C_hP_2}}$$

and compare the value of Q_2* with the quantity b which is required to avail the discount. If Q_2* ≥ b, then place orders for quantities of size Q_2* and obtain discount; otherwise move to step 2.

and compare the value of Q_2* with the quantity b which is required to avail the discount. If Q_2* ≥ b, then place orders for quantities of size Q_2* and obtain discount; otherwise move to step 2.

2. Compute Q_1* for price P_1 and compare TC(Q_1*) with TC(b). The values of TC(Q_1*) and TC(b) may be determined as follows:

$$TC(Q_1^*) = DP_1 + (D/\text{Q1}\,*) \times C_o + (Q_1/2) \times C_h \times P_1$$

$$TC(b) = DP_2 + (D/b) \times C_o + (b/2) \times C_h \times P_2$$

If TC (Q_1*) > TC (b), then place orders for quantities of size b to get the discount.

Illustration

A big cold drinks company, the Kaliya Soft Drinks buys a large number of pallets every year, which it uses in the warehousing of its bottled products. A local vender has offered the following discount schedule for pallets:

Order Quantity	Unit Price (Rs.)
Upto 699	10.00
700 and above	9.00

The average yearly replacement is 2000 pallets. The carrying costs are 12% of the average inventory and ordering cost per order is Rs. 100.

Solution:

Given

D = 2000 pallets/year, C_h = 0.12, C_o = Rs. 100, P_1 = Rs. 10, P_2 = Rs. 9.00

Step 1

The lowest price (highest discount) is RS. 9.00.

$$Q_2{}^* = \sqrt{\frac{2DC_o}{C_hP_2}}$$

$$Q_2{}^* = \sqrt{\frac{2 \times 2000 \times 100}{0.12 \times 9}}$$

= 608.58 pallets/order

Since Q_2* < b (i.e., 608 < 700), Q_2* is not feasible.

Step 2

$$Q_1{}^* = \sqrt{\frac{2DC_o}{C_hP_1}}$$

$$Q_1{}^* = \sqrt{\frac{2 \times 2000 \times 100}{0.12 \times 10}}$$

= 577.35 pallets/order

TC(Q_1*) = TC(577.35) = 2000 × 10 + (2000/577.35) × 100 + (577.35/2) × 0.12 × 10

= Rs. 20692.82

TC(b) = TC (700) = 2000 × 9 + (2000/700) × 100 + (700/2) × 0.12 × 9
= Rs. 18663.71

Since TC(b) < TC(Q_1*) and hence the optimal order quantity is the price discount quantity, i.e., 700 units.

II.(b) Inventory Model with Double Discount

Order Quantity	Unit Price (Rs.)
$1 \le Q_1 < b_1$	P_1
$b_1 \le Q_2 < b_2$	P_2
$b_2 \le Q_3$	P_3

Where b_1 and b_2 are the quantities, which determine the price discount.

Following steps are followed in this approach:

1. Compute the optimal order quantity for the lowest price (highest discount), i.e., Q_3* and compare it with b_2

a. If $Q_3^* \ge b_2$, then place order equal to this optimal quantity Q_3*

b. If $Q_3^* < b_2$, then go to step 2

2. Compute Q_2* and since $Q_3^* < b_2$, this implies Q_2* is also less than b_2. Thus, either $Q_2^* < b_1$ or $b_1 \le Q_2^* < b_2$

a. If $Q_2^* < b_2$, but $\ge b_1$, then proceed as in the case of single discount, i.e., compare TC(Q_2*) and TC(b_2) to determine the optimal purchase quantity.

b. If $Q_2^* < b_2$ and b_1, then move to step 3

3. Compute Q_1* and compare TC(b_1), TC(b_2) and TC(Q_1*) to determine the purchase quantity.

Illustration

A large dairy firm, the Cow and Buffalo Company, buys bins every year, which it uses in the warehousing of its bottled products. A local vender has offered the following discount schedule for bins:

Order Quantity	Unit Price (Rs.)
Upto 699	10.00
700 to 949	9
950 and above	8

The average yearly replacement is 2000 bins. The carrying costs are 12% of the average inventory and ordering cost per order is Rs. 100.

Solution:

Given
$D = 2000$ bins/year, $C_h = 0.12$, $C_o =$ Rs. 100, $P_1 =$ Rs. 10, $P_2 =$ Rs. 9, $P_3 =$ Rs. 8

Step 1

The lowest price (highest discount) is Rs. 8. Thus calculating Q_3* = corresponding to this range as follows:

$$Q_3{}^* = \sqrt{\frac{2DC_o}{C_hP_3}}$$

$$Q_3{}^* = \sqrt{\frac{2 \times 2000 \times 100}{0.12 \times 8}}$$

= 645.49 bins/order

Step 2

Since $Q_3^* < b_2$ (i.e., 645.49 < 950), go to step 2 to determine Q_2^*

$$Q_2{}^* = \sqrt{\frac{2 \times 2000 \times 100}{0.12 \times 9}}$$

= 608.58 bins/order

Again, since $Q_2^* < b_2$ and b_1 (i.e., 608.58 < 950 & 700) go to step 3 to calculate Q_1^* and compare total inventory cost corresponding to Q_1^*, b_1 and b_2.

Step 3

$$Q_1{}^* = \sqrt{\frac{2 \times 2000 \times 100}{0.12 \times 10}}$$

= 577.35 bins/order

$TC(Q_1^*)$ = TC(577.35) = 2000 × 10 + (2000/577.35) × 100 + (577.35/2) × 0.12 × 10 = Rs. 20692.82

$TC(b_1)$ = TC(700) = 2000 × 9 + (2000/700) × 100 + (700/2) × 0.12 × 9 = Rs. 18663.71

$TC(b_2)$ = TC(950) = 2000 × 8 + (2000/950) × 100 + (950/2) × 0.12 × 8 = Rs. 16666.52

The lowest total inventory cost is $TC(b_2)$ = Rs. 16666.52 and hence the optimal order quantity is the price discount quantity of 950 units, i.e., $Q^* = b_2 = 950$ units.

(b) Re-Order Point

After determining the optimum quantity of purchase order, the next problem is to specify the point of time when the order should be placed. Re-order level is that level of inventory at which an order should be placed for replenishing the current stock of inventory. The determination of re-order point depends upon the lead time, usage rate and safety stock. These terms are explained below:

1. **Lead Time:** Lead time refers to the time gap between placing the order and actually, receiving the items ordered.
2. **Usage Rate:** It refers to the rate of consumption of raw material per day.

Usage Rate = Total annual consumption / No. of days in a year

3. **Safety Stock:** It is the minimum quantity of inventory which a firm decides to maintain always to protect itself against the risk and losses likely to occur due to stoppage in production and loss of sale, due to non-availability of inventory.

Formulae:

Re Order Point = (Lead Time × Usage Rate) + Safety Stock or

Re Order Point = Maximum usage × Maximum Re Order Period

Safety Stock = Usage Rate × Days of safety

(c) Fixing Stock Levels

Fixing of the stock levels is necessary to avoid increased cost on account of high inventory levels and to avoid loss of sales or stoppage of production due to low level of inventory. Therefore, efforts should be made to keep the inventory level within the specified minimum and maximum limits. The maximum & minimum stock levels are fixed after considering the following factors:

- Availability of ample storage space.
- Lead time involved i.e. time required in receiving the goods ordered.
- Availability of working capital to meet the routine expenses.
- Average rate of consumption of material
- Cost of storage and insurance of inventory.
- Risk of obsolescence and deterioration of the inventory.
- Economy in prices such as making bulk purchases during period of low prices.
- Re-order level.

Formulae

Maximum Level = (ROL + ROQ) – (Minimum Usage × Minimum Re Order Period)

or

= Safety Stock + EOQ

Minimum Level = Re-order level – (Normal Usage Rate × Normal Re-order period)

or

= Re-Order Level – (Normal Usage × Average Re-Order Period)

Average stock level = (Maximum level + Minimum level) / 2

or

= (Minimum level + 1/2 Re-order Quantity)

Note: *ROL – Re Order Level*

ROQ – Re Order Quantity

ROQ is also known as EOQ (Economic Order Quantity)

Danger Level

Danger level refers to the level below the minimum stock level. The following factors should be considered to determine the danger level:

- Causes for failure of regular supplies

- Easy and quick sources of supply
- Rescheduling of work- order in the light of such exigencies
- Quickest means of transportation
- Emergency period of procurement

Formula

Danger Level = Minimum rate of consumption × Emergency delivery period.

or

= Maximum rate of consumption × Emergency delivery period.

(d) SELECTIVE INVENTORY CONTROL

Controlling all inventories in the stock is a very difficult task especially where huge inventories are maintained of variety of items. In such circumstances, following smart techniques for managing and controlling the different types of inventories held are as follows:

1) ABC Classification:

As there are enormous materials in the warehouse, we cannot manage all the materials in the same way. Important parts should be paid more attention to, and those cheaper and less important materials should be managed in a simple way or not managed. Materials are classified into three classes. In planning, order releasing, receiving, storing, counting, and costing, we use sophisticated and precise approach for class A materials, and simpler approach for class C materials.

Stock Keeping Unit (SKU)

An item may be stocked at many warehouses. An item at a particular geographic location is called an SKU. For example, one item stocked at two plants and four distribution centers would represent six SKUs. In determining the classification of a material, all the SKUs have to be included.

Application of Pareto's Law

Inventory control is exercised by controlling individual stock keeping units. Pareto's Law observes that a small number of items often dominate the results achieved. In inventory control, it is found that the relationship between the percentage of the number of items and the percentage of the annual dollar usage follows a pattern. We can classify items into three classes based on their observed dollar usage:

1. Class A: About 10% to 20% of the items account for about 50% to 80% of the dollar usage,

2. Class B: About 20% to 30% of the items account for about 15% to 20% of the dollar usage,

3. Class C: About 50% to 70% of the items account for about 5% to 10% of the dollar usage.

Steps in ABC classification include:

1. Determine the annual usage for each item,
2. Calculate the annual dollar usage for each item,
3. Sort the items according to their annual dollar usage,
4. Calculate the accumulated annual dollar usage, percentage of the accumulated annual usage, and the accumulated percentage of the items,
5. Group the items into A, B, and C classes based on the percentage of annual usage.

Control Approaches

"C" class items account for only a small percentage of total dollar usage but are vital to the entire production process. A shortage of a single C class material could result in interruption of the operations in a plant. Simple control approaches that call for large quantities and high safety stocks are used to ensure that there is an adequate amount of C class materials anytime. A two-bin system is an approach for inventory management of C class items.

"A" class items are extremely important and deserve the tightest control and the most frequent reviews. Tight control includes absolutely accurate records, regular reviews by management, frequent reviews of demand forecasts, and close follow-up and expediting to reduce the lead times. TPOP (for independent items), MRP (for dependent items), and close following up of purchase and shop orders are types of inventory planning and control used for A class items.

Normal controls with good record keeping are applied to B class items. Both MRP and ROP are commonly applied in planning and controlling B class items.

Illustration:

The following data is related to Paroma Ltd.:

Item No.	11	12	13	14	15	16	17
Unit Cost	5	10	14	7	6	15	20
Annual Demand	47000	1500	200	700	4700	1100	17000

Categorize the items according to ABC analysis.

Solution:

Total Spending per year

Item No.	**Unit Cost**	**Annual Demand**	**Total Cost Per Year**
11	5	47000	2,35,000
12	10	1500	15,000
13	14	200	2,800
14	7	700	4,900
15	6	4700	28,200
16	15	1100	16,500
17	20	17000	3,40,000

Usage of item in total usage

Item No.	**Unit Cost**	**Annual Demand**	**Total Cost Per Year**	**% of Total Usage**
11	5	47000	2,35,000	36.58%
12	10	1500	15,000	2.33%
13	14	200	2,800	0.44%
14	7	700	4,900	0.76%

15	6	4700	28,200	4.39%
16	15	1100	16,500	2.57%
17	20	17000	3,40,000	52.93%
			6,42,400	**100.00%**

Sort the items by usage

Item No.	Unit Cost	Annual Demand	Total Cost Per Year	% of Total Usage	Cumulative % of total
17	20	17000	3,40,000	52.93%	52.93%
11	5	47000	2,35,000	36.58%	89.51%
15	6	4700	28,200	4.39%	93.90%
16	15	1100	16,500	2.57%	96.47%
12	10	1500	15,000	2.33%	98.80%
14	7	700	4,900	0.76%	99.56%
13	14	200	2,800	0.44%	100%
			6,42,400	**100.00%**	

ABC classification

Category	**Items**	**% usage**	**Action Needed**
A	17,11	89.50%	Close control
B	15,16,12	9.27%	Regular review
C	14,13	1.23%	Infrequent review

ABC analysis is a valuable tool to enable companies dedicated to strategic cost management to measure the current status for their materials management system and introduce certain changes in the inventory control policies in such a manner that it yields the largest cost management benefits in the near and middle term periods. ABC analysis is based upon the Pareto principle which focuses on the concept 'Critical Few Trivial Many'. ABC analysis divides the inventory items into three categories - A, B and C. These categories are identified on the basis of the number of items and the total value in rupees for each inventory item. The process starts from the classification of inventory, then ascertaining their cost and assigning ranks which is followed by the calculation of percentages. On the basis of these, the categories A, B and C are determined. After determining the categories, the inventory management policies, control mechanisms, procurement and warehousing policies are framed for each category in a different manner according to their impact on overall inventory cost. Thus, ABC analysis suggests that inventories of an organization are not of equal value and so different policies and treatment should be given in order to minimize the efforts and time as well as maximize the profits through savings in cost.

2) **VED Analysis:** VED stands for Vital, Essential and Desirable. Highest control is over vital items, medium control is exercised over essential items and least control is inferred over desirable items.
3) **SDE Analysis:** SDE stands for Scarce, Difficult and Easy. Highest control is over scarce items, medium control is exercised over difficult items and least control is inferred over easily available items.
4) **FSN Analysis:** FSN stands for Fast Moving (F), Slow Moving (S) and Non-Moving (N). Highest control is kept over fast-moving items, medium control is exercised over slow-moving items and least control is inferred on non-moving items.

(II). TRADITIONAL TECHNIQUES

Traditional techniques refer to those techniques which are prevalent before the evolution of the modern techniques. These techniques were derived with the working practice and are based on experience and ease of usage by the workers and the small business enterprises. These techniques are explained as follows:

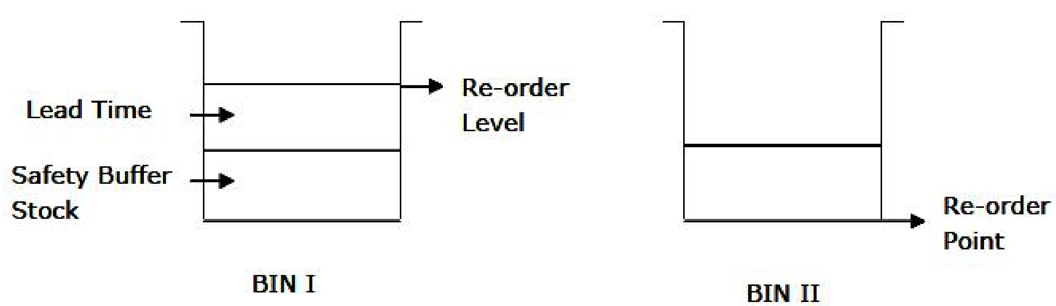
(A) INVENTORY CONTROL RATIOS

Ratios related to inventory are calculated and further used as a measure of control.

$$\textit{Stock Turnover} = \textit{Cost of goods sold} / \textit{Average Stock}$$

(B) TWO BIN SYSTEM

Under two bin systems, all the inventory items are stored in two separate bins. Bin means container of any size. In the first bin, a sufficient amount of inventory is kept to meet the current requirement over a designated period of time. In the second bin, a safety stock is maintained for use during lead time. When the stock of first bin is completely used, an order for further stock is immediately placed. The material in second bin is then consumed to meet stock needs until the new order is received. On receipt of new order, the stock used from the second bin is restored and the balance is put in the first bin. Therefore, depletion of inventory in the first bin provides an automatic signal to re-order. Thus, this technique is traditional yet logical and can be used by illiterate workers also without using any formula.



(C) PERPETUAL INVENTORY SYSTEM

Perpetual inventory system is defined as the method of recording stores balance after each receipt and each issue to facilitate regular checking of inventory. It is also known as continuous stock checking. The application of perpetual inventory control system involves:

(i) Attaching bin cards with bins.

(ii) Continuous stock taking to compare the actual stock.

Bin cards refers to the cards attached to every bin in which the details regarding the quantity of material received, issued and balance left in that bin is recorded hand to hand. Under this system, statement of material, follow up actions, monitoring etc. can be smoothly carried out.

(D) PERIODIC ORDER SYSTEM

Under this system, the stock levels of all types of inventories held, are reviewed after a fixed time interval. Time interval may be weekly, fortnightly, monthly, quarterly etc. depending upon the criticality of the item. Critical items may require a short review cycle and on the other hand, lower cost and non-moving items may require long review cycle. Therefore, for different items different time intervals should be used. After the review, the items which are less than the required level, order is placed to replenish their exhausted level.

Discussion Forum

Short Questions

1. Define Inventory.
2. What are the types of inventory?
3. What do you mean by inventory management?
4. Mention any 5 objectives of inventory management.
5. Mention the assumptions are made in calculating an economic order quantity?
6. What is the EOQ?
7. If we place orders that are larger than the EOQ, why does the total cost rise?
8. If we use the economic order quantity, which is bigger, the reorder cost component or the holding cost component?
9. What is the reorder level?
10. Define EOQ.

Essay Type Questions

1. Explain in detail about the factors affecting the level of inventory.
2. Describe your understanding of various techniques of inventory controls based on Modern techniques and Traditional techniques.
3. Discuss the Pareto principle on the basis of which ABC classification technique is developed.
4. A Keerthivel company will require 1, 00,000 units of a product during the next year. The cost of processing an order is Rs. 40 and the carrying cost per unit is Rs.2 per year. Lead time of an order is 5 days and the company will keep a safety stock of two days usage. Assume 250 days in a year.

You are required to calculate the following:
1. Economic order Quantity
2. Re-order Point
3. Minimum Inventory
4. Maximum Inventory
5. Average Inventory.

5. Haripranav enterprises manufacture a product ‘EMR’. The following particulars are collected for the year 2016:

1. Annual demand of EMR- 1,000 units
2. Cost of placing an order Rs. 100
3. Annual carrying cost per units Rs. 10
4. Normal usages 100 units per week
5. Minimum usages 50 units per week
6. Maximum usages 150 units per week
7. Re-order period 2 to 6 weeks

Calculate the following:
a. Re-order Quantity

b. Re-order level
c. Minimum Level
d. Maximum Level
e. Average stock level

6. If demand for an item is 10 units a week, the economic order quantity is 30 units and the lead time is 7 weeks, how many orders will be outstanding. when it is time to place another order?
7. Orders should be placed when stock on hand declines to the reorder level; does this mean that continuous monitoring of stock levels is needed?
8. The main concern of an organization is customer service, and this often needs high stocks. Why, then, are we concentrating on minimizing the cost of stock, when we should be more concerned with raising stock levels?
9. What costs are incurred by holding stock? How would you set about finding these? Why are shortage costs so difficult to find?
10. What are the assumptions of the economic order quantity? How valid are these? What factors in real inventory control are not included in the economic order quantity model?
11. The variable cost rises slowly around the EOQ, and the analysis is based on a series of assumptions and approximations. Why, then, do we bother with the calculations rather than allowing inventory managers to design policies based on their experience? Would they get good results without bothering with the formal analysis?
12. What are the benefits of short lead times? How can these be achieved in practice?
13. Saranya Enterprises require 2, 70,000 units of a certain item annually. The cost per unit is Rs.3, the cost per purchase order Rs.100 and the inventory carrying cost Rs.6 per unit per year. What is the economic order quantity?
14. If you are uncertain about the values used to find an EOQ, would you generally prefer larger or smaller orders?
15. If an economic order quantity is calculated, but an order is then placed which is smaller than this, will the variable cost increase or decrease?
16. If we place orders that are bigger than the EOQ, the variable cost rises quickly because of the increased holding cost. Do you think that this is true?
17. If items have to be ordered in integer quantities, it is always better to round the EOQ upwards. Do you agree with this?

Case Study: Inventory Management

How Do We Reduce Inventory Levels?

A manufacturer of computer peripheral devices was look-ing to improve its balance sheet and P & L by reducing inventory and the associated carrying costs, while improving customer service. The products required to support different customer channels varied from expensive long-lead time engineered systems to relatively low-value standalone units that supported personal computers. The company needed to completely revamp its inventory, manufacturing and product support policies, procedures and practices to reflect the dramatic and fast changes to its product line.

The two main questions that needed answered were:

1. What would the impact be on profit from the disposal of obsolete inventory in order to improve the balance sheet?
2. How do we institute a program to prevent the buildup of obsolete inventories by disposing of slow movers on a regular basis?

Establish performed a logistics cost/performance bench-mark for all of the divisions showing that inventory carrying costs were extremely high. The bulk of the problem was in inventory management, there were problems managing the broad mix of products required as well as large amounts of obsolete and slow-moving inventory.

A cross functional team was formed that included members from Operations, Marketing, Sales and Finance to evaluate and dispose of excess and obsolete inventories.

The process of creating inventory was benchmarked to "best-practices" to identify improvement opportunities in purchasing, materials management, inventory planning and management, and the manufacturing operations.

In purchasing and materials management it was recommended that the total purchasing power of the corporation be leveraged to obtain more favorable purchasing and consignment agreements by centralizing the purchasing function. At the same time, local materials management functions could be strengthened to improve requisitioning and materials usage and upstream supply chain partnerships were established to improve material flow and reduce purchased parts inventories.

In inventory planning and management, a centralized logistics function was recommended. Written policies and procedures were developed for inventory planning, management and reporting, and a new forecasting and inventory planning business process and information system was implemented. All inventories are now managed more intensively to avoid excess and obsolete inventories and active inventories are deployed and re-deployed based on well-defined forecast requirements.

The promotion process was also brought under control to avoid sudden unanticipated demand on the plants, and manufacturing performance criteria was changed from lowest unit cost and high absorption to meeting the schedule in time and quantity to improve customer service levels.

Source: https://www.establishinc.com/inventory-management

CHAPTER-15

MAINTENANCE MANAGEMENT

INTRODUCTION

In the current global competitive business environment, to be successful at both national and international levels, the organizations need to ensure that their production systems and equipment performs at its maximum level. Amidst of rapidly changing customer demands, there is a requirement for increased product quality, which can be ensured only through reduced cycle time and the ultimate operating efficiency. In this context the organizations today need to keep their infrastructure in its original form in order to meet the various requirements in the market. Hence, the organizations need to invest a sum of capital in the function of 'maintenance' to ensure the quality of their physical assets and other infrastructure.

In organizations, the plant and equipment, along with the associated capital assets have to be ensured in expected condition in order to ensure better productivity. A well-structured maintenance is very much required in the organizations to improve operational effectiveness, revenues and customer satisfaction while reducing capital, operating and overhead costs.

Maintenance Management is among the centre stage of operations management in many manufacturing sectors of the economy. As the industries move from being labor intensive to mechanization and to automation, the role of maintenance management is becoming crucial to maintain the quality and quantity of output. Modern factories are capital intensive. Adequate availability of equipment and facilities are necessary for uninterrupted productions which ensures high capacity utilization for quick recovery of investments.

CONCEPT OF MAINTENANCE

Maintenance is the activity to ensure the physical assets to continue to do what their users wanted to do. Maintenance includes activities to improve the quality over and above the design capability and also augment the capacity through debottlenecking, modification and modernization.

Maintenance needed to be started at the design of process and selection of equipments. This will ensure adequate attention to reliability and maintainability of equipments. The total cycle cost of equipment plays major role in the overall cost of the product and it should be maintained low in the organizations. The life cycle cost of equipment has two parts.

- Cost of the equipment including installation cost and commissioning cost.
- The yearly maintenance and operational cost

Equipment with low initial investments usually involves high operational and maintenance costs and for the same capacity or output equipment with high initial investments involves low operational and maintenance costs. Hence an optimum degree of reliability and maintainability have to be maintained, which in turn lead to low production costs.

Reliability

Reliability is defined as "the probability that the equipment will give design performance over a given length of time without failure or interruption."

There are a number of measures of reliability and the classic one is "Mean Time between Failures (MBTF)". MBTF is the average time between two successive failures of the equipment that can be repaired.

Maintainability

Maintainability refers to how easily the equipment can be repaired. The important measure of maintainability is "Mean Time To Repair". Usually the maintenance takes place as soon as the equipment fails and hence Mean

Time Down (MTD) is considered as the important measure of maintainability. A high maintainability leads to low mean time down.

Availability

An improved measure of reliability and maintainability is availability. Availability is defined as the fraction of total time the equipment is ready for production.

$$\text{Availability} = \frac{\text{Time for which equipment is ready for production}}{\text{Time for which equipment is ready for production} + \text{Time for which equipment is down}}$$

$$= \frac{\text{MBTF}}{\text{MBTF} + \text{MTD}}$$

Improving Availability

Availability can be improved in many ways and the important among them is Total Maintenance. It involves

- Better design of equipments
- Better training of maintenance crew
- Installing scientific maintenance systems and procedure
- Adopting suitable maintenance procedures
- Choosing appropriate maintenance policy for each groups of equipments based on critically, failure pattern, maintenance cost, down time cost.

Definition for Maintenance

Maintenance can be defined as "a productive activity undertaken to bring an equipment, facility or system back to its original level of performance in terms of quality and quantity of output."

Maintenance is defined as "the management, control, execution and quality assurance of activities which ensure the achievement of optimum availability and performance of a plant in order to meet business objectives."

MAINTENANCE MANAGEMENT

Maintenance management is a cross-disciplinary area involving different types of tasks such as

- Deciding on maintenance strategies
- Setting policies for maintenance and inventory management
- Scheduling specific tasks with regard to staff
- Resources and scheduled production, etc.

Generally maintenance management may include the following activities such as:

- Providing the required type of maintenance for the facilities and resources according to the nature and expectations.
- Ensuring the facilities monitoring activities to anticipate failure, including equipment self-check and diagnostic activities

- Preparing maintenance budget by estimating the maintenance cost and using performance reports
- Supervising the schedules and planned maintenance in organizations.
- Reporting on performed maintenance, including spare parts used, maintenance labours, and maintenance costs
- Coordinating planned tasks with operators and plant supervisors
- Monitoring performance of organization's resources and facilities through schedules inspections
- Maintaining and updating of maintenance files to support data collection and analysis

Definition

Maintenance Management is defined as "an orderly and systematic approach of administrative, financial, and technical framework for assessing, planning, organizing, monitoring and evaluating maintenance and operation activities and their costs on a continual basis."

NEED FOR MAINTENANCE

The organizations need to adapt good maintenance practices for the following reasons:

- The organizations need to improve their competitive advantage in order to compete in this global business environment. Hence, they need to ensure quality products and services to their customers to retain them. It can be done only through effective maintenance function. The facilities and resources in the organizations have to maintain in effective condition to ensure the process and product/service quality.
- Effective maintenance management practices are very important for the organizations to ensure cost control. Nowadays, most of the organizations adapt automation to improve the speed and quality of the process. Hence the resources and facilities are expected to function reliably and economically without any breakdowns to ensure high productivity. Moreover breakdowns lead to high damages in terms of cost as well as productivity. Therefore the maintenance function is very important.
- One of the performance measures that an organization uses to distinguish itself from others is 'Dependability'. Hence, they need to have reliable facilities and resources to respond to the customers demand and expectations whenever required. So, the organizations are expected to ensure their equipments in reliable condition using good maintenance strategies to remain competitive.
- Nowadays, most of the modern manufacturing organizations have started using Just-In-Time strategies which operate with zero inventories. These organizations can experience loss of productivity, market and revenue due to the breakdown of machineries. Hence, effective maintenance is very much needed for these kinds of organizations.
- The organizations operating in industries involving high investments such as airlines, refineries, power stations, etc. require good maintenance, since the breakdown may result in high damages for such companies. So they need to adapt an appropriate maintenance system in order to keep their facilities and resources in best condition.

ADVANTAGES OF EFFECTIVE MAINTENANCE

An effective maintenance system has the following advantages in the organizations:

- It increases the lifetime of machinery, equipment and other resources related to the plant and organization.

- It ensures the operations, according to the schedule and plans. This ensures that the products /services are generated and delivered to customers on time, according to the due dates and hence a high level of customer satisfaction is ensured.
- Since the machines and other resources are maintained in reliable and good condition, quality of the products is assured in the market.
- Since effective maintenance practices reduce damages and breakdowns in the resources and facilities, the loss in productivity is reduced.
- If the maintenance is happening according to the schedule, the idle time of both employees and machines can be controlled effectively. This results in increased productivity in the operations.

OBJECTIVES AND FUNCTIONS OF MAINTENANCE

The objectives of maintenance management should be decided in par with the overall organizational objectives so that finally the mission of the organization is accomplished. The major objective of maintenance function is to enhance and optimize the performance of operations, facilities and resources in the organizations to improve its productivity.

Some of the objectives of maintenance management are as follows:

(1) To minimize the loss of productive time due to equipment failure and maximize the availability of plant, equipment, machinery and other related resources for optimum utilization through planned maintenance.

(2) To extend the lifetime of the plant, machinery and other facilities by minimizing its wear and tear this improves the economy of the operations.

(3) To minimize the loss in productivity due to production stoppages.

(4) To ensure that the equipment and resources are ready for emergency purposes at all times such as fire-fighting equipment.

(5) To optimally utilize the maintenance equipment and personnel.

(6) To ensure safety of workforce through regular inspection and maintenance of facilities such as boilers, compressors and material handling equipment etc.

(7) To maximize the efficiency and economy of production through optimum utilisation of facilities and resources.

(8) To improve the quality of products and productivity of the plant.

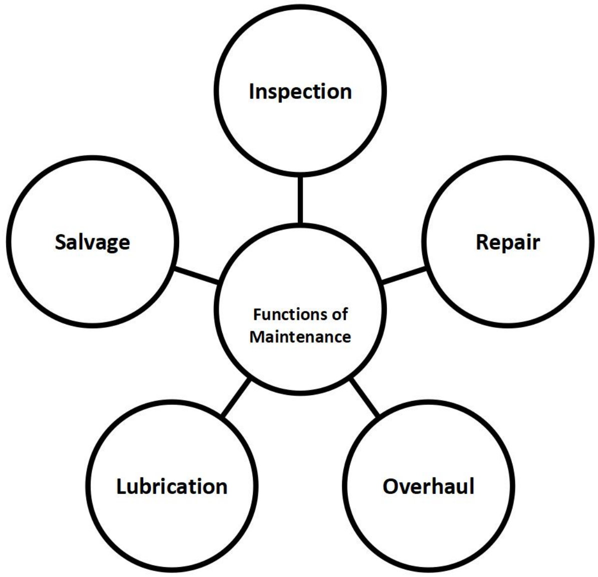
(9) To minimize the total maintenance cost which comprises of cost of repairs, the cost of preventive maintenance and inventory costs associated with spare parts/materials required for maintenance.

(10) To improve reliability, availability and maintainability of the operation system.

FUNCTIONS OF MAINTENANCE MANAGEMENT

The functions of maintenance management discussed as follows:

Fig-15.1 Functions of Maintenance



I. Inspection

Inspection is the critical appraisal of materials, items, or systems involving examination, testing, and gauging. In case of maintenance inspection is about:

- Periodic checking of machineries and other resources in the organization
- Giving proper attention to those equipments and other facilities which are required work in intervals
- Determine the status of repair feasibility
- Control of quality of work done by the system
- Detecting the faults, repairs and damages before the breakdown of equipment so that the equipment can be serviced on time before its breakdown.

II. Repair

- It is the process of repairing the component or replacing the item or part by another item to restore failed or broken down item in working order.
- Repair is any activity which returns the capability of an asset that has failed to a level of performance equal to, or greater than, that specified by its functions, but not greater than its original maximum capability.
- It is nothing but an activity which increases the maximum capability of an asset.

III. Overhaul

- Overhauling is defined as a process of general maintenance performed on a machine or other industrial equipment.
- The goal of overhauling is to keep the system in serviceable condition.
- Regular checks can prevent all kinds of critical damage and hence it falls under preventive maintenance
- Frequency of overhauling is less than lubrication and inspection
- Here the machine is stripped and the various parts are cleaned and oiled and components are replaced

- The frequency of overhauling in routine maintenance is usually scheduled for once a year.

IV. Lubrication

- It helps in maintaining the machine or equipment's accuracy and increases its life
- It can done by the operator himself/herself on the basis of daily, weekly, fortnightly or monthly
- Lubrication is the very important for running a machine without any pre-matured failure.
- It is used to minimize power losses, heat generation, and, wear and tear of mechanical components. Also, it is used for smooth running of the machine.

V. Salvage

- Salvage is the property that has value in excess of its value as a scrap and is cannot be used for its planned or original purpose.
- Maintenance process helps the organization to manage the salvage by recovering or saving abandoned, condemned, damaged, deteriorated, discarded, incomplete, obsolete, or worn out property through recycling, re-fabrication, restoration, reuse, or scrapping.
- The other functions of maintenance can be summarized as follows:
- To develop maintenance objectives, policies & strategies, procedures and standards for the maintenance function.
- To schedule the maintenance process on consultation with the concerned production departments.
- To carry out repairs and/or overhaul the equipment and other facilities for ensuring required level of availability and operational efficiency.
- To ensure scheduled inspection, lubrication and adjustment of plant machinery and equipment.
- To plan and execute periodic inspections of equipment and other facilities to ensure their conditions related to their failure and stoppage of operation.
- To estimate and prepare an inventory list of spare parts and other materials required for conducting the maintenance operations.
- To ensure economy in the maintenance process by effective cost control process.
- To forecast various costs associated with maintenance and prepare the maintenance budget. Also to have a better control over the maintenance expenditure as per the estimated budget.
- To recruit and train personnel to for effectively carrying out the maintenance functions.
- To ensure safety standards as for the use of equipment and other facilities, especially boilers, overhead cranes and chemical plants.
- To document and maintain records of all maintenance activities to help in future decision making.
- To collect and store the relevant information regarding the maintenance systems in Management Information Systems (MIS) to disseminate required information.
- To monitor and control the condition of equipment and other facilities using inspection methods at regular intervals to prevent the breakdowns.

Besides the rectification of the faults in the equipment, the advanced functions of the maintenance department include:

- Up gradation of the existing plants and equipment, and training maintenance personnel to attend the required technical skills.
- Cost optimization of all maintenance functions
- Reconditioning of serviceable spare parts.
- Development of indigenous sources for parts for import substitution
- Setting up of an effective Maintenance Information Management Systems (MIMS).
- Effective utilization of the maintenance workforce
- Setting up of in house R&D activities for effecting improvements in maintenance practices.

MAINTENANCE TYPES

Maintenance activities can basically be divided into two parts: planned maintenance activities and unplanned maintenance activities.

PLANNED MAINTENANCE

Planned maintenance is a proactive approach where maintenance work is scheduled and executed on a regular basis. The nature of maintenance work and frequency depends on the nature of equipment, and the environment in which it is operating. The primary objective of planned maintenance is to maximize equipment's performance by ensuring the equipment and other related facilities to function properly for the maximum period, without any deteriorations or unplanned outages.

Benefits of planned maintenance include:

- Reduces unplanned equipment downtime and improves overall equipment performance.
- Repair costs are greatly reduced since the problems associated with the system are fixed well in advance even they are minor.
- Manpower and other resources can be effectively utilized in this type of maintenance since the maintenance work, spare parts inventory, and tool costs can be evenly planned throughout the year.
- Functions such as spare parts inventory and purchasing are planned properly.
- Manufacturer's requirements for warranty compliance are properly assured to ensure good customer satisfaction.
- Overall maintenance costs are controlled effectively.

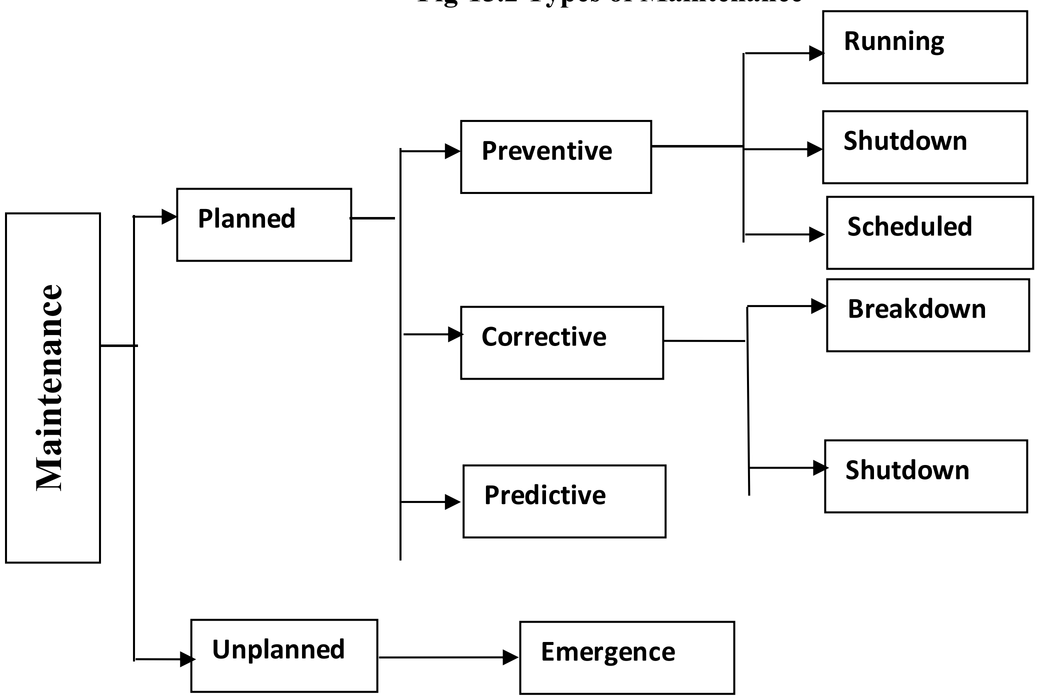
Further planned maintenance is classified into three categories such as:

a) Preventive maintenance

b) Corrective maintenance

c) Predictive maintenance

Fig-15.2 Types of Maintenance



a. Preventive Maintenance

Preventative maintenance is a type of planned maintenance aimed to prevent future breakdowns and failures in a properly functioning system. Preventive maintenance is actually performed to prevent equipment failure even before it actually occurs to keep the same work in expected condition and also to ensure the extended life of equipment and other related facilities.

- It is primarily based on the principle that 'prevention is better than cure'.
- It is a set of activities that are performed on plant equipment, machinery, and systems before the occurrence of a failure in order to protect them and to prevent or eliminate any breakdown in their operations.
- It is designed and executed in such a way to enhance the equipment's reliability by identifying and replacing/repairing the damaged components before they actually fail.
- Preventive maintenance activities include the following activities such as equipment checks, partial or complete overhauls at specified periods, oil changes, lubrication, etc.
- It is carried out at predetermined intervals or according to estimated schedules to reduce the probability of failure or degradation on the machineries, equipment and the other facilities.

Advantages

- Ensures the quality of the assets and keep them running for longer periods than other types of maintenances.
- Long-term repair costs get reduced since maintenance is carried out before the failures.
- Safety is greatly ensured due to the reduced likelihood of catastrophic failure

- Eliminates/ reduces undetermined break down on the equipment and resources which finally reduces the down time
- Since there is no odd-time repair, over time of crews is highly reduced
- Lower maintenance and repair costs
- Great control over stand-by equipment and spare parts
- Ensures better product quality from the system and hence results in fewer reworks and scraps
- Increases plant life
- High chances for the employees to get a production incentive bonus, since the system is supporting well to perform.

Preventive Maintenance is further classified into three types as follows:

i. Running maintenance

ii. Scheduled maintenance

iii. Shut down maintenance

i. Running Maintenance

Running maintenance includes those maintenance activities that are carried out while the machine or equipment is running. It is carried out by trained maintenance personnel. It is done on a regular basis to keep the machine functioning efficiently and safely. Some of the examples are lubrication, adjustment of nuts and screws, tightening of loose nut and bolts, etc.

ii. Scheduled Maintenance

Scheduled Maintenance is carried out at regular set intervals to ensure a smooth production line. It requires more cooperation from different departments associated with the operations. Scheduled Maintenance is a type of planned maintenance of a part or assembly of equipment. It is a scheduled service visit carried out by a competent service personnel or team, to ensure that equipment is operating correctly and thus avoid the unscheduled breakdown and downtime. A good example of scheduled maintenance is car maintenance. After estimated kilometers oil should be changed, parts need to be renewed, etc.

iii. Shut down Maintenance

Shutdown maintenance refers to that maintenance function carried out on the whole system while the plant, production line or fac1lity is shut down. It can be performed only when equipment is not in use. Shutting down the machinery is always costly. But sometimes, due to the nature of the defective part/machine, shutdown maintenance may be the only option left with the management. These are performed generally once in three or six months, depending upon the nature of the project. These involve the inspection of the facilities where damages are feasible to occur. Some specific needs of shutdown maintenance are as follows:

- Safety/Law
- Mechanical Efficiency/Productivity
- Turnaround

b. Corrective Maintenance

Corrective maintenance comprises of the actions taken to restore a failed equipment or system to its operational state. This maintenance involves replacing or repairing the component or equipment that causes failure of the overall system.

- This involves the set of tasks intended to correct the defects found in different equipment and facilities that are communicated to the maintenance department by operators of the equipment.
- Here, the activities such as repair or replacement will be carried out only after the failure. Further the source of this failure is inspected and rectified to reduce the frequency of its occurrence.
- It also includes the some of the actions like typical adjustment or redesign of the equipment.

Corrective maintenance is of two types:

i. Breakdown maintenance

ii. Shutdown maintenance

i. Breakdown Maintenance

The breakdown maintenance is a type of maintenance that uses an equipment or facility until it completely breaks down and then repairing it to working order. Breakdown maintenance is triggered by either a planned event such as run-to-failure maintenance or an unplanned event such as the need for reactive or corrective maintenance. After the breakdown, the maintenance staff inspects the faulty machine or equipment and locates any mechanical, electrical or any other fault to correct it immediately. This approach can be followed only when equipment failure does not significantly affect operations.

It is feasible for the small plants where

- There are few types of equipment.
- Simple machines and equipment are used and do not require any specialist to handle the maintenance.
- Where sudden failure does not cause any serious financial losses.

Advantages:

- Need not plan too much. Minimal planning is sufficient
- The process or the system is very simple and is easy to understand
- Since very less work is done per day, limited workforce cab ne used

Disadvantages:

- Sometimes failure is highly unpredictable
- It can also be sometimes extremely costly
- The process poses a safety risk to employees and other assets.

ii. Shutdown Maintenance

Shutdown Maintenance is the maintenance that can only be performed while the equipment is not in use. Shutting down machinery can be costly, but sometimes due to the nature of the defective part/machine, shutdown maintenance is the only viable maintenance procedure.

c. Predictive Maintenance:

Predictive Maintenance is a maintenance technique to predict the future failure point of a machine or equipment component, so that the component can be replaced, based on a plan, just before it fails. Thus, equipment downtime is minimized and the component lifetime is maximized in the system. It is carried out only after collecting and evaluating enough physical data on the performance or condition of equipment such as temperature, vibration or particulate matter in oil, etc., by performing periodic or continuous equipment monitoring.

- It involves the prediction of the failure before its occurrence, identifying the root cause of those failures and overcoming those causes before they result in extensive damage of the equipment.
- It is a type of maintenance performed continuously or at intervals according to the requirements to diagnose and monitor a condition or system. Hence it is also called condition based maintenance.
- The basic aim is to perform maintenance at a scheduled point in time when the maintenance activity is most cost effective but before the equipment fails in service.
- This type of maintenance is generally carried out on mechanical systems where historical data are available for validating the performance and maintenance models for the systems and the failure modes are known.

Advantages

- Increases the component operational life/availability of the equipment
- It allows for preemptive corrective actions in the system.
- It ensures decrease in equipment and process downtime.
- It decreases replacement/repair costs for parts and labour.
- It ensures high product quality, since the equipment finds itself in good condition mostly.
- It improves the safety for employees through environmental safety.
- It improves the worker morale since the employees find themselves in good working conditions.

Disadvantages

- There is a requirement for an increased investment in diagnostic equipment.
- It requires more investment in staff training.
- Much management fails to realize the savings potential through this process.

UNPLANNED MAINTENANCE

Maintenance action which is carried out without any fore thoughts or prior planning is called unplanned maintenance. Unplanned maintenance happens when

- Pre-determined job procedure is not documented
- Labor, materials, tools and equipment required to carry out the task are not estimated
- Their availability assured before commencement of the task.

Maintenance performed without planning which could be related to a breakdown, repair, or corrective work. It may be scheduled even during the normal work cycle. This type of maintenance can cost 3-9 times more than planned maintenance, due to overtime, Call outs and parts being needed quickly.

Disadvantages:

- Failures are expensive here when we use this type of maintenance. Emergency call outs, travel time, labor, parts and hotshot deliveries result in higher expenditure to fix the problem.
- Equipment in less than optimal condition or to the point of failure can reduce the life of the equipment, which is a loss for the organization.
- This type of maintenance mostly won't focus on detecting the root cause of the failures and will likely result in future failures.
- Unplanned maintenance is mostly done under emergency situations which can result in unwarranted risks.

An example for unplanned maintenance is emergency maintenance.

Emergency Maintenance

Emergency maintenance is one of the examples of unplanned maintenance. Emergency Maintenance means critical system changes that cannot wait for Scheduled Maintenance. These changes could destabilize the system if not addressed expeditiously. Examples are gas leakage in chemical plants, fire hazards, breakdown of boiler and turbine, etc.

TOTAL PRODUCTIVE MAINTENANCE (TPM)

TPM is a methodology was originated in Japan to support the lean manufacturing system which provides tools and processes to eliminate waste from the manufacturing process resulting in improved efficiency, effectiveness, and profitability. TPM is a manufacturing strategy that is successfully used globally for achieving the organizational objectives of core competence in the competitive environment.

The TPM implementation methodology provides organizations with guidelines to transform their shop-floor fundamentally by integrating culture, process and technology.

Total Productive Maintenance (TPM) is explained as follows:

Total: Signifies to consider all aspects and involving everybody from top to bottom

Productive: Emphasis on increasing the production and minimizing the troubles in the production function

Maintenance: Equipment kept in good condition by production operators through required repairing, cleaning, greasing, and inspections.

TPM, a Japanese concept was developed during the 1970s by extending preventive maintenance to become more like productive maintenance. TPM is an innovative approach to plant maintenance that is complementary with the concepts of Total Quality Management (TQM), Just in Time (JIT), Continuous Performance Improvement (CPI), and other world-class strategies. TPM is actually used as a strategic tool for improving manufacturing performance by enhancing the effectiveness of production facilities.

Originally it was introduced as a set of practices and methodologies focused on manufacturing equipment performance improvement. But now TPM has transformed into a comprehensive equipment-centric effort to optimize manufacturing productivity. TPM has become a necessary and important part in managing the business strategically and it is nowadays regarded as a profit activity. TPM describes a synergistic relationship among all organizational functions, particularly between production and maintenance, for ensuring:

- continuous improvement of product quality

- operational efficiency
- productivity
- safety

TPM is an indispensable strategic initiative to meet customer's demands on price, quality, and lead-times. TPM aims to promote a culture in which operators develop 'ownership' of their machines, learn more about them, and realize skilled trades to concentrate on problem diagnostic and equipment improvement projects.

From a lean manufacturing perspective, it can help in the elimination of waste to improve the efficiency and profitability of the organization. TPM focuses on systematic identification and elimination of waste, inefficient operation cycle time, and quality defects in manufacturing and processes. TPM is based on teamwork achieve world class levels of overall equipment effectiveness (OEE) through people and technology. TPM is not a maintenance specific policy; rather it is a culture, a philosophy, and a new attitude towards maintenance. An effective TPM program can facilitate enhanced organizational capabilities across a variety of dimensions.

Definitions

TPM is "an innovative approach to maintenance that optimizes equipment effectiveness, eliminates breakdowns, and promotes autonomous maintenance by operators through day-to-day activities involving the total workforce."

TPM is "a partnership between maintenance and production function organizations to improve product quality, reduce waste, reduce manufacturing cost, increase equipment availability, and improve organization's state of maintenance."

OBJECTIVES OF TPM

The objectives of TPM are given as below:

- To improve the effectiveness of the machines in the system
- To improve the efficiency, reliability and effectiveness of maintenance of facilities
- To schedule good maintenance plan for avoiding early maintenance
- To involve the operation team even in smaller scale maintenances such as checklist inspection before starting and after closing the machines
- To plan and execute training programmes for enhancing the skills of employees

The TPM is implemented in the organizations to fulfill the following needs:

- To become world class organizations by satisfying global customers and achieve sustained organizational growth
- Need to change for remaining competitive
- Achieving enhanced manufacturing flexibility
- To improve the organization's work culture and values
- To improve productivity and quality of the organizations
- Use the significant cost reduction opportunities in maintenance related expenses
- Minimize the investments in new technologies to maximize the return on investment.

- Ensuring appropriate manufacturing quality and quantities in a JIT environment
- Regulating the inventory levels and production lead-times for arriving at the optimal equipment available time.
- Optimizing life cycle costs for realizing competitiveness in the global market.
- To avoid problems faced by organizations in the form of tough competition, globalization, increase in raw material costs and energy cost.
- Ensuring more effective use of human resources, supporting personal growth and improving human resource competencies through adequate training and multi-skilling
- To liquidate the unsolved tasks
- To make the job simpler and safer
- To work smarter and not harder

BENEFITS OF TPM

Total Productive Maintenance is implemented in the organizations for ensuring the following benefits:

- TPM helps to take immediate action on small problems before it worsens.
- Helps in reducing the total manpower.
- Reduces the delays and downtime losses by minimizing breakdowns and equipment failures and by reducing setup times.
- Reduces speed losses by minimizing idle time and minor stoppages due to operator-maintenance interfacing and also by reducing losses due to lower output rates than designed.
- Reduces losses due to defects by improving the quality of output and by quicker stabilization of production.
- TPM ensures better energy saving measures and also better safety of men and machine.
- TPM ensures quicker availability of quality spare parts, equipment, tools and other services.

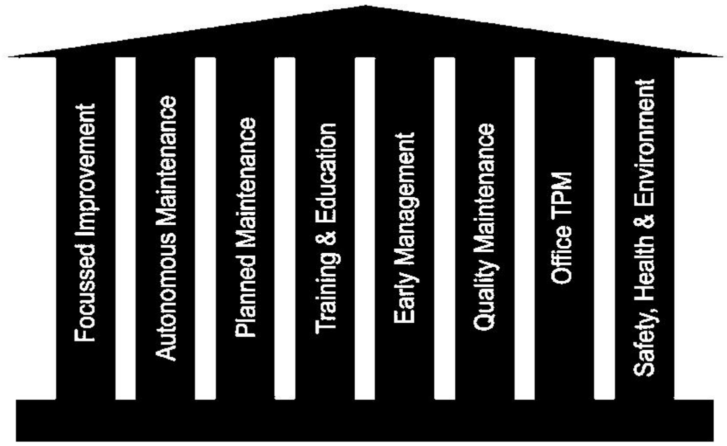
EIGHT PILLARS OF TPM

There are eight pillars on which Total Productive Maintenance rests, each one made up of a series of actions to be carried out, which seek to ensure the effectiveness of the procedure.

1. **Focused Improvement** (Kobetsu Kaizen)

At this stage, the operations team (machine operators) intervenes during the establishment of a maintenance system, which aims to carry out inspection, cleaning, conservation, control, and maintenance tasks. The so-called Kaizen events take place during this stage, not only in order to optimize the equipment, but also the general administrative management of the system.

Fig-15.3 Pillars of TPM



2. Autonomous maintenance

It involves the implementation of a series of incremental and continuous upgrades that aim to improve equipment operation and effectiveness, extend its life, as well as to optimize the system's processes.

This requires:

- A clear definition of the problem and its causes
- Establishment of objectives for improvement
- Formulation of an action plan
- Evaluation of the results of the actions taken

3. Planned maintenance

Planned maintenance seeks, through preventive and improvement actions, to eliminate problems in the system's equipment and installations. When you have a schedule with all the production process plans, it significantly reduces unplanned downtime and increases production rates.

4. Education and training

Since one of the objectives of the TPM is to get everyone in the working group involved, this pillar focuses on improving their skills and competencies. Based on people's performance and the organization's goals, the aim is to acquire, retain, and transfer knowledge.

5. Early equipment management

Unlike corrective maintenance, preventive maintenance seeks to anticipate eventual failures to mitigate their negative impact during the design and assembly phases of the equipment or procedures. What is sought, in addition to ensuring quality, is to reduce the costs arising from the need for the maintenance phase.

6. Quality maintenance

The establishment of a quality plan allows the delimitation and standardization of processes with the aim of reaching defined standards and minimizing non-conformities.

There are tools and systems that allow you to measure and monitor all the processes. It is necessary to:

- Identify the problematic situation,

- Carry out an analysis of the resources available to them
- Analyze the corrective actions to be implemented
- Evaluate the results, according to established standards

7. Administrative & office TPM

Although this pillar is not actually part of the production process, its importance lies in being a complementary support for it. The information and results obtained in the previous stages need to be clearly communicated to the other departments, so as to ensure their efficiency.

8. Safety, Health, Environment

This last pillar also has the individual at the center of its actions, seeking to ensure good working conditions and a safe environment to perform in. It also seeks to mitigate the possible negative impact that the actions carried out may generate. Thus, this transversal pillar acts under the principle of zero accidents and zero pollution.

Discussion Forum

Short Questions

1. Explain the concept of Maintenance.
2. Define Maintenance management.
3. Mention any four objectives of maintenance management.
4. Give the advantages of effective maintenance management.
5. What is the need for maintenance management?
6. Mention any 4 benefits of TPM.

Essay Type Questions

1. Explain the different types of maintenance.
2. Discus the various functions of maintenance management.
3. Explain the 8 pillars of Total Productive Maintenance.
4. ''In Breakdown Maintenance the equipment is allowed to run to its breakdown and then it is maintained and put back into operation.'' Explain in the light of the above statement the important steps required to accomplish a corrective maintenance task.
5. ''Overhauling of plant and equipment constitutes an important part of the preventive maintenance effort of a manufacturing organization.'' Discuss.

CHAPTER -16

QUALITY MANAGEMENT

INTRODUCTION

The word quality has different meanings ranging from conventional to those that are strategic in nature. The conventional meaning of quality usually describes a quality product as one which looks good, works well, which is reliable, etc. However the strategic meaning of quality is concerned with meeting customer requirements. When a manufacturer is able to meet the exact requirements of the customer consistently, then that is called as quality. Indian industry has been forced to be quality conscious. Many Indian industries are registering ISO 9000 or ISO 14000 certificate system for ensuring quality among the public. The opening up of Indian industry to global competition, the government's liberalization and privatization policies have increased the pressure of competition and survival. Now, they have realized the importance of quality as a competitive advantage for gaining the market share.

Quality management is of utmost importance to delight the customer through continuous innovation and improvement in meeting upon agreed specifications. Quality plays major role in today's manufacturing environment. Quality management ensures the quality of the product throughout its lifecycle. It is helpful in the reduction of wastes and defects therefore reducing the cost. It increases productivity. It is helpful in providing better services to the customers and in turn increasing the customer satisfaction.

Definitions of Quality

According to Webster's Dictionary, "Quality is physical or non-physical characteristics that constitutes the basic nature of a thing or is one of its distinguishing features".

According to Deming, "Quality should be aimed at the needs of the consumer, present and future".

According to ISO 9000, "Quality is defined as the degree to which a set of inherent characteristic fulfills requirements".

According to Philip B. Crosby, "Quality is defined as the conformance to requirements".

GARVIN'S NINE DIMENSIONS OF QUALITY

1. *Performance:* Performance is the primary product characteristic or operating characteristic. It combines product and user-based approach relationships between performances.
2. *Features:* These are secondary characteristics, added features of the product. These are secondary to basic functioning and less central to users.
3. *Reliability:* Reliability is the consistency of performance of the product over time. It is also the probability of the product failing within a given time period.
4. *Conformance:* Meeting specification of the operating characteristics or the industry standards is conformance.
5. *Durability:* It is the measure of product life or the useful life of the product.
6. Serviceability: It is the resolution of problems and complaints about the product. It includes speed, courtesy and competence of repair and ease of repair.
7. *Aesthetics:* Aesthetics are the sensory characters such as look, feel or finish of the product.
8. *Reputation:* It is the indirect measure of quality such as brand image, brand name, part performance, etc., which are often used as a measure of quality when other information about the product is not available.
9. *Response:* response is the human-to-human interface, such as the courtesy of the dealer, courtesy of shop floor employees, etc.

DIMENSIONS OF QUALITY IN SERVICES

Parasuraman, Zeithaml, and Berry (1986, 1990) identified the following generic factors or dimensions that contribute to the level of quality in the services.

1. *Tangibles:* Tangibles are the physical evidence of service. The type a restaurant's waiters wear and uniforms are some of the tangibles that we observe when we visit.
2. *Reliability:* Reliability relates to the consistency of performance and dependability of service.
3. *Responsiveness:* This refers to the willingness and the readiness of employees to provide service.
4. *Competence:* Competence relates to workers having the required skills and knowledge to effectively perform the service.

COST OF QUALITY (COQ)

The "cost of quality" is not the price of creating a quality product or service. Whenever work is redone in the organization, then the cost of quality increases.

Cost of quality (COQ) is defined as a methodology that allows an organization to determine the extent to which its resources are used for activities that prevent poor quality, appraise the quality of the organization's products or services, and result from internal and external failures. Some of the examples are:

- The reworking of a manufactured item.
- The retesting of an assembly.
- The rebuilding of a tool.
- The correction of a bank statement.
- The reworking of a service, such as the reprocessing of a loan operation or the replacement of a food order in a restaurant.

COST OF POOR QUALITY (COPQ)

Cost of poor quality (COPQ) is defined as the costs associated with providing poor quality products or services. There are three categories:

1. Appraisal costs are costs incurred to determine the degree of conformance to quality requirements.
2. Internal failure costs are the costs associated with defects found before the customer receives the product or service.
3. External failure costs are the costs associated with defects found after the customer receives the product or service.

Quality-related activities that incur costs may be divided into prevention costs, appraisal costs, and internal and external failure costs.

1. Prevention Costs

Preventive cost includes the costs of all activities specifically designed to prevent poor quality of products or services. Examples include the costs of new product review, quality planning, supplier capability surveys, process capability evaluations, quality improvement team meetings, quality improvement projects, quality education and training, etc.

2. Appraisal Costs

Appraisal costs are the costs associated with measuring, evaluating or auditing products or services to assure conformance with quality standards and performance requirements. These include the costs of:

- Incoming and source inspection/test of purchasing material
- In-process and final inspection/test

- Product, process or service audits
- Calibration of measuring and test equipment
- Associated supplies and materials

3. Failure Costs

Failure cost represents the costs resulting from products or services not conforming to requirements or customer/user needs. Failure costs are divided into internal and external failure costs.

a. Internal Failure Costs

Failure costs occurring prior to delivery or shipment of the product, or the furnishing of a service, to the customer. Some of the examples are the costs of scrap, rework, re-inspection, re-testing, material review, downgrading, etc.

b. External Failure Costs

Failure costs occurring after delivery or shipment of the product and during or after the furnishing of a service to the customer. Examples are the costs of processing customer complaints, customer returns, warranty claims, product recall, etc.

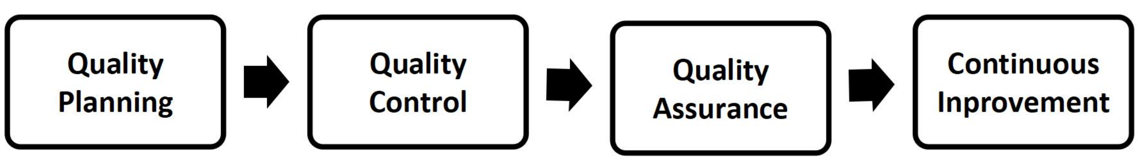
QUALITY MANAGEMENT

Quality management is a method for ensuring that all the activities necessary to design, develop and implement a product or service are effective and efficient with respect to the system and its performance.

Quality management has four stages:

1. Quality planning
2. Quality control
3. Quality assurance
4. Continuous Improvement

Fig-16. 1 Stages of Quality Management



1. QUALITY PLANNING

Quality planning is the process which identifies which quality standards are important to the project and determines a way to satisfy the relevant standards. Project managers normally develop the quality requirement as a part of the Planning Process Group.

The inputs to the quality planning process are:

- **Enterprise environmental factors**: Enterprise environmental factors comprises of the external environmental and internal organizational factors that influences a project's success.
- **Organizational Process Assets**: Organizational process assets are any process-related assets which can influence the project's outcome. Assets commonly include informal or formal quality policies, guidelines, and procedures, as well as historical databases related to quality.

- **Project Scope Statement**: The Project Scope Statement describes the major deliverables, acceptance criteria for the deliverables, objectives, assumptions, constraints, and a statement of work for the project. The Project Scope Statement provides a basis for making future project decisions. Project Managers commonly plan project activities so that the project deliverables meet the desired level of quality.
- **Project Management Plan**: The Project Management Plan defines how the project is expected to behave through the executing, monitoring and controlling, and closing process groups. In addition, it specifies that a quality plan and philosophy will be adopted, and it refers to other quality procedures that may be relevant. The Project Management Plan details the completed project work to be inspected and verified.

While engaged in Quality Planning, there are some common tools and techniques which project managers employ during the process. Quality Planning can be completed using the following **tools and techniques**:

Cost-benefit analysis

A cost-benefit analysis evaluates the cost-benefit tradeoffs for making a potential change. Since quality planning is the art of considering tradeoffs, project managers use cost-benefit analysis to determine the cost-effectiveness of assuring product quality.

The steps to perform a cost-benefit analysis are:

1. List and calculate the direct and indirect costs.
2. List and Calculate the Benefits.
3. Compare the resulting Costs to Costs and Benefits to Benefits.

Direct costs are the estimated financial costs from budget making and planning, including expenses from equipment, operators, personnel, training, materials, utilities, contractual services, and facility construction. Indirect cost estimate shared resources, including infrastructure maintenance, administration expenses, and safety costs.

Design of experiments (DOE)

Design of experiments is a statistical method which identifies influencing factors of the product or process being created. This technique provides a way to change all of the influencing factors at once instead of on a factor by factor basis.

Benchmarking

Benchmarking engages in comparing projects as a basis to measure performance.

Costs of Quality (COQ)

Costs of Quality are the total costs incurred by investing in preventing a nonconformance to requirements, appraising the conformance to requirements, and failing to meet the requirements.

Additional Quality planning tools

Additional Quality Planning tools which help project and quality managers are as follows:

- *Affinity diagramming*: The affinity diagram helps to categorize brainstorming ideas.
- *Force field analysis*: Force field analysis examines and evaluates all the forces for and against a decision. Project managers use this method to weigh the pros and cons of a decision.
- *Nominal group techniques*: Nominal group techniques are structured procedures that identify and rank major problems or key issues that need to be addressed. Project managers may use this method to obtain multiple ideas from team members on a particular problem or issue.
- *Matrix diagrams*: Matrix diagrams are used to compare the efficiency and effectiveness of alternatives based on the relationship between the two criteria. A project manager can use a matrix diagram to analyze the relationship between the project cost and project performance.

- *Flowcharts*: Flowcharts are graphical representations of a process. A flowchart allows a project team to create a diagram of the events in a process. By examining flowcharts carefully, the project team can often identify gaps in workflow that could cause problems and errors.

2. QUALITY CONTROL

In engineering and manufacturing, quality control and quality engineering are involved in developing systems to ensure products or services are designed and produced to meet or exceed customer requirements. This is a system for determining at which points in the production process deviations and deficiencies emerge. These systems are often developed in conjunction with other business and engineering disciplines using a cross-functional approach.

How to go about setting quality control?

- Workers and inspectors must be made well aware of the prerequisite standards, and tolerances must be set.
- A suitable number of inspection points must be decided upon.
- Reliable testing and inspecting measures must be used.
- A suitable number of inspections per inspection point must be decided upon.

Advantages of quality control

- Dealers and customers are assured of the quality of the goods that they are purchasing.
- It can serve as a reliable basis for wage incentive schemes.
- Workers are encouraged to continue to produce goods of a certain standard.
- Production costs can be lowered.
- It can lead to improved product design and quality.

3. QUALITY ASSURANCE

Quality assurance can be defined as "part of quality management focused on providing confidence that quality requirements will be fulfilled.

Quality Assurance covers all activities from design, development, production, installation, servicing and documentation. It includes the regulation of the quality of raw materials, assemblies, products and components; services related to production; and management, production, and inspection processes. A quality assurance system is meant to increase customer confidence and a company's credibility, while also improving work processes and efficiency, and it enables a company to better compete with others.

One of the most widely used paradigms for QA management is the PDCA (Plan-Do-Check-Act) approach, also known as the Shewhart cycle.

Quality assurance methods

Quality assurance utilizes one of three methods:

1. *Failure testing:* It continually tests a product to determine if it breaks or fails. For physical products that need to withstand stress, this could involve testing the product under heat, pressure or vibration. For software products, failure testing might involve placing the software under high usage or load conditions.
2. *Statistical process control (SPC):* It's a methodology based on objective data and analysis and developed by Walter Shewhart at Western Electric Company and Bell Telephone Laboratories in the 1920's and 1930's. This methodology uses statistical methods to manage and control the production of products.
3. *Total quality management (TQM):* It applies quantitative methods as the basis for continuous improvement. TQM relies on facts, data and analysis to support product planning and performance reviews.

4. CONTINUOUS IMPROVEMENT

There may be opportunities to improve management processes during the life of the project or information that assists the management of future projects. Continual systematic approaches to quality improvements such as adherence to Total Quality Management (TQM), ISO 9000, Six Sigma or any external industry standards, can be used.

This is part of corporate governance. If there is a variance in a project, then it must be corrected, however the root cause of the problem must be understood to ensure that the same problem does not occur on further projects. A continuous and systematic approach to Quality Management creates steady growth and improvement to keep a Company focused on its goals and priorities.

QUALITY IMPROVEMENT TOOLS

A tool is defined as a device used to help accomplish the purpose of a technique. Quality improvement tools are numeric and graphic devices used to help individuals and teams work with, understand, and improve processes. Walter Shewhart and W. Edward Deming began developing the initial quality improvement tools during the period 1930-40. In the 1950s, the Japanese began to learn and apply the statistical control tools and thinking taught by Kaoru Ishikawa, head of the Japanese Union of scientists and Engineers. These tools were further improved and expanded by the Japanese in the 1960s with the introduction of the following seven (Old) basic quality control tools:

1. Cause-and-effect diagram (Fishbone diagram)
2. Run chart
3. Scatter diagram
4. Flow chart
5. Pareto chart
6. Histogram
7. Control chart

Seven QC tools are fundamental instruments to improve the quality of the product. They are used to analyze the production process, identify the major problems, control fluctuations of product quality, and provide solutions to avoid future defects. Statistical literacy is necessary to effectively use the seven QC tools. These tools use statistical techniques and knowledge to accumulate data and analyze them. Seven QC tools are utilized to organize the collected data in a way that is easy to understand and analyze. Moreover, from using the seven QC tools, any specific problems in a process are identified.

Table-16.1 Seven Tools of Management

1.	**Check Sheet** is used to easily collect data. Decision-making and actions are taken from the data.
2.	**Pareto Chart** is used to define problems, to set their priority, to illustrate the problems detected, and determine their frequency in the process
3.	**Cause-and-Effect Diagram** (Fishbone Diagram) is used to figure out any possible causes of a problem. After the major causes are known, we can solve the problem accurately.
4.	**Histogram** shows a bar chart of accumulated data and provides the easiest way to evaluate the distribution of data.
5.	**Scatter Diagram** is a graphical tool that plots many data points and shows a pattern of correlation between two variables
6.	**Flow Chart** shows the process step by step and can sometimes identify an unnecessary procedure
7.	**Control Chart** provides control limits which are generally three standard deviations above and below average, whether or not our process is in control.

NEW TOOLS FOR QUALITY IMPROVEMENT

In 1976, the Japanese Society for quality Control Technique Development proposed the following seven new tools for quality improvement:

1. Relations diagram
2. Affinity diagram
3. Systematic diagram (Tree diagram)
4. Matrix diagram
5. Prioritization matrix
6. Process decision program chart (PDPC)
7. Arrow diagram

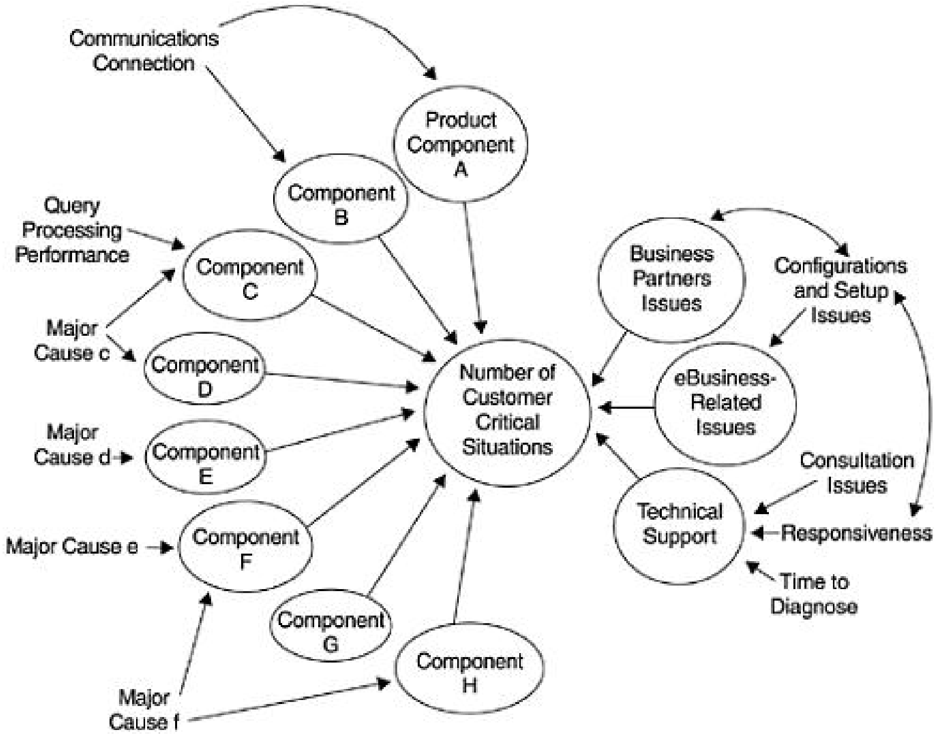
1. Relations Diagram

The relations diagramming method is a technique developed to clarify intertwined casual relationships in a complex situation in order to find an appropriate solution.

Relations diagrams can be used to:

- Determine and develop quality assurance policies
- Establish promotional plans for the total quality control introduction
- Design steps to counter market complaints
- Improve quality in the manufacturing process
- Promote quality control in purchased or ordered items
- Provide measures against troubles related to payment and process control
- Promote small group activities effectively
- Reform administrative and business departments

Fig- 16.2Relations Diagram



2. Affinity diagram

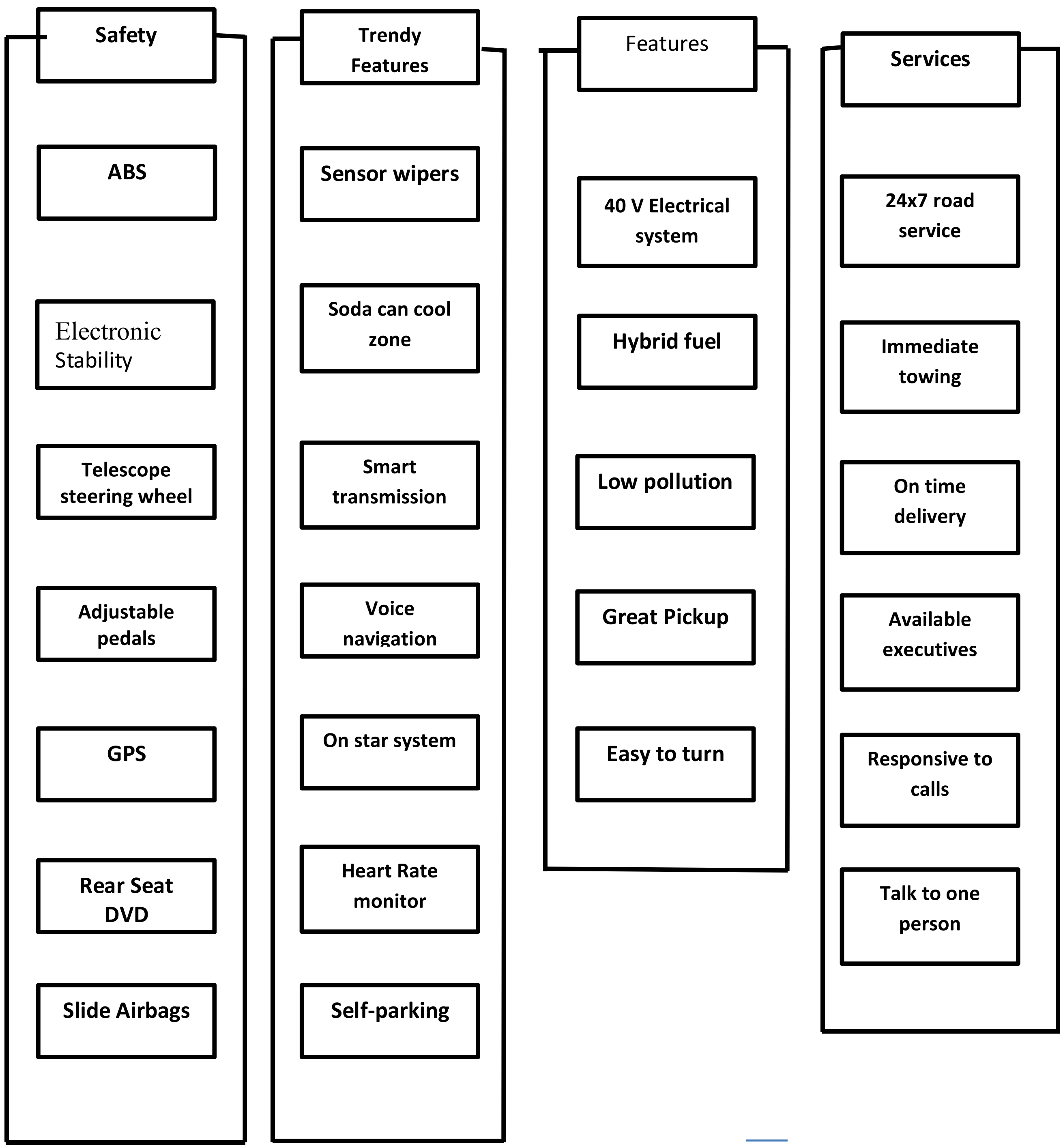
An affinity diagram is a tool to facilitate consideration and organization of a group of ideas about an issue with a team through a consensus decision. The team members take turns writing each of their ideas on separate slips of paper. The team then gathers all the ideas into natural (affinity) groups: in other words, it groups the ideas in a manner that allows those with a natural relationship or relevance to be placed together in the same group or category.

An affinity diagram is used to organize verbal information into visual pattern. It starts with specific ideas and helps work toward broad categories.

Affinity diagram can help:

- Organize and give structure to a list of factors that contribute to a problem
- Identify key areas where improvement is most needed

Fig- 16.3Example of Affinity Diagram

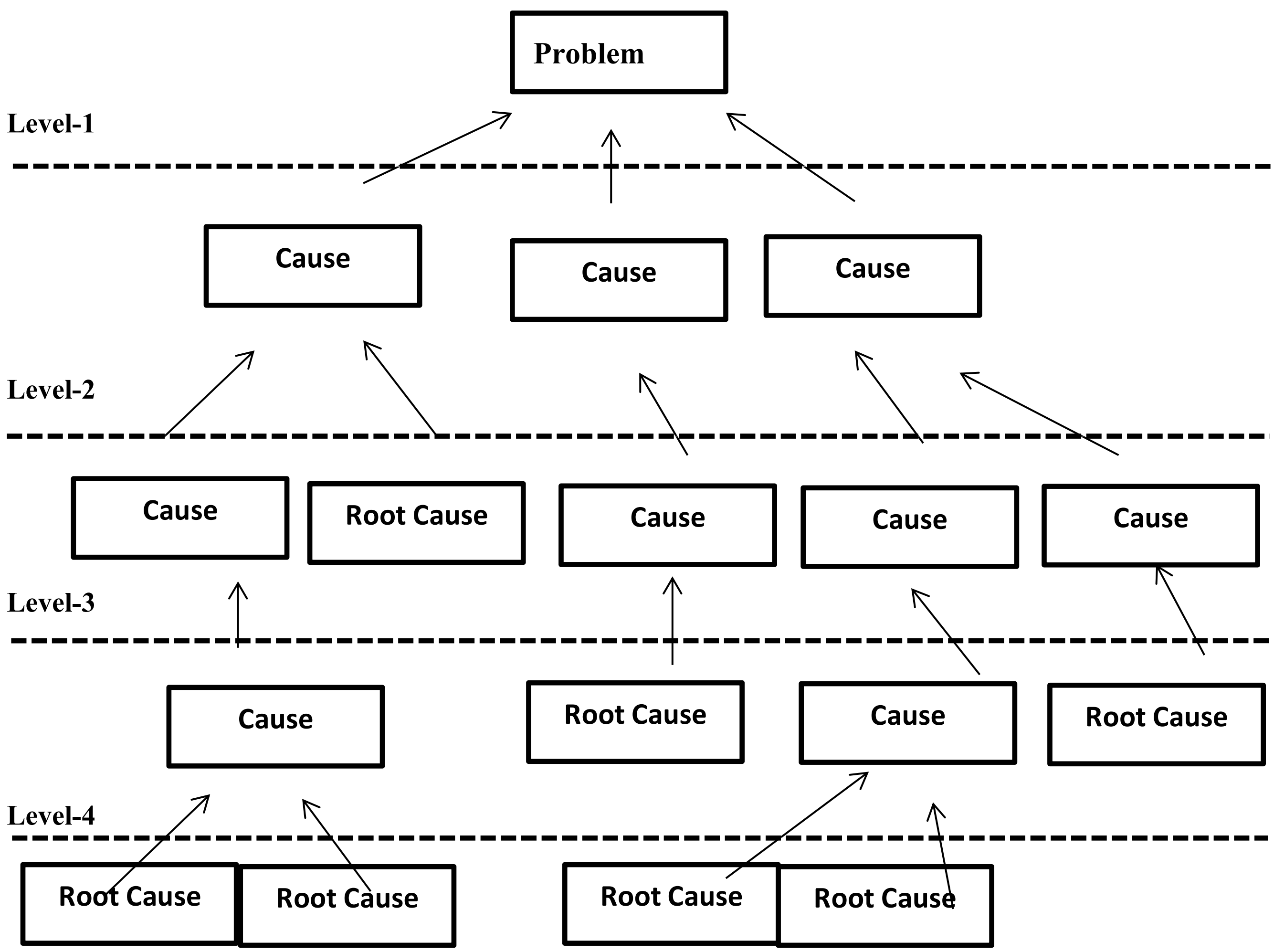


3. Systematic diagram (tree diagram)

Systematic diagram can also be called as tree diagram and it find its application in organizational charts. This can be used to determine the ways or means needed to achieve a specific goal or objective. The primary and secondary objectives for doing a process are identified and the various plans for achieving those objectives are generated. All the information is given in the chart so that one can easily identify the ways or steps to be followed to achieve the primary objectives.

The systematic diagram is very much useful in breaking down large problems into specific executable objectives.

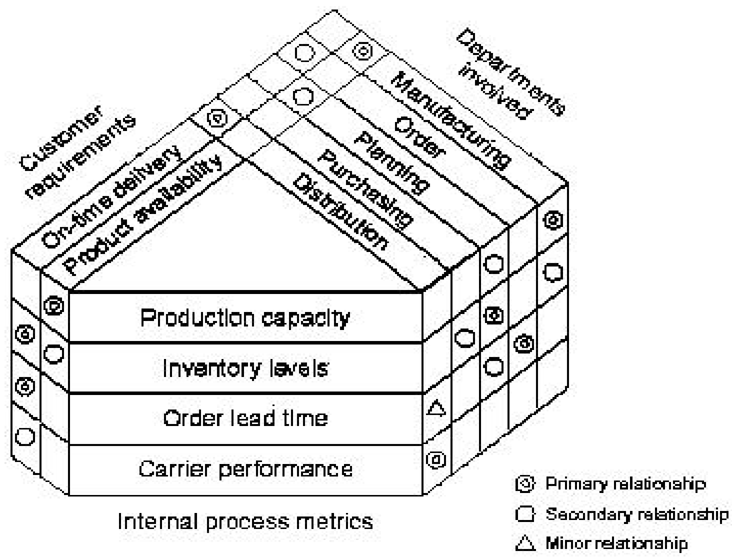
Fig-16.4 Tree Diagram



4. Matrix diagram:

The matrix diagram method clarifies problematic spots through multidimensional thinking. This method identifies corresponding elements involved in a problem situation or event. These elements are arranged in rows and columns on a chart that shows the presence or absence of relationships among collected pairs of elements. They are very useful to clarify the relationship between two or two factors. They also help in identifying, assigning and monitoring the actions that have been taken to solve a problem.

Fig-16.5 Matrix Diagram



5. Prioritization matrix

This is nothing but the extension of matrix diagram. The next step is to arrange the matrix that was developed by using the previous method and qualifying the relationship. This is achieved by getting numerical data for intersecting cells. After quantifying the things, the actions are prioritized in order to identify the most desirable or effective option. This involves analysis of numerical data and the variations are solved using the multivariate analysis technique.

Fig- 16.6 Prioritization matrix

		Ratings			**Weighted Scores**		
	Weightage	**Solution-1**	**Solution-2**	**Solution -3**	**Solution -1**	**Solution-2**	**Solution -3**
High Accuracy	10	8	7	9	80	70	90
Promise to delivery	9	6	7	8	54	63	72
Reliability	7	9	8	9	63	56	63
Cost	8	8	9	5	64	72	40
Program Management	7	5	4	6	35	28	42
Turnaround time	5	4	4	6	30	20	30
				Total	**316**	**309**	**337**

6. Process decision program chart (PDPC)

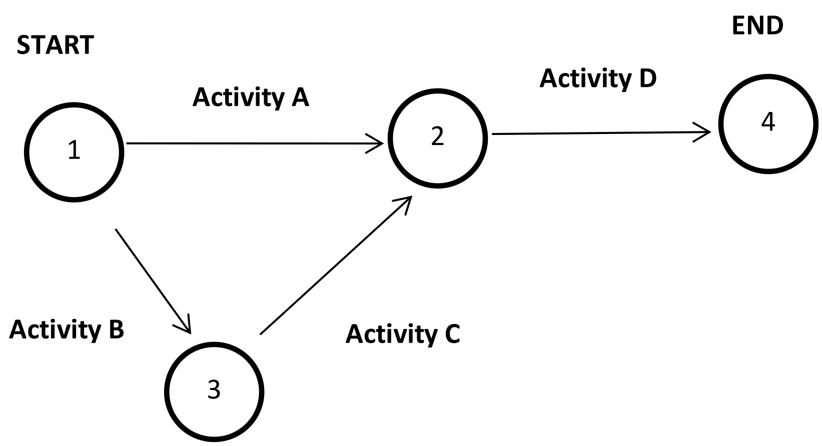
This chart helps in getting prepared for any unexpected problems that may occur while carrying out certain activities or it helps in identifying the contingencies likely to be faced while carrying out any activity and the countermeasures that can be taken during that particular situation.

This method is very useful in developing contingency plans. It is much useful when one is unaware about either the process or the product and also when one is not clear with the type of environment in which the activity is carried out.

7. Arrow Diagram:

The arrow diagram method establishes a sequenced plan and a tool for monitoring progress. It may be represented graphically by either a horizontal or vertical structure connecting the planned activities or events.

Fig-16.7 Example for Arrow Diagram



The arrow diagram method can be used to:

- Implement plans for new product development and its follow-up
- Develop product improvement plans and follow up actions
- Establish daily plans for experimental trials and follow-up activities
- Synchronise the preceding plans for quality control(QC) activities
- Develop plans for a facility move and for monitoring follow-up
- Implement a periodic facility maintenance plan and its follow-up
- Analyse a manufacturing process and draw up plans for improved efficiency
- Plan and follow-up QC inspections and diagnostic tests
- Plan and follow-up QC conferences and QC circle conferences

Benefits of QC tools

- Essential tools in the continuous Improvement Process
- Provides objective analysis of problems based on facts and data
- Encourages and enhances teamwork as problems are addressed through groups
- Able to anticipate potential problems and improve quality
- Greater customer satisfaction through superior quality and services

STATISTICAL PROCESS CONTROL

Statistical Process Control was pioneered by Walter A. Shewhart in the early 1920s. Statistical Process Control (SPC) is an effective method of monitoring a process through the use of control charts. It provides an effective way of controlling quality in any process. SPC helps to identify and reduce variability, the major reason for most of the quality problem. By collecting data from samples at various points within the process, variations in the process that may affect the quality of the end product or service can be detected and corrected, thus reducing waste and as well as the likelihood that problems will be passed on to the customer. With its emphasis on early detection and prevention of problems, SPC has a distinct advantage over quality methods, such as inspection, that apply resources to detecting and correcting problems in the end product or service.

In addition to reducing waste, SPC can lead to a reduction in the time required to produce the product or service from end to end. This is partially due to a diminished likelihood that the final product will have to be reworked, but it may also result from using SPC data to identify bottlenecks, wait times, and other sources of delays within the process. Process cycle time reductions coupled with improvements in yield have made SPC a valuable tool from both a cost reduction and a customer satisfaction standpoint.

CONTROL CHART

In statistical process control, the control chart, also known as the 'Shewhart chart' or 'process-behaviour chart' is a tool used to determine whether a manufacturing or business process is in a state of statistical control or not.

A control chart is a specific kind of run chart that allows significant change to be differentiated from the natural variability of the process. This is key to effective process control and improvement. The control chart is one of the seven basic tools of quality control (along with the histogram, Pareto chart, check sheet, cause-and-effect diagram, flowchart, and scatter diagram).

A control chart consists of the following:

- Points representing measurements of a quality characteristic in samples taken from the process at different times [the data]
- A centre line, drawn at the process characteristic mean which is calculated from the data
- Upper and lower control limits (sometimes called "natural process limits") that indicate the threshold at which the process output is considered statistically 'unlikely'

The main aim of control chart is to detect assignable causes of variations. Only common variation should be present in a process because they represent a stable and predictable process which leads to less variations. A process which is having only common cause of variation and no special or assignable causes of variations is said to be in the state of statistical control. If the process is in control, all points will plot within the control limits. Any observations outside the limits, or systematic patterns within, suggest the introduction of a new (and likely unanticipated) source of variation, known as a special-cause variation. Since increased variation means increased costs, a control chart "signaling" the presence of a special-cause requires immediate investigation. Control charts detects only the presence of a special or assignable cause and do not find the cause.

Advantages of control charts

- Chart clearly identifies whether a process is within control or not at a particular period.
- It ensures a particular level of quality in the process.
- It investigates the unusual variations taking place in the process.
- It helps in setting the tolerance limits.

TYPES OF CONTROL CHARTS

Control charts are broadly classified into:

1. Control chart for variables

- Average ($\bar{x}$) chart
- Mean chart (R)

2. Control charts for attributes

- P Chart
- Np Chart
- C Chart
- U Chart

Table-16.2 Types of charts

Chart	Process observation	Process observations relationships	Process observations type	Size of shift to detect
$\bar{x}$, R chart	Quality characteristic measurement within one subgroup	Independent	Variables	Large (≥ 1.5σ)
$\bar{x}$, S chart	Quality characteristic measurement within one subgroup	Independent	Variables	Large (≥ 1.5σ)
Three-way chart	Quality characteristic measurement within one subgroup	Independent	Variables	Large (≥ 1.5σ)
p-chart	Fraction nonconforming within one subgroup	Independent	Attributes	Large (≥ 1.5σ)
np-chart	Number nonconforming within one subgroup	Independent	Attributes	Large (≥ 1.5σ)
c-chart	Number of non-conformances within one subgroup	Independent	Attributes	Large (≥ 1.5σ)
u-chart	Non-conformances per unit within one subgroup	Independent	Attributes	Large (≥ 1.5σ)

QUALITY CIRCLE

Quality Circle is a small group of 6 to 12 employees doing similar work who voluntarily meet together on a regular basis to identify improvements in their respective work areas using proven techniques for analyzing and solving work related problems coming in the way of achieving and sustaining excellence leading to mutual upliftment of employees as well as the organization. It is "a way of capturing the creative and innovative power that lies within the work force".

Participate methods in the workplace are one way to improve both the work environment for employees and productivity and quality for the company.

Quality Circle is one of the employee participation methods. It implies the development of skills, capabilities, confidence and creativity of the people through a cumulative process of education, training, work experience and participation. It also implies the creation of good environment of work, which creates and sustains their motivation and commitment towards work excellence. Quality Circles have emerged as a mechanism to develop and utilize the tremendous potential of people for improvement in product quality and productivity.

Concept

The concept of Quality Circle is primarily based upon recognition of the value of the worker as a human being, as someone who willingly activates on his job, his wisdom, intelligence, experience, attitude and feelings. It is based upon the human resource management considered as one of the key factors in the improvement of product quality & productivity. The Quality Circle concept has three major attributes:

a. Quality Circle is a form of participatory management.
b. Quality Circle is a human resource development technique.
c. Quality Circle is a problem solving technique.

Objectives

The objectives of Quality Circles are multi-faced.

a) Change in Attitude.

- From "I don't care" to "I do care"
- Continuous improvement in quality of work life through humanization of work.

b) Self-Development

- Bring out 'Hidden Potential' of people
- People get to learn additional skills.

c) Development of Team Spirit

- Individual Vs Team – "I could not, do but we did it"
- Eliminate interdepartmental conflicts.

d) Improved Organizational Culture

- Positive working environment.
- Total involvement of people at all levels
- Higher motivational level.
- Participate in Management process.

TOTAL QUALITY MANAGEMENT

Total Quality Management or TQM is a new way of thinking about the organization or a business firm. TQM is also similar to the concept of quality which is customer oriented.

Total Quality Management (TQM) is a management strategy aimed at embedding awareness of quality in all organizational processes. TQM has been widely used in manufacturing, education, government, and service industries, as well as NASA space and science programs.

Total Quality provides an umbrella under which everyone in the organization can strive and create customer satisfaction at continually lower real costs. TQM starts with the assessment of customer requirement through market research which is basically articulating of customers' needs and wants. Then the customer requirements are translated into product features. Finally the product features are reduced to specifications of components, sub-assemblies and engineering specifications. The process is designed accordingly and the equipments, facilities, etc., with the suitable process capability are selected.

Definition

TQM is composed of three paradigms:

- Total: Involving the entire organization, supply chain, and/or product life cycle
- Quality: With its usual definitions, with all its complexities (External Definition)
- Management: The system of managing with steps like Plan, Organize, Control, Lead, Staff, provisioning, etc.

As defined by the International Organization for Standardization (ISO):

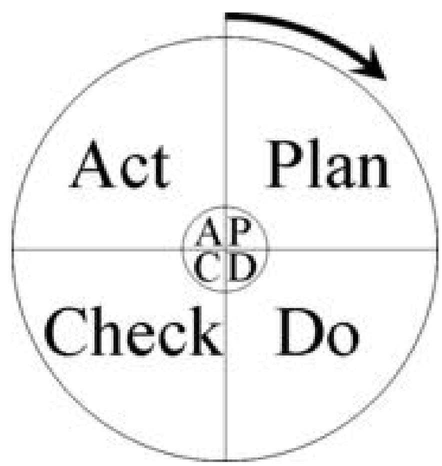
"TQM is a management approach for an organization, centered on quality, based on the participation of all its members and aiming at long-term success through customer satisfaction, and benefits to all members of the organization and to society."

QUALITY IMPROVEMENT

SHEWHART (PDCA) CYCLE

The following diagram is the Shewhart cycle (PDCA) for quality improvements, made popular by Deming.

Fig-16.8 PDCA Cycle



The philosophy is to keep improving the quality of an organization. It is defined by four keys:

Plan: Design or revise business process components to improve results. Identify the changes that have to be made to create improvements in the organization. The objective of introducing the change has to be specified and then plan the method to collect information regarding the change that has to be incorporated in the organization. Then finally we have to plan the method to measure the effectiveness of change implemented.

Do: Implement the plan and measure its performance. In this stage the plans put forth in the plan stage are carried out. The performance is measured by collecting the data regarding the impact of change. The analysis of data is starts at this stage.

Check: Assess the measurements and report the results to decision makers. The analysis of data is continued and completed at this stage. The process is analyzed to find out if there is any improvement. Also find out the alternatives if the expectations have not matched the reality.

Act: Decide on changes needed to improve the process. Make further changes and collect the data again for doing the further analysis of the process.

The consolidation phase enables the organization to take stock of what has been taking place and to ensure made to processes that require documentation (both to allow processes to be repeatable and to facilitate recognition of the achievement of some form of quality standard).

QUALITY STANDARDS

The International Organization for Standardization (ISO) created the Quality Management System (QMS) standards in 1987. These were the ISO 9000:1987 series of standards comprising ISO 9001:1987, ISO 9002:1987 and ISO 9003:1987; which were applicable in different types of industries, based on the type of activity or process: designing, production or service delivery.

The standards have been regularly reviewed every few years by the International Organization for Standardization. The version in 1994 and was called the ISO 9000:1994 series; comprising of the ISO 9001:1994, 9002:1994 and 9003:1994 versions.

The last revision was in the year 2000 and the series was called ISO 9000:2000 series. However the ISO 9002 and 9003 standards were integrated and one single certifiable standard was created under ISO 9001:2000. Since December 2003, ISO 9002 and 9003 standards are not valid, and the organizations previously holding these standards need to make a transition from the old to the new standards. The ISO 9004:2000 document gives guidelines for performance improvement over and above the basic standard (i.e. ISO 9001:2000). This standard provides a measurement framework for improved quality management, similar to and based upon the measurement framework for process assessment.

The Quality Management System standards created by ISO are meant to certify the processes and the system of an organization and not the product or service itself. ISO 9000 standards do not certify the quality of the product or service.

Recently the International Organization released a new standard, ISO 22000, meant for the food industry. This standard covers the values and principles of ISO 9000 and the HACCP standards. It gives one single integrated standard for the food industry and is expected to become more popular in the coming years in such industry.

ISO has a number of standards that support quality management, one group describes processes (including ISO 12207, ISO 15288) and another describes process assessment ISO 15504.

DEMING'S PHILOSOPHY

The philosophy of W. Edwards Deming has been summarized as follows:

"Dr. W. Edwards Deming taught that by adopting appropriate principles of management, organizations can increase quality and simultaneously reduce costs (by reducing waste, rework, staff attrition and litigation while increasing customer loyalty). The key is to practice continual improvement and think of manufacturing as a system, not as bits and pieces."

The System of Profound Knowledge is the basis for application of Deming's famous 14 Points for Management, described below.

Deming's 14 points

Deming offered fourteen key principles for management for transforming business effectiveness.

1. Create constancy of purpose toward improvement of a product and service with a plan to become competitive and stay in business. Decide to whom top management is responsible.
2. **Adopt the new philosophy.** We are in a new economic age. We can no longer live with commonly accepted levels of delays, mistakes, defective materials, and defective workmanship.
3. **Cease dependence on mass inspection.** Require, instead, statistical evidence that quality is built in (prevent defects instead of detect defects).
4. End of the practice of awarding business on the basis of price tag. Instead, depend on meaningful measures of quality along with price. Eliminate suppliers that cannot qualify with statistical evidence of quality.
5. **Find Problems.** It is a management's job to work continually on the system (design, incoming materials, composition of material, maintenance, improvement of machinery, training, supervision, and retraining)
6. Institute modern methods of training on the job

7. The responsibility of the foreman must be to change from sheer numbers to quality which will automatically improve productivity. Management must prepare to take immediate action on reports from the foremen concerning barriers such as inherent defects, machines not maintained, poor tools, and fuzzy operational definitions.
8. Drive out fear, so that everyone may work effectively for the company.
9. **Break down barriers between departments.** People in research, design, sales and production must work as a team to foresee problems of production that may be encountered with various materials and specifications.
10. Eliminate numerical goals, posters, slogans for the workforce, asking for new levels of productivity without providing methods.
11. Eliminate work standards that prescribe numerical quotas.
12. Remove barriers that stand between the hourly worker and his right of pride of workmanship.
13. Institute a vigorous program of education and retraining.
14. Create a structure in top management that will push every day on the above 13 points.

KAIZEN

Kaizen means, literally, change (Kai) to become good (Zen); the common English usage is "continual improvement". Kaizen is a philosophy, assuming that every aspect of our lives deserves to be continually improved. This method defines management's role in continuously encouraging and implementing small improvements to everyone. Kaizen is the process of continuous improvements in small increments that makes the process more efficient, effective and adaptable.

Kaizen is defined as "a continuous effort by each and every employee to ensure improvement of all processes and systems of a particular organization."

Kaizen aims to eliminate waste (as defined by Joshua Isaac Walters "activities that add cost, but do not add value"). It means "to take it apart and put back together in a better way." This is then followed by standardization of this 'better way' with others, through standardized work.

Kaizen is a daily activity whose purpose goes beyond simple productivity improvement. It is also a process that, when done correctly, humanizes the workplace, eliminates overly hard work (both mental and physical) "muri", and teaches people how to perform experiments on their work using the scientific method and how to learn to spot and eliminate waste in business processes.

To be most effective Kaizen must operate with three principles in place:

1. Consider the process and the results so that actions to achieve effects are surfaced
2. Systemic thinking of the whole process and not just that immediately in view in order to avoid creating problems elsewhere in the process; and
3. A learning, non-judgmental, approach and intent will allow the re-examination of the assumptions that resulted in the current process.

People at all levels of an organization and its stakeholders can participate in Kaizen when applicable. The format for Kaizen can be individual, suggestion system, small group, or large group. At Toyota, it is usually a local improvement within a workstation or local area and involves a small group in improving their own work environment and productivity. This group is often guided through the Kaizen process by a line supervisor.

While kaizen usually delivers small improvements, the culture of continual aligned small improvements and standardization yields large results in the form of compound productivity improvement. The key elements of Kaizen are quality, effort, involvement of all employees, willingness to change, communication, etc.

The Kaizen improvement focuses on the use of:

- Identifying value added and non-value added work activities in the operations
- *Elimination of Muda:* Muda refers to wastage and there are seven classes of wastes such as overproduction, delay, transportation, inventory, defective parts, wasted motion and processing.

- Principles of material handling and motion study
- Documentation of standard operating procedures
- The Five S framework for good housekeeping which are:

1. *Seiri (Sort)* - sort out and separate that which is needed and not needed in the area.
2. *Seiton (Straighten)* - arrange items that are needed so that they are ready and easy to use. Clearly identify locations for all items so that anyone can find them and return them once the task is completed.
3. *Seiso (Shine)* - clean the workplace and equipment on a regular basis, in order to maintain standards and identify defects.
4. *Seiketsu (Standardise)* - revisit the first three of the 5Ss on a frequent basis and confirm the condition of the factory floor using standard procedures.
5. *Shitsuke (Sustain)* - keep to the rules to maintain the standard and continue to improve every day.
   - Better communication through visual displays such as posters, bulletins, etc.
   - Just in time principles

- *Poka-yoke:* A poka-yoke is any mechanism in a process that helps an equipment operator avoid (yokeru) mistakes (poka) and defects by preventing, correcting, or drawing attention to human errors as they occur.
- Team effort on problem solving, conflict reduction and communication.

SIX-SIGMA (6 σ)

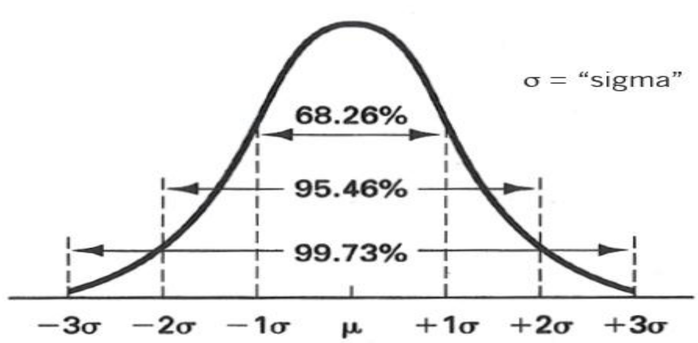
Six-Sigma is a set of practices originally developed by Motorola to systematically improve processes by eliminating defects. A defect is defined as nonconformity of a product or service to its specifications.

Sigma (σ) is used to represent standard deviation of a population. The term "six sigma process" comes from the notion that if one has six standard deviations between the mean of a process and the nearest specification limit, there will be practically no items that fail to meet the specifications.

While the particulars of the methodology were originally formulated by Bill Smith at Motorola in 1986, Six Sigma was heavily inspired by six preceding decades of quality improvement methodologies such as quality control, TQM, and Zero Defects. Like its predecessors, Six Sigma asserts the following:

- Continuous efforts to reduce variation in process outputs is key to business success
- Manufacturing and business processes can be measured, analyzed, improved and controlled
- Succeeding at achieving sustained quality improvement requires commitment from the entire organization, particularly from top-level management

Fig-16.9 Six Sigma



The term "Six Sigma" refers to the ability of highly capable processes to produce output within specification. In particular, processes that operate with six sigma quality produce at defect levels below 3.4 defects per (one) million opportunities (DPMO). Six Sigma's implicit goal is to improve all processes to that level of quality or better. The basic approach involved in Six Sigma is to measure performance of an existing process, compare it with a statistically valid ideal data and find out how to eliminate the variation. Some of the ways of achieving it are by:

- Reducing cycle time
- Improving customer satisfaction
- Cutting down costs
- Improving the speed and accuracy of order fulfilment

Methodology

Six Sigma has two key methodologies: DMAIC and DMADV both inspired by W. Edwards Deming's Plan-Do-Check-Act Cycle.

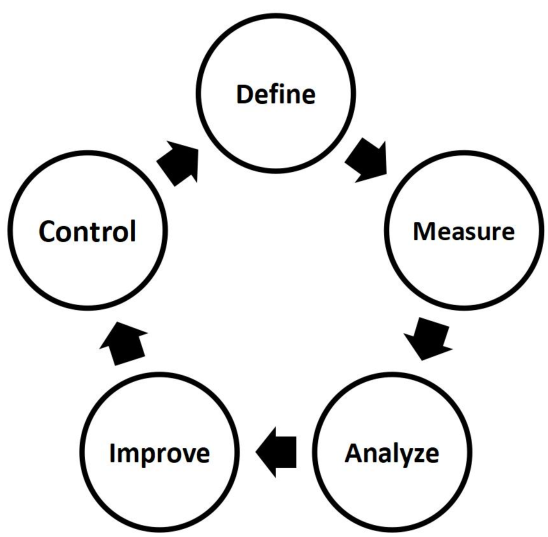
DMAIC is used to improve an existing business process, and DMADV is used to create new product or process designs for predictable, defect-free performance.

DMAIC Methodology

The basic methodology consists of the following five steps:

1. *Define:* Define the process improvement goals that are consistent with customer demands and enterprise strategy.
2. *Measure:* Measure the current process and collect relevant data for future comparison.
3. *Analyze:* Analyze to verify relationship and causality of factors. Determine the kind of relationship and ensure that all factors have been considered.
4. *Improve:* Improve or optimize the process based upon the analysis using techniques like Design of Experiments.
5. *Control:* Control to ensure that any variances are corrected before they result in defects. Set up pilot runs to establish process capability, transition to production and thereafter continuously measure the process and institute control mechanisms.

Fig-16.10 DMAIC Methodology



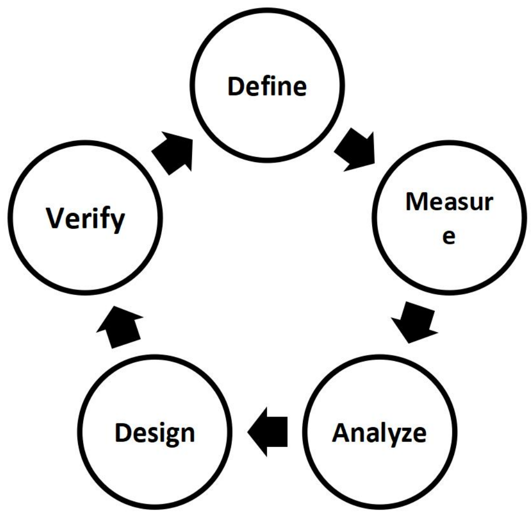
DMADV Methodology

The basic methodology consists of the following five steps:

1. *Define:* Define the goals of the design activity that are consistent with customer demands and enterprise strategy.

2. *Measure:* Measure and identify CTQs (Critical to Qualities), product capabilities, production process capability, and risk assessments.
3. *Analyze:* Analyze to develop and design alternatives, create high-level design and evaluate design capability to select the best design.
4. *Design:* Design using the details, optimizing the design, and plan for design verification. This phase may require simulations.
5. *Verify:* Verify the design, set up pilot runs, implement production process and handover to process owners.

Fig-16.11 DMADV Methodology



LEAN SIX SIGMA

Lean Six Sigma is a team-focused managerial approach that seeks to improve performance by eliminating waste and defects while boosting the standardization of work. It combines Six Sigma methods and tools and the lean manufacturing-lean enterprise philosophy, striving to reduce waste of physical resources, time, effort, and talent while assuring quality in production and organizational processes. Any use of resources that do not create value for the end customer is considered a waste and should be eliminated.

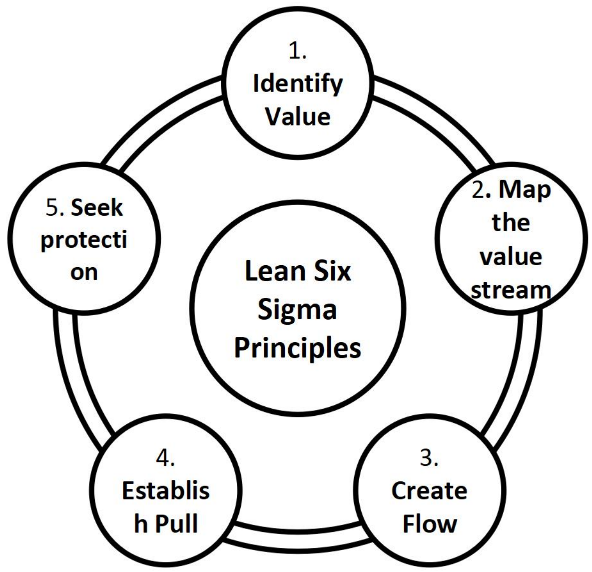
Benefits of Lean Six Sigma

- **Talent Development:** LSS deployment needs every person in the organization to understand the principles and practical application of the techniques. This enhances focus on talent development and embeds learning as a culture within the organization. Growth comes with improved outcomes and continuous learning/upskilling becomes a part of the organizational culture.
- **Quality delivery enabled through efficient Business Processes:** Data-driven decision making, right first time, improved throughput, and increased transparency are direct benefits of LSS. A customer-centric focus on quality ensures that customer voices are continuously heard and product/solution designs plus delivery mechanism quickly attuned to the new market realities.
- **Scalable across different sectors:** Lean Six Sigma is more applicable to manufacturing and engineering companies. Also the application of these principles within other sectors like BFSI, IT, and Retail has proven that LSS techniques have cross-industry application capabilities.
- **Becomes the Basis for cutting-edge technology deployment:** LSS drove continuous improvement initiatives blend with digitization and deployment of cutting-edge technology. LSS is vital to a successful

Digital Transformation and becomes a subset of the larger Business Transformation strategy for organizations.

- **Enhances brand value:** Customers trust organizations that are able to respond to their challenges in a timely manner and resolve the same with integrity. LSS sets-up a culture of people and a sequence of processes and practices that help build upon this customer success quotient, thereby enhancing brand value further.

Fig-16. 12 Principles of Lean Six Sigma



BENCH MARKING

Benchmarking is an evaluation technique in which an organization compares its own performance for a specific process with the "best practice" performance of a recognized leader in a comparable process. The evaluation helps the initiating organization identify shortcomings and establishes a baseline or standard against which to measure its progress in the development and maintenance of a quality assurance program.

Advantages of benchmarking

- Benchmarking is a powerful management tool because it overcomes "paradigm blindness." Paradigm Blindness can be summed up as the mode of thinking, "The way we do it is the best because this is the way we have always done it."
- Benchmarking helps the organizations adapt new methods, ideas and tools to improve their effectiveness.
- It helps to overcome resistance to change by demonstrating other methods of solving problems than the one currently employed, and demonstrating that they work, because they are being used by others.

Approaches to bench marking

Competitive: Comparisons with direct competitors, locally, nationally, or worldwide

Functional: Comparing with companies that have similar processes in the same function outside one's industry

Performance: Comparing pricing, technical quality, features, and other quality or performance characteristics

Process: Comparing work processes such as billing, order entry, or employee training

Strategic: Comparing how companies compete each other and examining winning strategies that have led to competitive advantage and market success

Procedure

There is no single benchmarking process that has been universally adopted. The wide appeal and acceptance of benchmarking has led to various benchmarking methodologies emerging. The most prominent methodology is the 12 stage methodology by Robert Camp (1989).

The 12 stage methodology consisted of:

1. Select subject ahead
2. Define the process
3. Identify potential partners
4. Identify data sources
5. Collect data and select partners
6. Determine the gap
7. Establish process differences
8. Target future performance
9. Communicate
10. Adjust goal
11. Implement
12. Review/recalibrate.

Types of Benchmarking

The different types of benchmarking are discussed below:

(i) Product Benchmarking (Reverse Engineering)

It is an age old practice of product oriented reverse engineering. Every organization buys its rival's products and tears down to find out how the features and performances etc. compare with its products. This could be the starting point for improvement.

(ii) Corporate Benchmarking

Corporate benchmarking has moved beyond product-oriented comparisons to include comparisons of process with those of competitors. In this type, the process studies may include marketing, finance, HR, R&D etc.

(iii) Process Benchmarking

This is the activity of measuring discrete performance and functionality against the organization through performance of excellent analogous business processes.

(iv) Internal Benchmarking

It is an application of process benchmarking, within an organization by comparing the performance of similar business units or business processes.

(v) Strategic Benchmarking

It differs from operational benchmarking in its scope. It helps to develop a vision of the changed organizations. It will develop core competencies that will help sustain competitive advantage.

(vi) Global Benchmarking

It is extension of strategic benchmarking to include benchmarking partners on a global scale

QUALITY FUNCTION DEPLOYMENT (QFD)

The Quality Function Deployment (QFD) philosophy was pioneered by Yoji Akao and Shigeru Mizuno. It aims to design products that assure customer satisfaction and value - the first time, every time. QFD is the latest approach to the product design.

QFD focuses on the "voice of the customer" and the QFD framework can be used for translating actual customer statements and needs ("The voice of the customer") into actions and designs to build and deliver a quality product.

QFD is also called as "customer driven engineering" and it translates the voice of the customer into technical and functional requirements at every stage of design and manufacture. The first application of QFD was at Mitsubishi Heavy Industries Ltd., in the Kobe Shipyard, Japan in 1972.

Tools and Techniques of QFD

Typical tools and techniques used within QFD include:

- *Affinity Diagrams:* To surface the "deep structure" of customer requirements.
- *Relations Diagrams*. To discover priorities and root causes of process problems and unspoken customer requirements.
- *Hierarchy Trees:* To check for missing data and other purposes.
- *Various Matrixes:* For documenting relationships, prioritization and responsibility.
- *Process Decision Program Diagram:* To analyze potential failures of new processes and services.
- *Analytic Hierarchy Process:* To prioritize a set of requirements, and to select from alternatives to meet those requirements.
- *Blueprinting:* To depict and analyze all the processes which are involved in providing a product or service.
- *House of Quality.*

Definition

QFD may be defined as "a system for translating customer requirements into appropriate requirements at every stage from research through product design and development, manufacture, distribution, installation and marketing, sales and service."

QFD Team

QFD teams are composed of members from marketing, design, quality, Finance and production departments.

Objectives of QFD

The following are some of the objectives of QFD

- Understanding the customer requirements (customer's voice)
- Translate customer requirements in Technical parameters in the product.
- Design the product considering the voice of the customers.
- Make the system robust in design to achieve customer satisfaction
- Achieve global quality using benchmarking through QFD.

Advantages of QFD

- *Customers driven:* QFD is a customer driven process and it Create focus on customer requirements.
- *Reduces implementation time:* QFD helps in decreasing the mid-stream design changes and Limits post introduction problems
- *Promotes teamwork:* QFD promotes cross functional teams and improves internal communication.
- *Provides documentation*

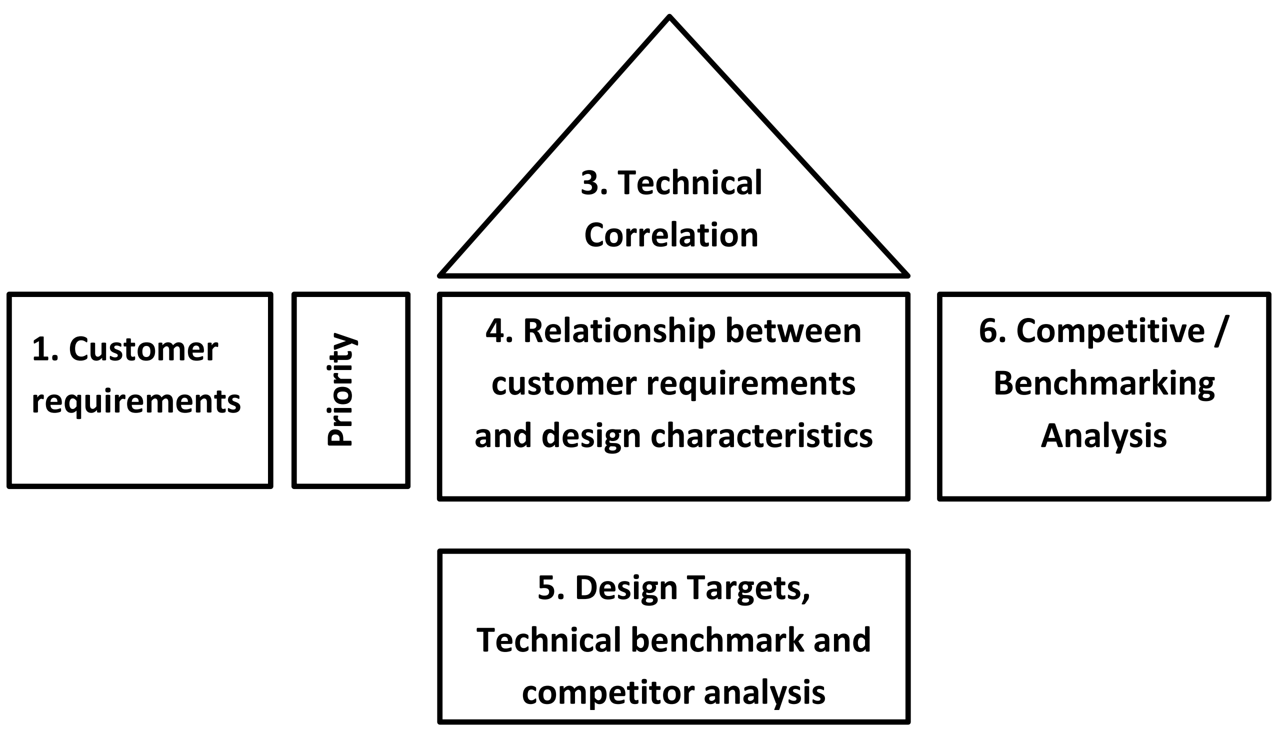
House of Quality

The House of Quality is a collection of several deployment hierarchies and tables, including the Demanded Quality Hierarchy, Quality Characteristics Hierarchy, the Relationships Matrix, the Quality Planning Table, and the Design Planning Table that resembles the connected houses called "House of Quality".

The House of Quality is used by multidisciplinary teams to translate a set of customer requirements, using market research and benchmarking data, into an appropriate number of prioritized engineering targets to be met by a new product design.

The House of Quality is a sort of conceptual map, which provides a means to the inter-functional planning and coordination of product improvement and product development. In a way this method brings the customer needs with the focus to design or to redesign the product and service. In this method the starting point would be the customer needs which are found from any market research survey about the product. Primary, secondary and tertiary customer attributes are found. These form the base of the house. Corresponding engineering characteristics is specified which should be in clear measurable terms. Now the interdependencies are mapped which are in the form of the roof of the house. Accordingly, technical difficulties in achieving the desired changes are calculated. With the help of imputed importance of each characteristic the cost is worked out. Then final targets are set in clear measurable terms. In essence, with the help of customer needs, the product is redesigned in clear unequivocal measurable terms.

Fig-16.13 House of Quality



The House of Quality contains six major components:

1. Customer requirements (Voice of customer):

A structured list of requirements derived from customer statements. The left side of matrix shows the requirements of the customer (Voice of the customer).The customer requirements are generally vague and it is necessary to look beyond to find the hidden requirements.

2. Prioritized customer requirements:

The right side of matrix illustrates the planning matrix. It illustrates customer perceptions observed in market surveys. It also includes the relative importance of customer requirements, company and competitor performance in meeting these requirements. Here the importance rating, competitive analysis, the target value, sales points is listed. From this the planning weight will be calculated to focus greater yield Potential for success in the market place.

3. Technical Descriptors:

The ceiling of the house contains the technical descriptors. Product design characteristics are located in this ceiling.

4. Relationship matrix:

The interior wall of the house is the relationship between customer requirements and technical descriptors (manufacture's terms). It is where the interactions between the customer and manufacturer takes place so that the Synergistic effect is seen.

5. Importance Rating

It is the result of calculating the total sum of each column when multiplied by the customer importance factor. It helps to determine where to assign the most resources. Then calculate the percent of importance.

6. Competitive Evaluation

It helps to understand competitor products to fulfil the customer requirements. It is also a good idea to ask customers how the product or service rates in relation to the competition. Use surveys, customer meetings, or focus groups/clinics to obtain feedback. Measure the satisfaction in 1 to 5 scales. Where 1 being highly dissatisfied and 5 being highly satisfied..

QFD Process

QFD process has the following stages:

1. Derive top level product requirements or technical characteristics from customer needs, using the Product Planning Matrix.
2. Develop product concepts to satisfy these requirements.
3. Evaluate product concepts to select the most optimal concept, using the Concept Selection Matrix.
4. Partition the system concept or architecture into subsystems or assemblies, and transfer the higher level requirements or technical characteristics to these subsystems or assemblies.
5. Derive lower-level product requirements (assembly or part characteristics) and specifications from subsystem/assembly requirements (Assembly/Part Deployment Matrix).
6. For critical assemblies or parts, derive lower-level product requirements (assembly or part characteristics) into the process planning.
7. Determine manufacturing process steps that correspond to these assembly or part characteristics.
8. Based on these process steps, determine set-up requirements, process controls and quality controls to assure the achievement of these critical assembly or part characteristics.

Discussion Forum

Short Questions

1. Define Quality.
2. List down the seven tools of quality.
3. What is Total Quality Management?
4. Define cost of quality.
5. What is quality planning?
6. Define Quality Control.
7. What is SPC?
8. What do you mean by quality charts for attributes?
9. Define Six Sigma.
10. What is Kaizen?

Essay Type Questions

1. What are the various dimensions of quality?
2. Explain the classification of cost of poor quality.
3. Discuss the various stages of quality management.
4. Illustrate the new tools of quality.
5. Explain the concept of quality circle.
6. Explain PDCA cycle.
7. Briefly discuss the 14 principles of Deming in TQM.
8. What is the contribution of Kaizen in TQM?
9. Explain the two different methods of Six Sigma.
10. Write a short note on Lean Six Sigma.
11. What do you mean by benchmarking? How do different types of benchmarking help the firms to maintain quality?
12. What are the different tools used in the process QFD?
13. Explain the concept of House of Quality.

Mini Case - COOPER TIRE & RUBBER COMPANY

Cooper Tire & Rubber Company is a global organization that specializes in the design, manufacture, marketing, and sales of passenger car, light truck, medium truck tires, while subsidiaries also specialize in motorcycle and racing tires. With headquarters in Findlay, Ohio, Cooper Tire has 67 manufacturing, sales, distribution, technical, and design facilities within its family of companies located around the world.

The challenge

Along with creating cost-effective operations, Cooper has sought to streamline its supply chain with low-cost, high quality raw materials that include natural rubber, synthetic rubbers, carbon black, reinforcing fabrics, and steel.

Cooper's continuous improvement activities are leading the company to develop innovative quality improvements. To establish more efficient production processes, they first had to understand and benchmark their baseline capabilities. One goal was to make better use of production data and, from an operations standpoint, use the data to help guide the decision making process. They needed a quality solution that could satisfy their scalability needs while offering insight into potential quality improvements.

Logistically, Cooper needed an enterprise-wide standard for reports in a system that would initially be implemented in North America, with the ability to go worldwide. As a global entity, Cooper's implementation would take place in phases, so they needed a flexible solution with options for training, consulting, and support.

One of Cooper's objectives was to employ a quality expert at each location to oversee the implementation and ensure the stability of corporate standards.

The solution

To achieve their process improvement goals, Cooper standardized on InfinityQS® Statistical Process Control (SPC) software. "Because quality is synonymous with the Cooper brand, we looked to InfinityQS to ensure that every process met the Cooper standard," said Bruce. "We investigated a few different options and decided that InfinityQS provided the best SPC solution to handle the complexities of our manufacturing operations."

InfinityQS integrates with MES and ERP systems to provide real-time detailed quality analysis capabilities at the process level that MES and ERP products were never designed to provide. The unique capabilities of InfinityQS solutions contribute to more fluid processes and allow the quality personnel to take a proactive approach to improving the capabilities of the various processes throughout the operations.

As opposed to the other real-time SPC solutions that Cooper was initially considering, InfinityQS uses a relational database structure, a simple, flexible format that was able to give Cooper the versatility they needed for a thorough analysis of parts across various production processes. InfinityQS's unique relational databases allow users to quickly and easily manage thousands of parts in a single set-up (project) as opposed to the hundreds of thousands of data files other SPC systems force users to configure. This structure allows Cooper to conduct comparative analyses of any part running across any process with just a few clicks of a mouse.

InfinityQS International is currently helping Cooper instill a culture of innovation throughout all the manufacturing sites. Rather than a reactive approach that dedicates resources to putting out fires, Cooper is bringing about change with a data-driven culture. InfinityQS's data analysis functions give Cooper a full grasp of their process capabilities. InfinityQS control charts illustrate process control limits, and create automated alerts when a process exceeds these limits. Instituting process control across production lines helps ensure that each Cooper tire is produced to the highest quality standards.

This robust data analysis allows Cooper to shift resources away from processes within specification and control limits toward areas that can enhance the overall operations. The first phase of Cooper's corporate-wide InfinityQS implementation took place in four North American facilities, before being rolled out in China.

Powerful tools allowed Cooper to become ISO 9001 certified

With InfinityQS ProFicient™, operational process improvements, significant cost savings, and increased productivity were achieved

In a single plant, Cooper was able to realize over $400,000 in annual savings by using ProFicient's data analysis tools

The results

Cooper was able to drive and sustain continual improvement using the InfinityQS SPC system. The software gave them additional tools to help them as they headed down the path to become ISO 9001 certified. With InfinityQS, Cooper effectively monitors processes to ensure effectiveness, keeps adequate records, checks output for issues and applies CAPA where necessary – all requirements of ISO 9001.

Cooper Tire & Rubber Company was able to use InfinityQS software to drive operational process improvements with significant cost savings and increased productivity. In one plant, Cooper realized $400,000 in annual savings on the belt line by analyzing the dimensional data of components. These cost savings represent just one line in one plant. Similar savings were recognized on other production lines and throughout other facilities using InfinityQS software. Cooper also attained measurable process performance index improvements in the inner line, extrusion, and cutting processes.

Cooper's road to success is driven by a combination of lower production costs and increased productivity. The significant annual savings on the beltline alone demonstrate how Cooper is able to significantly reduce its costs of production. In addition to cost savings, Cooper also made substantial improvements in process performance index. With the InfinityQS solution, Cooper Tire is systematically driving process improvements that ensure the optimal quality levels that consumers have come to expect from the Cooper brand.

CHAPTER-17

AUTOMATED SYSTEMS

INTRODUCTION

Automation is the art of making processes or machines self-acting or self-moving. Automation is also understood as the technique of making a device, machine, process, or procedure more fully automatic. Automated machinery ranges from simple sensing devices to autonomous robots and other sophisticated equipment. Automation of operations may be either automation of a single operation or the entire facility.

The firms have various reasons to automate their process. Increased productivity which enhances its competitive advantage is one of the main reasons for the firms to automate. Automation results in low operational variability which is directly related to quality and productivity. Other reasons for automation include the presence of a hazardous working environment and the high cost of human labor. Also many business firms automate their processes in order to reduce production time, increase manufacturing flexibility, reduce costs, eliminate human error, compensate labor shortage, etc. Decisions associated with automation are usually concerned with economic and social considerations.

For small business owners, weighing the pros and cons of automation can be a daunting task. The high velocity of the technological changes combined with a natural resistance to change helps an entrepreneur to manage the changes and hope for more powerful automation equipment for their operations in the near future.

Automation is a technology concerned with the application of mechanical, electronic, and computer-based system to operate and control production. It is the machinery that has sensing and control devices that facilitate it to operate automatically. Industrial automation or numerical control is the use of control systems such as computers to control industrial machinery and processes by replacing human operators. Automation in factories ranges from completely automated to a single automated operation.

Automation can be defined as "the technology that performs a task or set of tasks based on programmed commands."

Mechanization encouraged many machineries and technologies to satisfy the physical requirements of work. It replaced the hard work of labor but not the labor itself. On the other hand automation greatly reduced the need for human sensory and mental requirements as well. In automating the manufacturing process is carried out using computers where the human contribution is reduced to the minimum. Automation is used to control, monitor and execute manufacturing activities and it includes a set of procedures, guidelines based on which machines can automatically perform activities performed by humans.

Automation plays a progressive imperative role in the global economy and in daily experience. Engineers strive to combine automated devices with mathematical and organizational tools to create complex systems for a rapidly expanding range of applications and human activities. Automation also helps the organizations to control and manage their operations to gain a considerable economic and competitive advantage in the industry. Automation in services is also becoming very vital and are applied in the activities such as Insurance, Banks, Wholesale and resale distribution, Communications, Educational institutions, etc.

ADVANTAGES OF AUTOMATION

Automation offers many advantages over manual operations. Some of them are discussed as follows:

- It results in increased output and enhanced productivity, which help the firms gain economic and competitive advantage
- It offers low variability and hence high quality is assured
- It results in low variable costs, which finally results in lower manufacturing costs

- The use of labor is restricted in hazardous areas which reduces the accidents
- The methods are standardized and hence it results in better production control
- Automation can be widely used for dangerous and unpleasant tasks where human cannot be employed.
- Automation employs modern production methods and hence it results in reduced inventories
- Offers greater operating flexibility
- Reduces scrap during manufacturing
- Provide improved reliability
- Ensures design freedom

REASONS FOR AUTOMATING

Companies undertake projects in manufacturing automation and computer integrated manufacturing for various reasons. Some of the reasons used for automation are discussed as below:

1. *To increase labor productivity:* Automating a manufacturing operation increases production rate and labor productivity, which leads to a greater output per hour of labor input.

2. *To reduce labor cost*: Labor cost has been steadily increasing across the world. Higher investment in automation has become economically justifiable to replace manual operations. Machines are nowadays substituted for human labor in many areas to reduce unit product cost.

3. *To mitigate the effects of labor shortages:* There is a great shortage of labor in many developed nations, and this has motivated the development of automated operations as a substitute for human.

4. *To reduce or eliminate routine manual and clerical tasks:* There is social value in automating operations that are routine, boring, fatiguing, and possibly irritating. Automating such tasks, improves the general level of working conditions.

5. *To improve worker safety*: The safety and physical well-being of the worker has become a national objective with the enactment of the Occupational Safety and Health Act (OSHA) in 1970. This has provided a drive for automation in the hazardous areas where safety needs to be ensured.

6. *To improve product quality:* Automation not only results in higher production rates than manual operations, but also performs the manufacturing process with greater uniformity and conformity to quality specifications. Reduction of fraction defect rate is one of the main benefits of automation.

7. *To reduce manufacturing lead time:* Automation helps to reduce the elapsed time between customer order and product delivery, providing a competitive advantage to the manufacturer for future orders. By reducing manufacturing lead time, the manufacturer also reduces work in process inventory.

8. *To accomplish processes that cannot be done manually:* Certain operations cannot be accomplished without the help of machinery. These processes have requirements for precision, miniaturization, or complexity of geometry that cannot be achieved manually. Such processes can only be realized by computer controlled systems.

AUTOMATED MANUFACTURING SYSTEM (AMS)

An Automated Manufacturing System (AMS) is an interconnected system of material processing stations capable of automatically processing a wide variety of part types simultaneously under computer control. The system is not only interconnected by a material transport system, but also by a communication network for integrating all aspects of manufacturing. Such a system exhibits flexibility in parts routing, part processing, part handling, and tool changing. Additionally an automated manufacturing system exhibits the following characteristics:

- High degree of automation
- High degree of integration
- High degree of flexibility

An automated manufacturing system may include several enabling technologies such as Computer Aided Design (CAD), Computer Aided Process Planning (CAPP), Computer Aided Manufacturing (CAM), Flexible Manufacturing System, Computer Aided Testing (CAT), production planning and control, process technologies, robotics and automated material handling.

TYPES OF AUTOMATED SYSTEMS

Automated production systems can be classified into three types:

1. Fixed automation

Fixed automation is a system in which the sequence of processing operations is fixed by the equipment configuration. The operations in the sequence of processing are simple, and many such operations are integrated into complex systems. Generally it uses high-cost, specialized equipment for a fixed sequence of operations. It can be used for producing high volume of products at low costs.

The typical features of fixed automation are:

- High initial investment for custom engineered equipment
- High production rates
- Relatively inflexible in accommodating product changes

The economic justification for fixed automation is found in products with very high demand rates and volumes. The high initial cost of the equipment can be adjusted over manufacturing a very large number of units, thus making the unit cost low when compared to alternative methods of production. Some of the examples of fixed automation are mechanized assembly and machining transfer lines.

2. Programmable Automation

With programmable automation, the production equipment is designed with the capability to change the sequence of operations to accommodate different product configurations. The operation sequence is effectively controlled by a program. The program Is a set of instructions coded so that the system can read and interpret them. New programs can be prepared and entered into the equipment to produce new products. Some of the features of programmable automation are given below :

- High investment in general purpose equipment
- Low production rates relative to fixed automation
- Flexibility to deal with changes in product configuration
- Most suitable for batch production

Programmable Automated production systems are usually used in low and medium volume production. The parts or products are usually made in batches. To produce each new batch of a different product, the system must be reprogrammed with the set of machine instructions that correspond to the new product. The physical setup of the machine must also be changed. Tools must be loaded, fixtures must be attached to the machine table and the machine settings altered must be entered. Hence the change over procedure takes time. Consequently, the typical cycle for given product includes a period during which the setup and reprogramming takes place, followed by a period in which the batch is produced. Examples of programmed automation include numerically controlled machine tools and industrial robots.

3. Flexible Automation

Flexible Automation System is an extension of programmable automation. It is capable of producing a variety of products or parts without any loss of time for change overs from one product to the next. Also, there is no production time lost while reprogramming the system and altering the physical setup (i.e. tooling, fixtures, and machine setting). Consequently, the system can produce various combinations and schedules of products instead of doing in separate batches. The features of flexible automation can be summarized as follows:

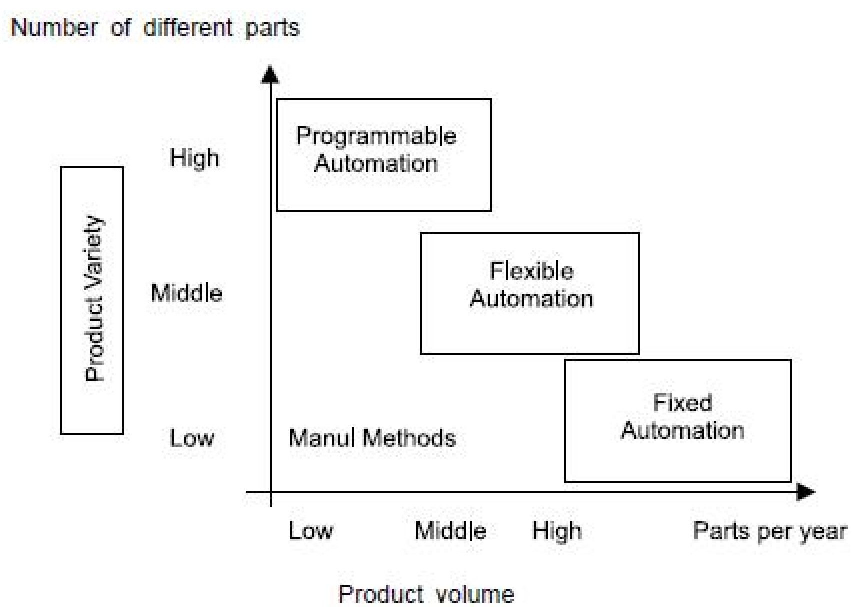
- High investment for a custom-engineered system
- Continuous production of variable mixtures of products
- Medium production rates
- Flexibility to deal with product design variations

The essential features that distinguish flexible automation from programmable automation are:

- The capacity to change part programs without affecting the production time
- The capability to change over the physical setup without affecting the production time

These features allow the automated production system to continue production without the downtime between batches. Changing the part programs is generally accomplished by preparing the programs offline on a computer system and electronically transmitting the programs to the automated production system. Therefore, time required to do the programming for next job does not interrupt production on current job. Advances in computer systems technology are largely responsible for the programming capability in flexible automation. Changing the physical setup between parts is accomplished by making the changeover offline and then moving it into place simultaneously as the next part comes into position for processing. For these approaches to be successful; the variety of parts that can be made on a flexible automated production system is usually more limited than a system controlled by programmable automation.

Fig-17.1 Types of production automation



AUTOMATED MACHINES

Industrial automation has bought numerous automatic machines with diverse features. Some of them are Machine attachments, Numerically Controlled (NC) machines, Robots, Automated quality controlled inspection, Automated Identification System (AIS), and Automatic process control

- **Machine attachments**

These are attachments done with machines that reduce human effort with the use of machine efforts in performing simple.

- **Numerically Controlled (NC) Machines**

Numerically Controlled (NC) machines are machines using control systems that read the instructions and translate them into machine operations. NC machines are further explained in detail in the later part of this chapter.

- **Robots**

Robots are general-purpose, programmable, multifunction manipulators that possess some human like physiological characteristics which are used in the automation process. Robots are further explained in the later part of robotics.

- **Automated Quality Controlled Inspection**

Automated Quality Controlled Inspection system consists of automated machines that perform part or entire inspection process in the manufacturing process of an organization.

- **Automated Identification System (AIS)**

Automated Identification System (AIS) consist of the technologies that are used in the automatic acquisition of product data for entry into a computer.

- **Automatic Process Control**

Automatic Process Control is the computer systems that receive data on the production process settings.

AUTOMATION IN DESIGN AND CONTROL

The computers can be used to improve the process of designing a product and also they can be used to design a product which is generally referred to as Computer Aided Design (CAD). Computers are also nowadays used in controlling the activities of various stages of manufacturing processes. It offers a set of procedures and equipment that automatically performs those activities that were traditionally considered to be activities of human which was named as the process of control. This is referred to as computer aided manufacturing (CAM)

COMPUTER AIDED DESIGN (CAD) SYSTEMS

Computer Aided Design (CAD) is the use of computers in interactive engineering drawing and storage of designs. It is related to automation of certain phases of product design. A CAD system incorporates computer graphics and computer aided engineering systems. The physical attributes of the process or products can be illustrated using computer graphics while the computer aided engineering systems can highlight the operational capabilities of the proposed design. Once the design procedure of the product is completed, CAD system helps to develop detailed drawings about the assemblies and sub-assemblies of the product.

Advantages:

The advantages of CAD are as follows:

- Increased productivity of designers

- Improved quality of designs
- Improvement in product standardization and design documentation
- Creation of a manufacturing database.

COMPUTER-AIDED MANUFACTURING (CAM)

Computer Aided Manufacturing (CAM) refers to the use of computers in process control ranging from robots to automated quality control system. CAM is concerned with automating the planning and controlling of production. It controls the machine tools on the shop floor. The machines perform a variety of operations and receive instructions from a computer on the sequence and specification of operations. The computers are either directly or indirectly used to control the processing equipment in order to support manufacturing process. The automated machineries can be controlled by using the installed Computer programs. Computer programs can also be stored in a database which can be reviewed, updated and revised whenever a component is designed or redesigned. CAM can be indirectly used in production and operational activities such as capacity planning, inventory control, quality control, etc., by using the method of bar coding which provides necessary information about the products and process. Computer Numeric Controlled (CNC) machines employ the concept of CAM.

COMPUTER NUMERIC CONTROLLED (CNC) MACHINES

CNC machines store operational instructions based on mathematical relationships on their on-board computers which control their operations. The machines work according to the instructions that are fed to them without any human intervention. The instructions are stored on the devices using the storage systems.

Advantages of CNC

The advantages of CNC are as follows:

- CNC uses instructions from a computer that are more reliable than those from a skilled operator
- Parts with complex geometry can be manufactured in small batches.
- Product quality is very consistent.
- Close tolerances can be obtained.
- Lower labor costs are achieved.
- There is a possibility of frequent changes in design

Disadvantages of CNC

However, there are some disadvantages due to automation in factories. Some of them are given as follows:

- Heavy capital investment
- Displacement of labor
- Tighter specification may be needed
- Costs of supply failure increase
- Slack season would be disastrous
- Dehumanization
- Problems of developing countries

AUTOMATED PRODUCTION SYSTEMS

Four categories of Automated Production Systems are discussed as follows:

1. AUTOMATED FLOW LINES

Several automated machines are linked together with automated parts transfer and handling machines. The lines of machines are used to produce one type of component or product. Machines on the line use automatic feeders and the processes are completed without any human intervention. The processed product or component is automatically transferred to the next machine in an assembly line, according to the fixed sequence to complete the entire process.

2. AUTOMATED ASSEMBLY SYSTEMS

The automated assembly machines are linked together with automated materials handling equipment. Materials are automatically fed to machines which may be robots that perform the assembly operations and transfer the partly completed assembly to the next assemble machine. The process is repeated again and again until we get completed products.

3. FLEXIBLE MANUFACTURING SYSTEMS (FMS)

FMS are groups of production machines, arranged in a sequence, connected with automated materials handling and transferring machines and integrated by a computer system.

It is appropriate when

- All products are variations on a stable basic design
- All products utilize the same family of components.
- The number of components is only moderate.

A flexible manufacturing system (FMS) is a manufacturing system in which there is some amount of flexibility that allows the system to react in the case of changes, whether predicted or unpredicted. This flexibility is generally considered to fall into two categories, which both contain numerous subcategories.

1. *Machine flexibility*: It covers the system's ability to be changed to produce new product types, and ability to change the order of operations executed on a part.
2. *Routing flexibility*: It consists of the ability to use multiple machines to perform the same operation on a part, as well as the system's ability to absorb large-scale changes, such as in volume, capacity, or capability.

The work machines which are often automated CNC machines are connected by a material handling system to optimize parts flow and the central control computer which controls material movements and machine flow.

The main advantage of an FMS is its high flexibility in managing manufacturing resources like time and effort in order to manufacture a new product. The best application of an FMS is found in the production of small sets of products like those from a mass production.

Advantages

- Productivity increment due to automation
- Preparation time for new products is shorter due to flexibility
- Saved labor cost, due to automation
- Improved production quality, due to automation

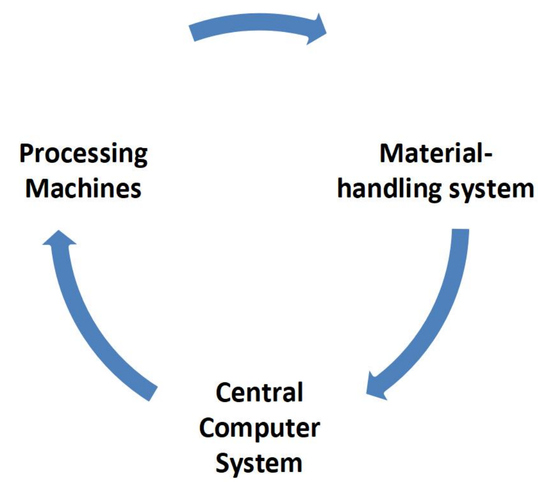
The components of an FMS are as follows:

(1) Processing machines, which are usually CNC machine tools that perform machining operations, although other types of automated workstations such as inspection stations are also possible

(2) A material-handling system, such as a conveyor system, which is capable of delivering work parts to any machine in the FMS

(3) A central computer system that is responsible for communicating NC part programs to each machine and for coordinating the activities of the machines and the material-handling system

Fig- 17.1 Components of FMS



In addition, a fourth component of an FMS is human labor. Although the flexible manufacturing system represents a high level of production automation, people are still needed to manage the system, load and unload parts, change tools, and maintain and repair the equipment.

5. AUTOMATED STORAGE AND RETRIEVAL SYSTEMS (ASRS)

ASRS deals with receiving orders for materials from anywhere in operations, collecting the materials from locations within a warehouse and delivering the materials to work stations in operations.

Three major elements of ASRS are as follows:

1. Computer and communication systems
2. Automated materials handling and delivery systems
3. Storage and retrieval systems in warehouse

Types of automated storage and retrieval systems

The two primary types of AS/RS include unit-load and mini-load systems.

Unit-load Systems:

Unit-load AS/RS are used for large loads such as handling full pallets or cases of items. Unit-load AS/RS handle the big jobs that may require moving objects or pallets that weigh a few thousand pounds. A typical unit-load AS/RS uses moveable-aisle cranes or fixed-aisle cranes.

- Fixed-aisle cranes usually stay fixed to one area or row of pallets, in this scenario. They travel along the designated area or path to retrieve items.
- Moveable-aisle cranes are similar, but they're designed to retrieve or store items in multiple areas instead of along one path or aisle.

Mini-load AS/RS:

Mini-load AS/RS, such as case-handling or tote-stacking systems, are smaller cranes or robots that handle lightweight loads such as trays or cartons. Mini-load AS/RS typically use cranes or shuttles.

- Mini-load AS/RS cranes move along narrow aisles to retrieve or store products. It's essentially a much smaller version of a fixed-aisle crane.
- Mini-load AS/RS shuttles run along a track and deliver items or move them between racking systems. They can work at multiple levels if designed for the job, but most of them run along a single path.

Benefits of AS/RS

By automating the low-value and easily repeated task of inventory storage and retrieval, AS/RS ensures many benefits to the operations including:

- More efficient use of floor space
- Ability to reclaim unused vertical space
- Increased inventory storage density
- Improved ergonomics and safety, resulting in fewer accidents
- Increased throughput
- Reduced labor costs
- Fewer labor constraints due to labor shortages
- Often modular design for maximum flexibility
- Increased order picking accuracy
- Improved product security for premium inventory

ASRS Systems Applications

The automated storage systems are used to manage small parts inventories, sub-assembly, work-in-process, maintenance and repair parts, and large tools and dies in a variety of applications found within manufacturing and distribution facilities. Some of the common applications include:

Storage: Providing high density storage parts and components used in a manufacturing process

Order picking: Offering compact, fast and reliable access to items required for distribution, bringing stored items to the operator for fast order fulfillment, supported by software integration

Kitting: Managing the process of receiving inventory, group (kitting) component parts for assembly and storing kits until required

Order Consolidation: Providing a compact solution to temporarily hold incomplete orders awaiting additional items before shipment

Buffering: offering a highly dense storage solution for inventory or process buffering

Assembly: Storing work-in-process or sub-assemblies for later use

Tools, Dies & Molds: Ergonomic and secure handling of heavy and often expensive tooling required in an automated production process

Maintenance & Repair Parts: Providing compact storage of maintenance parts onsite to reduce downtime

Replenishment & Returns: Managing inventory for replenishment and returns processes

Climate Controlled and Clean Room Environments: Provides cold, clean and dry management of storage

ARTIFICIAL INTELLIGENCE (AI)

Artificial Intelligence is the concept that the computers can be substitutes for human brain. Nowadays computers are substituting human brain in many organizations by their ability to process data, perform logical and mathematical calculations much faster and reliable than human without any fatigue. However conventional computer can only substitute human work but cannot completely replace them. But the systems equipped with artificial intelligence can perform high intellectual activities like human beings such as ability to reasoning,

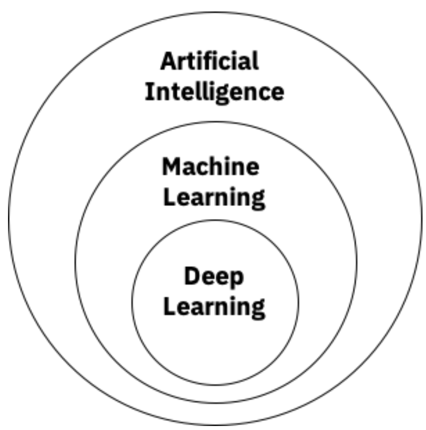
Artificial intelligence (AI) is the ability of a digital computer or computer-controlled robot to perform tasks commonly associated with intelligent beings. The term is frequently applied to the project of developing systems endowed with the intellectual processes characteristic of human, such as the ability to reason, discover meaning, generalize, or learn from past experience.

According to John McCarthy, Artificial Intelligence is defined as "the science and engineering of making intelligent machines, especially intelligent computer programs. It is related to the similar task of using computers to understand human intelligence, but AI does not have to confine itself to methods that are biologically observable."

COMPONENTS OF AI:

The components of artificial intelligence are as discussed below:

Fig-17.2 Components of AI



Machine Learning

Machine learning (ML) is a type of artificial intelligence that allows software applications to become more accurate at predicting outcomes without being explicitly programmed to do so. Machine learning algorithms use historical data as input to predict new output values.

Machine learning is important because it gives enterprises a view of trends in customer behavior and business operational patterns, as well as supports the development of new products. Many of today's leading companies, such as Facebook, Google and Uber, make machine learning a central part of their operations. Machine learning has become a significant competitive differentiator for many companies.

Deep Learning

Deep learning is a type of machine learning and artificial intelligence (AI) that imitates the way humans gain certain types of knowledge. While traditional machine learning algorithms are linear, deep learning algorithms are stacked in a hierarchy of increasing complexity and abstraction.

The main reasons for using deep learning are as follows:

- Deep learning requires large amounts of labeled data. For example, driverless car development requires millions of images and thousands of hours of video.

- Deep learning requires significant computing power. High-performance Graphics Processing Units (GPU) has a parallel architecture that is efficient for deep learning. When combined with clusters or cloud computing, this enables development teams to reduce training time for a deep learning network.

APPLICATIONS OF AI

Typical problems where AI methods could be applied are as follows:

- Pattern recognition including optical character recognition, handwriting recognition, speech recognition, face recognition, etc.
- Artificial Creativity
- Computer vision, Virtual reality and Image processing
- Diagnosis
- Game theory and Strategic planning
- Game artificial intelligence and Computer game bot
- Natural language processing, Translation and Chatter bots
- Non-linear control and Robotics

Other fields in which AI methods are implemented:

- Artificial life
- Automated reasoning
- Automation
- Biologically-inspired computing
- Colloquies
- Concept mining
- Data mining
- Knowledge representation
- Semantic Web
- E-mail spam filtering
- Robotics
- Evolutionary robotics
- Hybrid intelligent system
- Intelligent agent
- Intelligent control
- Litigation

ADVANTAGES OF AI:

The following are the primary advantages of AI:

1) Reduction in Human Error

Human make mistakes from time to time, but computers do not make these mistakes if they are programmed properly. With Artificial intelligence, the decisions are taken from the previously gathered information applying a certain set of algorithms. So errors are reduced and the chance of reaching accuracy with a greater degree of precision is a possibility.

2) Takes risks instead of Human

Many risky limitations of humans are overcome using AI Robots which can do the risky things for the firms. AI Robots are generally used in situations where interventions are hazardous.

3) Available 24x7

An Average human will work for 4–6 hours a day excluding the breaks. Human activities are planned in such a way to get some time out for refreshing themselves and get ready for a new day of work. Also they have to be provided with weekly off to ensure their work-life and personal life balance. But using AI we can make machines work for 24x7 without any breaks, unlike human.

4) Helping in Repetitive Jobs

Human will be performing many repetitive works like sending a thanking mail, verifying certain documents for errors and many more things. Using artificial intelligence we can automate these mundane tasks and can even remove “boring” tasks for human so that they can be allotted increasingly creative jobs.

5) Digital Assistance

Some of the highly advanced organizations use digital assistants to interact with users which save the need for human resources. The digital assistants also used in many websites to provide things that users want. We can chat with them about what we are looking for. Chatbots are designed in such a way that it is become hard to find out whether we are chatting with a chatbot or a human being.

6) Faster Decisions

Using AI with other technologies we can make the machines to take decisions faster than a human and carry out actions fast. While taking a decision, human will analyze many factors both emotionally and practically but AI-powered machine delivers the results in a faster way.

7) New Inventions

AI is powering many inventions in almost every domain which will help humans solve the majority of complex problems.

DISADVANTAGES OF AI

1) High Costs of Creation

As AI is getting updated frequently, the hardware and software need to get updated accordingly to meet the latest requirements. Machines need repairing and maintenance which involves high costs.

2) Making Human Lazy

AI is making human lazy with its applications by automating the majority of work. Human tend to get addicted to these inventions which can cause a problem to future generations.

3) Unemployment

As AI is replacing the majority of the repetitive tasks and other works with robots, human interference is becoming less which will lead to unemployment problems. Organizations are looking towards replacing the minimum qualified individuals with AI robots to do the similar work with more efficiency.

4) No Emotions

There is no doubt that machines are much better when it comes to working efficiently but they cannot replace the human connection that makes the team. Machines cannot develop a bond with humans which is an essential attribute when comes to Team Management.

5) Lacking Out of Box Thinking

Machines can perform only those tasks which they are designed or programmed to do, anything out of that they tend to crash or give irrelevant outputs which could be a major backdrop.

ROBOTICS

Recently, robots have become common in many industries and they are often given jobs that are considered dangerous to human. Robots have proven effective in jobs that are highly repetitive which may lead to mistakes or accidents. General Motors uses around 16,000 robots for tasks such as painting, welding, and assembly. Japan is the leader in using and producing robots for various purposes in the world. According to the International Federation of Robotics (IFR) study World Robotics 2020, there were about 2,722,077 operational industrial robots by the end of 2019. This number is estimated to reach 3,788,000 by the end of 2021.

Manufacturing robots automate repetitive tasks, reduce margins of error to negligible rates, and enable human workers to focus on more productive areas of the operation. Fully autonomous robots in manufacturing are commonly needed for high-volume, repetitive processes where the speed, accuracy and durability of a robot offers unparalleled advantages. Other manufacturing automation solutions include robots to help people with more complicated tasks. The robot executes the repetitive processes such as lifting, holding and moving heavy pieces.

Robotic process automation in manufacturing allows companies to remain competitive globally offering an efficient, viable alternative to offshoring and fulfilling the skills gap in areas where it may be difficult to recruit the necessary employees. Manufacturing robots enable employees to focus on innovation, efficiency and more complicated processes that ultimately lay the groundwork for growth and success. With a dedicated manufacturing automation solution in place, we can witness increased productivity, improved worker safety and satisfaction, and a better bottom line.

Reasons to use Robotics in Manufacturing

Some of the reasons for using robots in manufacturing process are as follows:

- Robots used in manufacturing create efficiencies all the way from raw material handling to product packaging.
- Robots can be programmed to operate 24/7 for ensuring continuous production.
- Robotic equipment is highly flexible and can be customized to perform even complex functions.
- With rapid expansion in the field of robotics, manufacturers increasingly need to embrace automation to stay competitive.
- Automation can be highly cost-effective for nearly every size of company, including small shops.

APPLICATIONS OF ROBOTS

Today most robots are used in manufacturing operations; the applications can be divided into three categories: (1) Material handling, (2) Processing operations, and (3) Assembly and Inspection.

Material Handling

Material-handling applications include material transfer and machine loading and unloading which has been explained in detail in chapter-13. Material-transfer applications use the robot to move materials or work parts from one location to another. Many of these tasks are relatively simple but repeating, requiring robots to pick up parts from one conveyor and place them on another. Other transfer operations are more complex, such as placing parts onto pallets in an arrangement that must be calculated by the robot. Machine loading and unloading operations can utilize a robot to load and unload parts at a production machine.

Processing Operations

In robotic processing operations, the robot manipulates a tool to perform a process on the work part. Examples of such applications include spot welding, continuous arc welding, and spray painting. Spot welding of automobile bodies is one of the most common applications of industrial robots in automobile industries. The robot positions a spot welder against the automobile panels and frames to complete the assembly of the basic car body. Arc welding is a continuous process in which the robot moves the welding rod along the seam to be welded. Spray painting involves the manipulation of a spray-painting gun over the surface of the object to be coated. Other operations in this category include grinding, polishing, and routing, in which a rotating spindle serves as the robot's tool.

Assembly and Inspection

The third application area of industrial robots is assembly and inspection. The use of robots in assembly is expected to increase because of the high cost of manual labor common in these operations. Since robots are programmable, one strategy in assembly work is to produce multiple product styles in batches, reprogramming the robots between batches. An alternative strategy is to produce a mixture of different product styles in the same assembly cell, requiring each robot in the cell to identify the product style as it arrives and then execute the appropriate task for that unit.

The design of the product is an important aspect of robotic assembly. Assembly methods that are satisfactory for humans are not necessarily suitable for robots. Using a screw and nut as a fastening method, for example, is easily performed in manual assembly, but the same operation is extremely difficult for a one-armed robot. Designs in which the components are to be added from the same direction using snap fits and other one-step fastening procedures enable the work to be accomplished much more easily by automated and robotic assembly methods.

Inspection is another area of factory operations in which the utilization of robots is growing. In a typical inspection job, the robot positions a sensor with respect to the work part and determines whether the part is consistent with the quality specifications.

COMPUTER INTEGRATED MANUFACTURING (CIM)

Computer-integrated manufacturing (CIM) is a method of manufacturing in which the entire production process is controlled by computer. Typically, it relies on closed-loop control processes, based on real-time input from sensors. It is also known as flexible design and manufacturing.

Three components distinguish CIM from other manufacturing methodologies:

1. Means for data storage, retrieval, manipulation and presentation
2. Mechanisms for sensing state and modifying processes
3. Algorithms for uniting the data processing component with the sensor/modification component

CIM is defined as "the integration of total manufacturing enterprise by using integrated systems and data communication coupled with new managerial philosophies that improve organizational and personnel efficiency."

A CIM system is not the same as a *"lights out" factory*, which would run completely independent of human intervention, although it is a big step in that direction. Part of the system involves flexible manufacturing, where the factory can be quickly modified to produce different products, or where the volume of products can be changed quickly with the aid of computers.

Some or all of the following subsystems may be found in a CIM operation:

- CAD/CAM (Computer-aided design/Computer-aided manufacturing)
- CAPP (Computer-aided process planning)

- ERP (Enterprise resource planning)
- CNC (computer numerical control) machine tools
- DNC (direct numerical control machine tools)
- FMS (flexible machining systems)
- ASRS (automated storage and retrieval systems)
- AGV (automated guided vehicles)
- Robotics
- Automated conveyance systems
- CAQ (Computer-aided quality assurance)
- A business system integrated by a common database
- Lean Manufacturing

Key Challenges

There are three major challenges to development of a smoothly operating CIM system:

- Integration of components from different suppliers: When different machines, such as CNC, conveyors and robots, are using different communications protocols. In the case of AGVs, even differing lengths of time for charging the batteries may cause problems.

- Data integrity: The higher the degree of automation, the more critical is the integrity of the data used to control the machines. While the CIM system saves on labor of operating the machines, it requires extra human labor in ensuring that there are proper safeguards for the data signals that are used to control the machines.

- Process control: Computers may be used to *assist* the human operators of the manufacturing facility, but there must always be a competent engineer on hand to handle circumstances which could not be foreseen by the designers of the control software.

AUTOMATION IN SERVICE INDUSTRIES

Automation of service industries include collection of which include health care, banking and other financial services, government, and retail trade.

AUTOMATION IN HEALTH CARE

In health care the use of automation in the form of computer systems has increased dramatically to improve services and relieve the burden on medical staffs. In hospitals computer terminals on each nursing care contain floor record data on patient status, medications administered, and other relevant information. Some of these systems are used to perform additional functions such as ordering drugs from the hospital pharmacy and calling for other relevant services. The system provides an official record of nursing care given to patients and is used by the nursing staff to give a report at shift-change time. The computer system is connected to the hospital's business office so that proper charges can be made to each patient's account for services rendered and medicines provided.

Robotics is likely to play great role in future health care delivery systems. The work that is done in hospitals by nurses, orderlies, and similar staff personnel includes some tasks that are routine and repetitive. Duties that might be automated using robots include making beds, delivering linens, and moving supplies between locations in the hospital. Robots might even become involved in certain aspects of patient care such as transporting patients to services in the hospital, passing food trays, and similar functions in which it is not critical that a hospital staff member be present. Research is currently in progress to develop robots that would be capable of providing assistance to paraplegics and other physically handicapped persons. These robots would respond to voice commands and would be able to interpret statements in natural language from patients requesting service.

The process that could be automated in hospitals includes the following:

- Admission Processes

- Emergency Room Operations
- Transfers to Other Hospitals
- Medication Processes
- Medical Documentation
- Supply of Drugs
- Patient Flow

AUTOMATION IN BANKING AND FINANCIAL SECTOR

Banking and financial institutions have embraced automation in their operations principally through computer technology to facilitate the processing of large volumes of documents and financial transactions. The sorting of cheque is done by optical character-recognition systems utilizing the special alphanumeric characters at the bottom of cheques. Bank balances are computed and recorded using computer systems installed by virtually all financial institutions. Many banks have established electronic banking systems, including Automatic Teller Machines (ATMs).

Robotic Process Automation (RPA) has been significantly adopted in this sector, for making the time consuming banking operations more organized and automated. According to reports, the largest revenue share for 2019 was dominated by BFSI segment in terms of application of RPA.

Robotic process automation has also dramatically streamlined a wide variety of back office processes that once bogged down bank workers. By shifting much of these tedious, manual tasks from human to machine, banks have been able to significantly reduce the need for human involvement, which has had a direct impact on everything from performance and efficiency levels to staffing issues and expenses.

RPA finds its applications in the following banking functions:

- Customer Service
- Accounts Payable
- Mortgage Processing
- KYC
- Credit Card Processing
- Fraud detection
- Compliance
- Report Automation
- Account Origination & Receivable
- Collection
- Deposits
- General Ledger
- Account Closure Process
- Surrender

Benefits of RPA in banking

Cost Savings

Many argue that RPA does not reduce cost but provide more value addition to the overall organizational benefits and efficiency. Whereas, the various implementation show slightly different data. Banks are always looking to cut cost in such competitive industry. Research shows that implementing RPA drives about 25% to 50% cost savings, improving the output metrics of applied functions.

Expediting the Operational Efficiency

Banks play a very important role in influencing the economy. If all the banks become more efficient, it’ll have direct and ripple effect on many other industries. RPA is an extensive solution which requires employee training, governance, comprehensive setup. But once it is in place, research says that banks will save 40-60% in the first year of implementation making processes faster and much more efficient.

Agile Businesses

With the growing technology penetration in every industry and globalization, banks need to be more agile and flexible than ever. The effect of things happening on the other side of the world can be seen in hours instead of days. With RPA, banks get a chance to prepare for any situation and respond in no time. Also, by freeing up the human resources from daily mundane tasks, more focus can be given coming up with innovative strategies to grow business.

Growth with Legacy Data

Technology has allowed us to digitize the data from the paper entries making it available for businesses. With RPA, banks are using legacy and new data to bridge the gap between processes. With the availability of data in one system allows creating faster and better reports for the business strategies.

Reduced Business Response Time

Banks are incorporating Robotic Process Automation for faster process execution and operational efficiency. Research says that banks will be able to save 75% of the cost while retaining the quality output. Banks like HDFC and ICICI are using RPA to bring down process execution time by around 60%. RPA is disrupting the way banks are operating and the adoption will increase with the CAGR of 65%.

Leveraging the Existing Infrastructure

Implementing Robotic Process Automation does not require setting up new infrastructure. The unique quality of RPA technology allows it to integrate with any system irrespective of the development technology making it applicable enterprise wide. Banks are already using RPA in operations, sales, Human Resources, Admin, Finance functions to optimize process with efficiency and reduced cost.

Faster Implementation with No Coding

Most of the RPA tools like Automation which provides drag and drop technology to automate process. This technology allows creating automation workflow without any or minimal coding. This makes it easy to implement and maintain.

AUTOMATION IN RETAIL SECTOR

Automation in stores, distribution warehouses, and back-office operations provides retailers with the flexibility to identify and adjust for changes in customer traffic and buying patterns, both in-store and online.

With increasing competition and price war in e-commerce, retail businesses are focusing more on improving customer experience; cost reduction, product availability and employee productivity. Considering the pressure to provide experience and quality product, the scope of human error also increases. To achieve efficient and error-free operations, the retail industry is integrating disruptive technologies like Robotic Process Automation (RPA). The retail organizations have a massive stack of processes like inventory management, invoice processing, customer queries, business analytics, order processing, sales spreadsheet management, employee on-boarding & off-boarding which are the best cases for automation to achieve high efficiency and reduce cost. The impact of RPA in retail industry is discussed below:

- **Automate Invoice Processing**

Automating invoice, contracts and quotation processing will reduce Turnaround time significantly with improved accuracy. Paper-based invoices in different formats can also be processed using Optical character recognition (OCR) technology.

- **Employee On-boarding**

Automating employee on-boarding process includes screening resumes, entering employee details in different systems, providing respective access as well as enrolling for training. RPA can also predict the trend in employee resignation and retention.

- **Inventory Management**

RPA can help predict the fluctuation in the market using machine learning. This helps retail companies to prepare in advance to meet the changing market requirement. By integrating different systems, RPA can significantly reduce order processing time.

- **Sales Analytics**

The sales team in retail relies on excel sheets to track monthly or quarterly sales. It takes significant time to consolidate and sent these numbers to the central management. Automation Edge is the fastest RPA solutions to process structured as well as unstructured data in excel spreadsheets.

- **Efficient Customer Support**

Using past data, Chatbot and machine learning together can automate customer support for structured and unstructured requests. Natural Language Processing helps understand requests in plain English in email or chat.

- **Consumer Behavior**

RPA when used in consumer behavior analysis for factors like social media emotions, past shopping and browsing history, can help in effective new product launch, analyze market trends, store planning, trade promotions and many more.

Benefits of RPA in Retail

- Better product availability to fulfill changing market demand
- More value to the customer through smarter promotions
- Reduced cost and errors in business operations
- Real-time analytics of sales and inventory for efficient planning
- Market trend prediction for successful new product launch
- Improved customer satisfaction with low TAT and high availability

Discussion Forum

Short Questions

1. Define Automation.
2. Give the advantages of automation.
3. What are the reasons for automating the firms?
4. What is AMS?
5. Write a note on CIMS.
6. Mention any 4 reasons for using robots in industrial processes.
7. What is AS/RS?
8. Give any 4 benefits of AS/RS.
9. What is CAD?
10. What do you mean by a robot?

Essay Type Questions

1. What do you mean by Artificial Intelligence?
2. Discuss the applications of AI in various fields.
3. Explain the different types of Automation.
4. What are the different types of automated machines? Explain in detail.
5. Discuss the various automation tools used in production design and control
6. Discuss the advantages and disadvantages of AI.
7. Why are robots used in the factories and work places?
8. Discuss the various applications of robotics?
9. Explain the process of automation in Financial and banking sector.
10. How retail sector is automated in the modern business?
11. Explain the various automation procedures in hospital sector.

Mini Case-17.1 Ford's Ever-Smarter Robots Are Speeding Up the Assembly Line

IN 1913, HENRY Ford revolutionized car-making with the first moving assembly line, an innovation that made piecing together new vehicles faster and more efficient. Some hundred years later, Ford is now using artificial intelligence to eke more speed out of today's manufacturing lines.

At a Ford Transmission Plant in Livonia, Michigan, the station where robots help assemble torque converters now includes a system that uses AI to learn from previous attempts how to wiggle the pieces into place most efficiently. Inside a large safety cage, robot arms wheel around grasping circular pieces of metal, each about the diameter of a dinner plate, from a conveyor and slot them together.

Ford uses technology from a startup called Symbio Robotics that looks at the past few hundred attempts to determine which approaches and motions appeared to work best. A computer sitting just outside the cage shows Symbio's technology sensing and controlling the arms. Toyota and Nissan are using the same tech to improve the efficiency of their production lines.

The technology allows this part of the assembly line to run 15 percent faster, a significant improvement in automotive manufacturing where thin profit margins depend heavily on manufacturing efficiencies.

"I personally think it is going to be something of the future," says Lon Van Geloven, production manager at the Livonia plant. He says Ford plans to explore whether to use the technology in other factories. Van Geloven says the technology can be used anywhere it's possible for a computer to learn from feeling how things fit together. "There are plenty of those applications," he says.

AI is often viewed as a disruptive and transformative technology, but the Livonia torque setup illustrates how AI may creep into industrial processes in gradual and often imperceptible ways.

Automotive manufacturing is already heavily automated, but the robots that help assemble, weld, and paint vehicles are essentially powerful, precise automatons that endlessly repeat the same task but lack any ability to understand or react to their surroundings.

Adding more and more automation is highly challenging task. The jobs that remain out of reach for machines include tasks like feeding flexible wiring through a car's dashboard and body. In 2018, Elon Musk blamed Tesla Model 3 production delays on the decision to rely more heavily on automation in manufacturing.

Researchers and startups are exploring ways for AI to give robots more capabilities, for example enabling them to perceive and grasp even unfamiliar objects moving along conveyor belts. The Ford example shows how existing machinery can often be improved by introducing simple sensing and learning capabilities.

"This is very valuable," says Cheryl Xu, a professor at North Carolina State University who works on manufacturing technologies. She adds that her students are exploring ways that machine learning can improve the efficiency of automated systems.

One key challenge, Xu says, is that each manufacturing process is unique and will require automation to be used in specific ways. Some machine learning methods can be unpredictable, she notes, and increased use of AI introduces new cybersecurity challenges.

The potential for AI to fine-tune industrial processes is huge, says Timothy Chan, a professor of mechanical and industrial engineering at the University of Toronto. He says AI is increasingly being used for quality control in manufacturing, since computer vision algorithms can be trained to spot defects in products or problems on production lines. Similar technology can help enforce safety rules, spotting when someone is not wearing the correct safety gear, for instance.

Chan says the key challenge for manufacturers is integrating new technology into a workflow without disrupting productivity. He also says it can be difficult if the workforce is not used to working with advanced computerized systems.

This doesn't seem to be a problem in Livonia. Van Geloven, the Ford production manager, believes that consumer gadgets such as smartphones and game consoles have made workers more tech savvy. And for all the talk about AI taking blue collar jobs, he notes that this isn't an issue when AI is used to improve the performance of existing automation. "Manpower is actually very important," he says

Source: https://www.wired.com/story/fords-smarter-robots-speeding-assembly-line/

Mini Case- 17.2 Revolutionizing the Shipping Industry with Fully Automated Terminal Operations

Ports have adopted automation at a relatively slow rate compared with other industries. Sectors such as mining and warehousing have been faster to recognize the benefits of automation and implement the technology into their processes. Automation allows ports to operate more safely, minimize human-caused disruption, and enhance performance.

The up-front cost of setting up fully automated shipping solutions has previously acted as a barrier to automating the shipping industry on a global scale. Global mechatronics solution provider Stäubli has now launched its Quick Charging Connection solution integrated into PSA Singapore's container transshipment hub. The technology will allow the port to become fully automated. It will also likely act as an example to the wider industry of how automation technology can be adopted to leverage numerous benefits.

The Fully Automated Port

While the world's first automated container port was created back in the 1990s in Europe, automation has not fully taken off in the industry. To date, roughly 40 more ports have become fully or partially automated, with around half of these being established in the last few years.

Data estimates that approximately $10 billion in total has been invested into port automation projects, with $15 billion more expected in the next five years. There is a keen interest in automation technology in the shipping industry. However, there are limited examples of seamless, fully automated operations to provide case studies to ports for developing automation in their location.

Quick-Charging AGVs to Automate Port Operations

The world's largest container transshipment hub, PSA Singapore, will soon become fully automated. The port connects shipping lines to more than 600 global ports. Annually, it handles over 85 million twenty-foot equivalent units (TEUs) of containers. To prepare for inevitable future growth, PSA is adopting Stäubli technology to integrate fully automated shipping solutions into its hub.

Automated guided vehicles (AGVs) are key to the fully automated port. They are vehicles that can move shipping containers without the need for manual (human) labor. To optimize the operations of automated ports, AGVs must be efficient and reliable.

The PSA hub is trialing AGVs that can carry 65 tons and move at a crushing speed of 25 km/h. The AGVs are more cost-effective and energy-efficient than their traditional counterparts. They also require less maintenance and help the port reduce its carbon footprint by being fully electric, and, therefore, do not release emissions into the atmosphere.

Stäubli supports the adoption of these vehicles with its Quick Charging Connection solution that allows AGVs to charge their batteries in just 20 minutes, proving four to five hours of operation time. Fast Battery Replacement During Maintenance

Stäubli's Multi Connect System provides fast battery replacement for efficient maintenance. With numerous AGVs operating simultaneously, it is vital to the seamless running of port operations that battery replacement of the AGVs must be equally speedy at all hours of the day.

To address this need, Stäubli has developed its Multi Connect System (MCS) that centralizes different energy sources and can connect them with a single movement. The MCS is perfectly designed to support automatic and rapid operations.

The Future of Fully Automated Shipping Solutions

A recent McKinsey report has highlighted the value of automating the shipping industry. According to current data, successfully automated ports can benefit from a 25-55% reduction in operating expenses and a 10-35% increase in productivity. These figures demonstrate the benefits of fully automated shipping solutions. The project's potential success at PSA, where Stäubli has been integrated, will likely act as an example to other ports across the globe hoping to benefit from automating their shipping systems. These projects in particular will also likely further Singapore's connectivity, enforcing its importance as a shipping hub, in addition to inspiring other locations to do the same.

In the even longer term, the PSA/Stäubli project's inspiration may usher in a new paradigm known in the industry as Port 4.0, which represents a shift from asset operator to service orchestrator. Port 4.0 acts as part of the more significant paradigm shift called industry 4.0, which joins and optimizes production and operations activities with intelligent digital technology, machine learning, and big data. As a result, more value will be generated for the operators of ports, supplies, and customers. While there will be a lot to be leveraged from implementing fully automated shipping solutions, innovative business models will be required to get the most out of this technology.

Source: https://www.azom.com/article.aspx?ArticleID=20302

CASE STUDIES

CASE STUDY-1

MAKE OR BUY DECISION

XYZ Ltd. is a manufacturing company engaged in the manufacturing of valves. They have been in the business for last 3 years and have been manufacturing only one type of valves. They started their business initially with sales of 10,000 valves per month and now they have grown the volume to about 50,000 valves per month. They have been buying all the raw material for the valve and were doing all the manufacturing in house. Now they have established themselves in the market and are planning to expand and produce different varieties of valves. They have their plant in the main city and the total area of the plant is 50,000 sq. ft. Now if they want to expand and continue doing all the activities of manufacturing of all the varieties in house, they would need another 50,000 sq.ft. of the area. In the recent times, the land prices in the area have more than doubled in the last 3 years and still land is available with great difficulty. Mr. Sathish is the production head of XYZ Ltd. and has been successful with the production and the level is continuously increasing. But in recent times, he is facing the problem of quality complaints which have gone up from average 0.2 % in previous 2 years to 0.5 % this year. Also, he is finding that there is a high level of dissatisfaction among the workers regarding workload as well as salary levels. The workers are regularly complaining about the over work.

Although, Mr. Sathish has found that the workers have been spending lot of time on tea breaks, lunch breaks and even in between the production spending lot of time talking to each other. But, due to insufficient workers and staff, he is unable to take strict action and the workers are taking advantage of this situation. For completing the work and delivering the products timely, he has to employ workers on overtime and his overtime cost has also increased 3 times. Mr. Sathish is worried about the new expansion plan of the management and is worried where the new workers would come from as he is already finding shortage of workers for the existing job. He has requested the management not to go for expansion immediately and look at improving and consolidating the existing set up. He has sent his request to Mr. Ramesh, Director – Operations.

Mr. Ramesh has gone through the request of Mr. Sathish and called a meeting of all the department heads and explained the situation to all concerned. The marketing manager has expressed very bullish prospect about the company's growth and said that the company should take advantage of growing economy and established brand image of the company and definitely go for expansion. The finance manager also expressed that this will result in economy of scale for the products and will further increase the profitability of the products. Mr. Sathish again expressed his problems regarding availability of manpower as well as production control and effect on quality and productivity. The Marketing manager asked the Production manager about the option of outsourcing. Mr. Sathish is skeptical about the outsourcing option as he felt that the outside agency will always charge more as he will try to make his profit as well and also is worried about the possible problems of deliveries. Mr. Ramesh asked the Mr. Naresh who is the Purchase manager about his views. He said that since the suppliers would also be interested in doing the business, they would not like to delay as with delay they also incur loss. The Finance manager said that we can look at cost comparison for buying against in house manufacturing.

After listening to all the views, Mr. Ramesh told Mr. Sathish to work out the cost of production for future sales as per the forecast given by the Marketing department. He also told Mr. Naresh to collect the details of the future requirements to get the purchase cost details for few components of the valve. Mr. Sathish and Mr. Naresh have collected their data and they have presented the data in the meeting called by Mr. Ramesh to review the plan. First the marketing head Mr. Suresh presented his market forecast and then Mr. Sathish presented his report and explained the details as follows.

One supervisor with monthly salary of Rs. 5000 with expected increase of 10 % per year.

Direct wages of worker as Rs. 4 per unit.

With 10 % reduction in second year, no change in 3rd year and increase of 10 % every subsequent year.

Material cost of Rs. 14 per unit with an increase of 10 % every year. Power and fuel cost of Rs. 2 per unit with increase of 10 % every year.

Indirect labor as 50 % of direct labor.

They will have to buy a new machine with a cost of Rs. 50 lac.

With usable life of 5 years Mr. Naresh explained his details as follows:

Component price from supplier at Rs. 20 for the first 2 years with an increase of 10 % every subsequent year.

Transportation cost of Rs. 2 per unit for the first year with increase of Rs. 0.20 every subsequent year. Inventory cost (storage cost) as 5 % per year of the basic material cost.

The Marketing manager has given the sales forecast for next 5 years as follows:

Year	1	2	3	4	5
Sales Quantity	300000	500000	700000	900000	1000000

Questions

1. Based on this data, is it economical for ABC Ltd.to go for buying the product from market or manufacturing in house.

2. What other factors should ABC Ltd. look at for making this decision?

CASE STUDY - 2

PRODUCT DEVELOPMENT RISKS

Mr. Kavin has the opportunity to invest INR 100 billion for your company to develop a jet engine for commercial aircrafts. Development will span 5 years. The final product costing Rs. 500 million / unit could reach a sales potential, eventually of Rs. 2500 billion. The new engine can be placed in service 5 years from now, but only if it qualifies four years from now for certification clearing commercial use and only if it meets America's Federal Aviation Administration's (FAA) ever tightening standards for noise reduction. Certification also has to be obtained from India's Director General of Civil Aviation (DGCA). There is competition from world-class manufacturers like Pratt and Whitney and Rolls Royce who are developing competing engines. If Mr. Kavin decides to proceed with the project, he must also determine where the new engines will be produced and develop the manufacturing facilities. If Mr. Kavin decline to proceed, his company could invest its resources elsewhere and based on its track record, get attractive returns.

Questions:

(a) What would be Mr. Kavin's line of action?

(b) In case of lengthy product design and development time, what kinds of risks are there?

CASE STUDY – 3

PROJECT MANAGEMENT

The Assam Gas Cracker Project conceived as part of the Assam Accord signed in 1985 is yet to see the light of the day. It has been plagued by a host of problems starting from location to economic viability. Originally planned at Tengakhat, it was later shifted to a place called Lepetkata. The project is now being implemented by GAIL (a Government of India enterprise) as the lead promoter (70% share) with another public enterprise OIL (20% share) and the Government of Assam as minor Himadri Barman, Centre for Management Studies, Dibrugarh University, Dibrugarh 786 004 (Assam) Downloaded from http://himadri.cmsdu.org 2 partners. GAIL had to be brought in after India's largest private sector enterprise Reliance Industries backed out of the project saying that it was economically unviable. The land acquisition for the project (as of mid-2008) is yet to be completed and there is still a lot of uncertainty regarding the availability of raw materials for production. In the meantime, the project cost has spiraled many times over to INR 50 billion, which is likely to go up further.

Questions:

(a) Discuss the importance of Project Management in the light of the above situation.

(b) As a project manager employed with GAIL, what would be your line of action to see to it that the project is not delayed any further?

(c) Why do projects suffer from time and cost overruns?

CASE STUDY– 4

JIT IN ACTION

A new phenomenon called 'Apparel on Demand' is slowly making its presence felt. It is an extension of JIT linking retailers and manufacturers for a just-in-time responsiveness. NaaR Clothing Inc., promoted by a young management graduate has recently ventured into the business of making reasonably priced custom jeans for women. It has partnered with many stores selling women garments. In the stores, women are electronically measured and information like colour, fabric, style, etc., are recorded. The information reaches the NaaR manufacturing facility at Ahmedabad almost immediately through a state-of-the-art information system.NaaR guarantees delivery of the custom jeans within 10 days. With the growing acceptance of jeans among the women in India, especially in the urban areas, the market for women's jeans is growing at a fast pace. NaaR with its unique business model hopes to garner a significant share of this market. The promoter of NaaR along with her top executives is confident that their concept of JIT jeans would work.

Questions:

(a) Do you think NaaR's strategy would work? Why or why not? What is the importance of retailers in its business strategy?

(b) Will customers wait for 10 days to have the jeans delivered? What can NaaR do to compete on customer service if delivery takes this much time?

(c) Comment on the necessity of a robust supply chain in the context of NaaR Clothing Inc.

CASE STUDY- 5

FORECASTING

Ms. Madonna had worked for the same Fortune 500 Company for most 15 years. Although the company had gone through some tough times, things were starting to turn around. Customer orders were up, and quality and productivity had improved dramatically from what they had been only a few years earlier due companywide quality improvement program. So, it comes as a real shock to Ms. Madonna and about 400 of her co-workers when they were suddenly terminated following the new CEO's decision to downsize the company.

After recovering from the initial shock, Ms. Madonna tried to find employment elsewhere. Despite her efforts, after eight months of searching she was no closer to finding a job than the day she started. Her funds were being depleted and she was getting more discouraged. There was one bright spot, though: She was able to bring in a little money by mowing lawns for her neighbors. She got involved quite by chance when she heard one neighbor remark that now that his children were on their own; nobody was around to cut the grass. Almost jokingly, Ms. Madonna asked him how much he'd be willing to pay. Soon Ms. Madonna was mowing the lawns of five neighbors. Other neighbors wanted her to work on their lawns, but she didn't feel that she could spare any more time from her job search.

However, as the rejection letters began to pile up, Ms. Madonna knew she had to make an important decision in her life. On a rainy Tuesday morning, she decided to go into business for herself taking care of neighborhood lawns. She was relieved to give up the stress of job hunting, and she was excited about the prospects of being her own boss. But she was also fearful of being completely on her own. Nevertheless, Ms. Madonna was determined to make a go of it.

At first, business was a little slow, but once people realized Ms. Madonna was available, many asked her to take care of their lawns. Some people were simply glad to turn - the work over to her; others switched from professional lawn care services. By the end of her first year in business, Ms. Madonna knew she could earn a living this way. She also performed other services such as fertilizing lawns, weeding gardens, and trimming shrubbery. Business became so good that Ms. Madonna hired two part-time workers to assist her and, even then, she believed she could expand further if she wanted to.

Questions

1. In what ways are Ms. Madonna's customers most likely to judge the quality of her lawn care services?

2. Ms. Madonna is the operations manager of her business. Among her responsibilities are forecasting, inventory management, scheduling, quality assurance, and maintenance

(a) What kinds of things would likely require forecasts?

(b) What inventory items does Ms. Madonna probably have? Name one inventory decision she has to make periodically.

(c) What scheduling must she do? What things might occur to disrupt schedules and cause Ms. Madonna to reschedule?

(d) How important is quality assurance to Ms. Madonna's business? Explain.

(e) What kinds of maintenance must be performed?

3. What are some of the trade-offs that Ms. Madonna probably considered relative to:

(a) Working for a company instead of for herself?

(b) Expanding the business?

4. The town is considering an ordinance that would prohibit putting grass clippings at the curb for pickup because local landfills cannot handle the volume. What options might Ms. Madonna consider if the ordinance is passed? Name two advantages and two drawbacks of each option.

CASE STUDY - 6

WEGMANS FOOD MARKETS- QUALITY MANAGEMENT

Wegmans Food Markets, Inc., is one of the premier grocery chains in the United States.

Headquartered in Rochester, NY, Wegmans operates over 70 stores. The company employs over

23,000 people, and have annual sales of over Rs. 2.0 billion.

Wegmans has a strong reputation for offering its customers high product quality and excellent service. Through a combination of market research, trial and error, and listening to its customers,

Wegmans has evolved into a very successful organization. In fact, Wegmans is so good at what it does that grocery chains all over the country send representatives to Wegmans for a firsthand look at operations.

Superstores

Many of the company's stores are giant 100,000 square foot superstores, double or triple the size of average supermarkets. A superstore typically employs from 500 to 600 people. Individual stores differ somewhat in terms of actual size and some special features. Aside from the features normally found in supermarkets, they generally have a large bakery Section (each store bakes its own bread, rolls, cakes, pies, and pastries), and extra-large produce sections. They also offer film processing a complete pharmacy, a card shop and video rentals.

In-store floral shops range in size up to 800 square feet of space, and offer a wide variety of fresh-cut flowers, flower arrangements, varies and plants. In-store card shops covers over 1000 square feet of floor of floor space. The bulk foods department provides customers with the opportunity to select what quantities they desire from a vast array of foodstuffs and some nonfood items.

Each store is a little different. Among the special features in some stores are a dry cleaning department, a wokery, and a salad bar. Some feature a Market Cafe that has different food stations, each devoted to preparing and serving a certain type of food. For example, one station has pizza and other Italian specialties, and another oriental food. There is also being a sandwich bar, a salad bar and a dessert station. Customers often wander among stations as they decide what to order. In several affluent locations, customers can stop in on their way home from work and choose from a selection of freshly prepared dinner entrees. Some stores have a coffee shop section with tables and chairs where shoppers can enjoy regular or specialty coffees and variety of tempting pastries.

Produce Department

The company prides itself on fresh produce. Produce is replenished as often as 12 times a day. The larger stores have produce sections that are four to five times the size of a produce section of an average supermarket. Wegmans offers locally grown produce a season. Wegmans uses a 'farm to market' system whereby some local growers deliver their produce directly to individual stores, bypassing the main warehouse. That reduces the company's inventory holding costs and gets the produce into the stores as quickly as possible. Growers may use specially designed containers that go right onto the store floor instead of large bins. This avoids the bruising that often occurs when fruits and vegetables are transferred from bins to display shelves and the need to devote labor to transfer the produce to shelves.

Meat Department

In addition to large display cases of both fresh and frozen meat products, many stores have a full-service butcher shop that offers a variety of fresh meat products and where butchers are available to provide customized cuts of meat for customers.

Ordering

Each department handles its own ordering. Although sales records are available from records of items scanned at the checkouts, they are not used directly for replenishing stock. Other factors, such as pricing, special promotions, local circumstances must all be taken into account. However, for seasonal periods, such as holidays, managers often check scanner records to learn what past demand was during a comparable period.

The superstores typically receive one truckload of goods per day from the main warehouse. During peak periods, a store may receive two truckloads from the main warehouse. The short lead-time greatly reduces the length of the time an item might be out of stock, unless the main warehouse is also out of stock. The company exercises strict control over suppliers, insisting on product quality and on-time deliveries.

Employees

The company recognizes the value of good employees. It typically invests an average of Rs.7000 to train each new employee. In addition to learning about stores operations, new employees learn the importance of good customer service and how to provide it. The employees are helpful, cheerfully answering customer questions or handling complaints. Employees are motivated through a combination of compensation, profit sharing, and benefits.

Quality

Quality and Customer satisfaction are utmost in the minds of Wegmans management and its employees. Private label food items as well as name brands are regularly evaluated in test kitchens, along with the potential new products. Managers are responsible for checking and maintaining products and service quality in their departments. Moreover, employees are encouraged to report problems to their managers.

If a customer is dissatisfied with an item and returns it, or even a portion of the item, the customer is offered a choice of a replacement or a refund. If the item is a Wegmans brand food item, it is then sent to the test kitchen to determine the cause of the problem. If the cause can be determined, corrective action is taken.

Questions

1. How do customers judge the quality of a supermarket?

2. Indicate how and why each of these factors is important to the successful operation of a supermarket:

(a) Customer satisfaction.

(b) Forecasting.

(c) Capacity planning.

(d) Location

(e) Inventory management.

(f) Layout of the store.

(g) Scheduling.

CASE STUDY- 7

ESCOM- CAPACITY PLANNING

ESCOM is a producer of electronic home appliances, including VHS (Video Home System) television recorders, located in northern California. The packaged product weighs about 75 kg. ESCOM was not the innovator of the system. Rather, its managers sat back and let RCA and others develop the market, and ESCOM is currently producing under license agreements. SCOM has a conscious strategy of being a follower with new product innovations. It does not have the financial resources to be a leader in research and development.

ESCOM's present opportunity is indicated by the fact that industry sales of VHS recorders have increased 30 per cent per year for the past two years, and forecasts for the next year and the two following are even more enticing. ESCOM has established a 10 per cent market share position and feels that it can at least maintain this position if it has the needed capacity; it could possibly improve its market share if competitors fail to provide capacity at the time it is needed.

	Year					
	0	1	2	3	4	5
Forecast, 1000 Units	100	140	195	270	350	450
450Capacity (gap), or slack 1000 units	5	(35)	(90)	(165)	(245)	(345)

The forecasts and capacity gaps are indicated in Table. ESCOM regards the first year forecast as being quite solid, based on its present market share and a compilation of several industry forecasts from different sources. It is less sure about the forecasts for future years, but it is basing these forecasts on patterns for both black and white and color TV sales during their product life cycles.

ESCOM's VHS model has a factory price of Rs 600. Variable costs are 70 percent of the price. Inventory carrying costs are 20 per cent of inventory value, 15 percentage points of which represents the cost of capital. ESCOM's facility planners estimate that a 40,000 unit plant can be built for Rs. 5 million and a 20000 unit plant, for Rs. 10 million. Land and labour are available in the area, and either size plant can be built within a year.

(a) What capacity plans do you think ESCOM should make for next year? Why?

(b) What longer-term capacity plans should ESCOM make? Why?

(c) What are the implications of these plans for marketing, distribution, and production?

[Source: Modern Production/Operations Management by Elwood S.Buffa & Rakesh K.Sarin]

CASE - 8

MEDI MANUFACTURING- FINDING THE RIGHT QUALITY FIT

medi Manufacturing is one of the world's leading manufacturers of medical compression products, orthopedics, prosthetics, and compression sportswear. Headquartered in Bayreuth, Germany, medi applies 60 years of German design, research, and manufacturing to garments for people who suffer from venous disease, lymphedema, swelling, and varicose veins. medi's products are available through distributors, pharmacies, retailers, and hospitals in more than 125 countries.

The challenge

As a Medical Device manufacturing company, medi is committed to delivering quality garments that consumers feel safe and confident wearing. At its Whitsett, North Carolina, facility, medi was using its own proprietary software for data collection and quality monitoring in its manufacturing processes. However, error codes in the software produced a large amount of paperwork because operators could not easily make changes to incorrectly entered information. Making corrections often took as long as an hour and a half and duplicate data entry created variations in reporting.

Also, in order to maintain compliance with medical safety regulations on technology used in manufacturing, medi needed to validate its software to demonstrate its reliability and effectiveness. The homegrown system was outdated, and medi was uncertain whether it could satisfy the strict validation requirements. Rather than continue with its homegrown software, medi sought a new solution that could drive quality improvements and increase efficiency while facilitating the validation process.

The solution

medi found its answer in InfinityQS® ProFicient™, an enterprise quality hub powered by a Statistical Process Control (SPC) analysis engine. medi installed ProFicient on its Whitsett facility's terminal server and purchased 30 user licenses. To provide medi's shop-floor operators with an intuitive experience, InfinityQS custom-configured ProFicient's graphical user interface. Before the "go-live," an InfinityQS third-party affiliate validated the software to ensure compliance with industry regulations. Validation by medi's own staff would have taken six months; with InfinityQS's thorough template and work instructions, it took only a week.

With InfinityQS's Dynamic Scheduler, medi's operators now obtain a shop-floor checklist for scheduled quality checks and receive notifications when data collection is needed. Dynamic Scheduler automatically notifies key personnel if data collection is not performed, ensuring quality checks are completed in a timely manner.

To reduce manual input, save over 500 labor hours per year, and improve data collection, medi integrated a number of its machines with ProFicient: knitting, dyeing, sewing, finishing, returns, and final inspection. In some cases, medi enabled measurements to feed directly into the database. A key integration is with the CMD-100 machine, which checks stocking compression. medi's stockings have multiple levels of compression to accommodate different severities of affliction; too much compression can be harmful.

In the returns department, quality assurance managers use ProFicient to track returns and customer complaints (stockings too tight or too long, susceptible to holes, or with inaccurate measurements). medi can then review a Pareto chart to identify patterns and pinpoint which items are producing a high number of returns or complaints. From there, medi can make corrections to their processes.

medi also uses ProFicient in its final inspection department, where the company requires 100% inspection of its stockings. Inspectors can now easily scan a barcode that pulls a stocking's measurements from the database, enabling a quick pass-or-fail determination.

- Completed software validation in just a week, a task that typically would have taken medi's staff six months
- Minimized errors and paperwork by increasing the accuracy and efficiency of data collection
- Enabled continuous improvement through advanced reporting and charts

- Saved the 100-person manufacturing staff approximately 300-350 man-hours per year in data corrections and accuracy
- Eliminated more than 500 labor hours per year by integrating many production machines with ProFicient
- Achieved ROI within 10 months of implementing the software

The results

In addition to streamlining regulatory compliance, ProFicient has helped medi gain control over product quality and safety with a systematic approach to data collection. With advanced reporting capabilities, quality assurance managers are better able to make data-based, informed decisions that drive continuous improvement.

By monitoring error codes and addressing them with Assignable Cause and Corrective Action, medi takes a more preventative — rather than responsive — approach to maintaining its equipment and processes. Error codes can help indicate if a machine requires maintenance or is about to break down. If a specific machine is repeatedly producing errors, a report is issued and quality assurance managers can notify mechanics to address the problem before the machine fails. Previously, generating such reports took four hours; now, it takes between five and 10 minutes.

Also, ProFicient has helped medi minimize errors and paperwork by increasing the accuracy and efficiency of data collection. Without the need to correct errors or enter duplicate data, medi estimates that it is saving 300-350 man-hours per year. Moreover, the company achieved a return on investment (ROI) within 10 months of implementing the software.

medi plans to introduce ProFicient's Data Management System to gather and compare quality-related data from multiple departments for real-time insight into its manufacturing processes. medi also hopes to implement ProFicient's Lot Genealogy to trace the root causes of quality issues back to suppliers and vendors.

CASE - 9

SCHEDULING PROBLEM

The Fitzgerald Machine Company is a $25MM per year custom metal fabrication shop. It has a work force of 30 machinists and 15 office personnel. Don Bradish was hired from Peptine Corporation three months ago as Fitzgerald's production scheduler. His background includes an undergraduate industrial engineering degree and three years of purchasing experience with Peptine immediately after college. This made him a good fit for Fitzgerald's needs. He was hired by Jane Fitzgerald, Vice President of Operations and daughter of the company president.

Recently the company has been having difficulty meeting delivery schedule deadlines. Don was hired to improve the company's performance in on-time deliveries. So far, he has been learning the systems of the operations and studying possible solutions, but he has not yet determined the best course of action to recommend.

On Friday, June 21, a $300,000 order, which had been in the shop for nearly two months, was scheduled for shipment. On the Wednesday before scheduled delivery, the customer called and asked that delivery be delayed due to a labor dispute and work stoppage at his location.

Although he expected the strike to be settled within one week or less, he was concerned that delivery of the order from Fitzgerald during the strike might cause unnecessary misunderstandings in the labor dispute. Don discussed this request with Jane, and they agreed to accommodate the customer's request on the condition that the customer agrees to being billed on the originally scheduled delivery date and to pay on the originally contracted payment terms. The customer accepted those terms.

On Friday morning, June 21, the production manager reported to Don that the order would not be completed as scheduled and would probably require at least one more week to finish.

Concerned about the impact of this delay on his job status, Don decided to investigate the cause of the delay before informing Jane of the problem. Before he could complete his inquiry, Jane called to inform him that she had just mailed the invoice for the order as agreed She also suggested that Don negotiate with the customer a storage fee for the order, which would be paid in addition to the billing arrangement. Don wondered what he should say to Jane next.

Question:

1. What should Don do now to tackle this issue?

CASE- 10

FACILITY LOCATIONS AT BMW

Location decisions require careful analysis as they have long-lasting effects, particularly in offshore operations. Effective offshore location decisions have two features: (1) they are good for the organisation, and (2) they are good for the society where the facility is located. Established in 1917 and headquartered in Munich, Germany, Bavarian Motor Works (BMW), is a manufacturer of world's most premium brands, such as BMW, MINI and Rolls-Royce motor cars. BMW was facing a need to find an offshore manufacturing site as it frequently required to deal in international markets. BMW finally selected Spartanburg, South Carolina as its offshore manufacturing site.

Let us study why BMW found Spartanburg, South Carolina, a suitable location for establishing a new plant. After realising the need for an offshore manufacturing site, BMW followed a 'blank page' approach to compile a list of 250 potential facility sites worldwide. The company analysed various factors before selecting the plant site. These factors included the proximity of the location to a large market segment for BMW's automobiles, labour climate in each country, geographical requirements and government policies of each country.

Considering the complex nature of the automotive manufacturing process, the construction of a facility largely depended on the availability of technologically capable workforce. As the cost of training a single worker in the automotive industry ranges from \$10,000 to \$20,000; evaluating the labour climate of each prospective country was specifically critical. The company also needed to analyse geographical factors as thousands of automobile parts needed to be delivered from both domestic and foreign suppliers. Therefore, in order to keep the supply chain cost low, the new location required to have sufficient highway/interstate access. In addition, proximity to the port was also necessary to ensure easy transportation of both supplies and finished goods. Apart from all these, the final factor was government related policies. BMW was looking for a 'business friendly' location, where it could make concessions on various subjects, such as infrastructure improvements, tax abatements, employee screening and education programmes. The company also wanted to develop a mutually beneficial relationship between BMW and the local community through a coordinated improvement effort.

After three and a half years of the search process, the analysts at BMW trimmed the list of 250 potential facility sites down to 10 workable options. Among 10 alternatives, BMW finally selected Spartanburg, South Carolina as its new facility site and decided to build a new two-million-square-foot facility at that location. The final decision was taken after a careful evaluation of the aforementioned selection criteria and Spartanburg's environment.

The government policies at South Carolina were flexible enough to address the needs set forth by BMW. The South Carolina government agreed to acquire 500 acres of land necessary to build the facility, improve highway infrastructure around the facility, lengthen the runway and modernise the Spartanburg airport terminal. In addition, the government also agreed to provide tax incentives and property tax relief. It helped the company to establish an employee screening and training programme so that the right mix of workers could be hired for jobs.

The location also proved to be a good one from the viewpoint of community benefits. The BMW facility, which started in 1994, saw subsequent expansion in December 2013 with an investment of \$6.3 billion. Today, South Carolina's BMW Manufacturing Corporation is a part of BMW Group's global manufacturing network. It is BMW's largest plant in the world and employs more than 8,000 people to manufacture the X3 and X5 Sports Activity Vehicle, the X4 Sports Activity Coupe, the X5 xDrive35d fuel-efficient vehicle and the X6 Sports Activity Coupe.

In addition, supply chain activities carried by this facility have created more than 31,000 jobs in South Carolina with the help of huge investments. The plant produces 450,000 vehicles annually, which is more than any of the BMW factories in Germany. According to Ludwig Willisch, the CEO of BMW of North America, "We are very fortunate that years ago, the company decided to go to the United States and build a plant at a time when everyone was withdrawing. It was not only a brave move, but it shows how right the move was. It is a big, important footprint for us. Overall, selecting Spartanburg, South Carolina was a success story all around as it helped BMW in reaping rewards in terms of business growth and community improvements."

Questions

1. Why was the selection of a suitable location so important for BMW?
2. Discuss the impact of government policies and programmes on the selection of BMW facility location

CASE- 11

THE BOEING COMPANY - FACILITY LOCATION & LAYOUT

The Boeing Company, headquartered in Chicago, Illinois, is one of the two major producers of aircraft in the global market. The other major producer is European Airbus. Boeing produces three models in Everett, Washington: 747s, 767s, and 777s. The planes are all produced in the same building. At any one time, there may be as many as six planes in various stages of production. Obviously the building has to be fairly large to accommodate such a huge undertaking. In fact, the building is so large that it covers over 98 acres and it is four stories high, making it the largest building by volume in the world. It is so large that all of Disneyland would fit inside, and still leave about 15 acres for indoor parking! The windowless building has six huge doors along one side, each about 100 yards wide and 40 yards high (the size of a football field)—large enough to allow a completed airplane to pass through. Boeing sells airplanes to airlines and countries around the globe.

There isn't a set price for the planes; the actual price depends on what features the customer wants. Once the details have been settled and an order submitted, the customer requirements are sent to the design department. Design Designers formerly had to construct a mock-up to determine the exact dimensions of the plane and to identify any assembly problems that might occur. That required time, materials, labor, and space. Now they use computers (CAD) to design airplanes, avoiding the cost of the mock ups and shortening the development time. The Production Process Once designs have been completed and approved by the customer, production of the plane is scheduled, and parts and materials are ordered. Parts come to the plant by rail, airplane, and truck, and are delivered to the major assembly area of the plane they will be used for.

The parts are scheduled so they arrive at the plant just prior to when they will be used in assembly, and immediately moved to storage areas close to where they will be used. Time-phasing shipments to arrive as parts are needed helps to keep inventory investment low and avoid having to devote space to store parts that won't be used immediately. There is a tradeoff, though, because if any parts are missing or damaged and have to be reordered, that could cause production delays. When missing or defective parts are discovered, they are assigned priorities according to how critical the part is in terms of disruption of the flow of work. The parts with the highest priorities are assigned to expediters who determine the best way to replace the part. The expediters keep track of the progress of the parts and deliver them to the appropriate location as soon as they arrive. In the meantime, a portion of the work remains unfinished, awaiting the replacement parts, and workers complete other portions of the assembly. If the supplier is unable to replace the part in a time frame that will not seriously delay assembly, as a last resort, Boeing has a machine shop that can make the necessary part. The partially assembled portions of the plane, and in later stages, the plane itself, move from station to station as the work progresses staying about five days at each station.

Giant overhead cranes are used to move large sections from one station to the next, although once the wheel assemblies have been installed, the plane is towed to the remaining stations. Finished planes are painted in one of two separate buildings. Painting usually adds 400 to 600 pounds to the weight of a plane. The painting process involves giving the airplane a negative charge and the paint a positive charge so that the paint will be attracted to the airplane. Testing and Quality Control Boeing has extensive quality control measures in place throughout the entire design and production process. Not only are there quality inspectors, individual employees inspect their own work and the work previously done by others on the plane. Buyers' inspectors also check on the quality of the work.

There are 60 test pilots who fly the planes. Formerly planes were tested to evaluate their flight worthiness in a wind tunnel, which required expensive testing and added considerably to product development time. Now new designs are tested using a computerized wind tunnel before production even begins, greatly reducing both time and cost. And in case you're wondering, the wings are fairly flexible; a typical wing can flap by as much as 22 feet before it will fracture. Re-engineering Boeing is re-engineering its business systems. A top priority is to upgrade its computer systems. This will provide better links to suppliers, provide more up-to-date information for materials management, and enable company representatives who are at customer sites to create a customized aircraft design on their laptop computer. Another aspect of the re-engineering involves a shift to lean production. Key goals are to reduce production time and reduce inventory.

Boeing wants to reduce the time that a plane spends at each workstation from 5 days to 3 days, a reduction of 40 percent. Not only will that mean that customers can get their planes much sooner, it will also reduce labor costs and inventory costs, and improve cash flow. One part of this will be accomplished by moving toward late-stage customization, or delayed differentiation. That would mean standardizing the assembly of planes as long as possible before adding custom features. This, and other time-saving steps, will speed up production considerably, giving it a major competitive advantage. It also wants to reduce the tremendous amount of inventory it carries (a 747 jumbo jet has about 6 million parts, including 3 million rivets). One part of the plan is to have suppliers do more pre-delivery work by assembling the parts into kits that are delivered directly to the staging area where they will be installed on the aircraft instead of delivering separate parts to inventory. That would cut down on inventory carrying costs and save time. Boeing is also hoping to reduce the number of suppliers it has, and to establish better links and cooperation from suppliers. Currently Boeing has about 3,500 suppliers. Compare that with GM's roughly 2,500 suppliers, and you get an idea of how large this number is.

Questions:

1. Analyze Boeing strategy in the location selection and layout of the venue where the airplanes are manufactured
2. What is the type of inventory management does Boeing embrace? How does Boeing manage its inventory? Why it is important to manage inventory?
3. Describe and critique the company's strategy to overcome delays in manufacturing.
4. What other strategies Boeing is planning to implement to cut cycle times?

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MULTIPLE CHOICE QUESTIONS (MCQs)

MULTIPLE CHOICE QUESTIONS (MCQs)

Exercise-1

1. Which of the following is (are) important consideration(s) concerning activity times?

(A) Activity time should be obtained from the person responsible for the completion of an activity

(B) Activity time must be independent of any influence which the preceding or succeeding activity may have on it.

(C) Activity time may assume that just the normal quantity of resources required to carry out the activity are available.

(D) All of the above

2. Which of the following are assignable causes?

(A) Large variations in hardness of material

(B) Tool wear

(C) Errors in setting

(D) All of the above

3.What is the reason of excessive friction between parts?

(A) Improper or lack of lubrication

(B) Material of parts

(C) Both (A) and (B)

(D) None of above

4. Which kind of labour force is required in case of Jobbing Production?

(A) Highly Skilled

(B) Semi skilled

(C) Unskilled

(D) Any of the above

5. What is the location of lower control limit in the X bar-R control chart?

(A) 3 standard deviations below central line

(B) 2 standard deviations below central line

(C) 1 standard deviations below central line

(D) Any of the above

6. Which photographic technique is used to record path of motions of the members of the body during method study?

(A) Acrograph

(B) Cyclograph

(C) Cyclogram

(D) Cycloscope

7. The term ________ implies the foregone profit due to inability of company to produce.

(A) Opportunity cost

(B) Marginal cost

(C) Overhead cost

(D) All of the above

8. In case of an OC curve, the risk of rejecting a good quality lot may vary between ________.

(A) 0.01 to 5%

(B) 0.01 to 10%

(C) 0.01 to 15%

(D) 0.01 to 20%

9. Objective of Work Study is to improve _______

(A) Cycle time

(B) Productivity

(C) Production

(D) All of the above

10. Which of the following are activities of corrective maintenance?

(A) Overhauling

(B) Emergency repairs

(C) Modifications and improvements

(D) All of the above

11. Capacity decisions have a direct influence on performance of production system in respect of ________

(A) Delivery performance

(B) Quality control

(C) Plant size

(D) Manpower

12. Which of the following is not the characteristic of Project Production?

(A) Continuous flow of material

(B) Highly mechanized material handling

(C) Virtually zero manufacturing cycle time

(D) All of the above

13. Which of the following Principles of Management is not advocated by F W Taylor?
(A) Selection of best worker for each particular task
(B) Division of work between worker and management
(C) Training and development of the workmen
(D) Involvement of workers in strategy planning

14. How does 'structure' reduce external uncertainty arising out of human behaviour
(A) Research and planning
(B) Forecasting
(C) Both (A) and (B)
(D) None of the above

15. The following is not a major contributor in the development of Control Charts and Sampling plan
(A) F H Dodge
(B) H G Roming
(C) Walter Schewhart
(D) J M Juran

16. Limitations of Traditional cost accounting are
(A) Assumes factory as an isolated entity
(B) It measures only the cost of producing
(C) Both (A) and (B)
(D) None of the above

17. Business is rated on which dimensions
(A) Market attractiveness
(B) Business strength
(C) Both (A) and (B)
(D) None of the above

18. Like roots of a tree, ________of organization is hidden from direct view.
(A) Goodwill
(B) Core competence
(C) Higher management
(D) Capital investment

19. OC curve of ideal sampling plan suggests that all lots less than 3% defectives have the probability of acceptance of ________.

(A) 0.25

(B) 0.5

(C) 0.75

(D) 1

20. Inadequate production capacity ultimately leads to

(A) Poor quality

(B) Poor Customer Service

(C) Poor inventory control

(D) All of the above

ANSWERS

1	2	3	4	5	6	7	8	9	10
D	**D**	**A**	**A**	**A**	**B**	**A**	**B**	**B**	**D**

11	12	13	14	15	16	17	18	19	20
A	**D**	**D**	**C**	**D**	**C**	**C**	**B**	**D**	**B**

Exercise-2

1. Which of the following explain the need for facility location selection?

(a) When the existing business unit has outgrown its original facilities and expansion is not possible.

(b) When a business is newly started.

(c) When the lease expires and the landlord does not renew the lease.

(d) All of these.

2. Which of the following is the first step in making a correct location choice?

(a) Develop location alternatives

(b) Decide the criteria for evaluating location alternatives

(c) Evaluate the alternatives

(d) Make a decision and select the location

3. Which of the following technique emphasizes transportation cost in the determination of facility location?

(a) Location rating factor technique

(b) Transportation technique

(c) Centre-of-gravity technique

(d) Both (b) and (c)

4. Transportation cost mainly depends on which of the following factors?

(a) Distance

(b) Weight of merchandise

(c) Time required for transportation

(d) All of the above

5. In which of the following site selection techniques, a weightage between ‘0’ to ‘1’ is provided to factors that influence its location decision?

(a) Location rating factor technique

(b) Transportation technique

(c) Centre-of-gravity technique

(d) None of these

6. Which of the following does not cause to production delay?

(a) Shortage of space

(b) Long distance movement of materials

(c) Spoiled work

(d) Minimum material handling

7. Process layout is also known as ________.

(a) Functional layout

(b) Batch production layout

(c) Straight line layout

(d) Both (a) and (b)

8. Which of the following facility layout is best suited for the intermittent type of production, which is a method of manufacturing several different products using the same production line?

(a) Product layout

(b) Process layout

(c) Fixed position layout

(d) Cellular manufacturing layout

9. In which of the following layout type, materials are fed into the first machine and finished products come out of the last machine?

(a) Product layout

(b) Process layout

(c) Fixed position layout

(d) Cellular manufacturing layout

10. Which of the following is not an advantage of using product layout?
(a) Minimum material handling cost
(b) Minimum inspection requirement
(c) Specialized supervision requirement
(d) None of these

11. In break-even analysis, total cost consists of
(a) Fixed cost
(b) Variable cost
(c) Fixed cost + variable cost
(d) Fixed cost + variable cost + overheads

12. Which one of the following techniques is used for determining allowances in time study?
(a) Acceptance sampling
(d) Linear regression
(c) Performance rating
(d) Work sampling

13. Expediting function consists in keeping a watch on
(a) Operator's activity
(b) Flow of material and in case of trouble locate source of trouble
(c) Minimizing the delays
(d) Making efficient dispatching

14. Bin card is used in
(a) Administrative office
(b) Workshop
(c) Foundry Shops
(d) Stores

15. Inventory control in production, planning and control aims at
(a) Achieving optimization
(b) Ensuring against market fluctuations
(c) Acceptable customer service at low capital investment in inventory
(d) Discounts allowed in bulk purchase

16. Value engineering aims at finding out the
(a) Depreciation value of a product
(b) Resale value of a product
(c) Major function of the item and accomplishing the same at least cost without change in quality
(d) Break-even point when machine requires change

17. A-B-C analysis
(a) Is a basic technique of materials management
(b) Is meant for relative inventory control
(c) Does not depend upon the unit cost of the item but on its annual consumption
(d) All of the above

18. Gantt charts are used for
(a) Forecasting sales
(b) Production schedule
(c) Scheduling and routing
(d) Linear programming

19. For handling materials during manufacture of cement, a _________ is widely used.
(a) Belt conveyor
(b) Bucket conveyor
(c) Fork-lift truck
(d) Overhead crane

20. Work study involves
(a) Only method study
(b) Only work measurement
(c) Method study and work measurement
(d) Only motion study

ANSWERS

1	2	3	4	5	6	7	8	9	10
d	**b**	**c**	**d**	**a**	**d**	**d**	**b**	**a**	**c**

11	12	13	14	15	16	17	18	19	20
c	**d**	**d**	**c**	**c**	**c**	**d**	**b**	**c**	**c**

Exercise-3

1. ___________refers to the transformation of the state of input in to output.
A. transportation
B. alteration
C. inspection
D. all of these

2. __________refers to preserving goods in a protected environment.
A. alteration
B. inspection
C. storage
D. bargaining

3. ______________refers to the verification of and confirmation towards the requirements of an entity.
A. inspection
B. pricing
C. alteration
D. none of these

4. ____________is the management of all activities directly related to the production of goods and services
A. production management
B. finance control
C. employee development
D. all of these

5. Which of the following statement is not true in the case of goods?
A. tangibility
B. can be stored
C. physical shape
D. intangibility

6. Which of the following is not an objective of operations management?
A. customer satisfaction

B. profitability

C. timeliness

D. employee punishment

7. All of the following are differences between manufacturing and service operations EXCEPT:

A. quality is more easily measured in service operations.

B. productivity is easier to measure in manufacturing operations

C. contact with customers is more prevalent with persons working in service operations.

D. accumulation or decrease in inventory of finished products is more

8. __________is measure of the quantity of output per unit of input.

A. productivity

B. marketability

C. sociability

D. none of these

9. ____________is a system that is used to maintain a desired level of quality in a product or service.

A. economic ordering quantity

B. quality control

C. knowledge management

D. manpower planning

10. Operations management is applicable

A. mostly to the service sector

B. mostly to the manufacturing sector

C. to manufacturing and service sectors

D. to services exclusively

11. Walter Shewhart is listed among the most important people of POM because of his contributions to

A. assembly line production

B. measuring productivity in the service sector

C. statistical quality control

D. just-in-time inventory methods

12. Which of the following is not an objective of operation management?

A. to improve product quality

B. to reduce cost of production

C. material cost control

D. trading on equity

13. Moving of materials from the store room to the machine and from one machine to the next machine during the process of manufacture is called___________.

A. VED analysis

B. ABC analysis

C. material handling

D. none of these

14.___________is the term used to describe the set of statistical tools used by quality professionals for the purpose of quality control

A. accounting standards

B. statistical quality control

C. population study

D. none of these

15. _______ is the process of selection of path, which each part of the product will follow

A. routing

B. scheduling

C. follow-up

D. dispatching

16. _________is the fixation of time and date for each operation as well as it determines the sequence of operations to be followed.

A. dispatching

B. scheduling

C. routing

D. all of these

17. ____________ is the process of verification or correction in the quality of the product when the deviations in the quality are found to be more than expected.

A. policies

B. quality control

C. quantity measurement

D. none of these

18. ____________ is the process of setting of productive activities in motion through release of orders and instructions, in accordance with previously planned timings.

A. time study

B. follow-up

C. dispatching

D. none of these

19. ___________ is a time-table of operations specifying the time and date when each operation is to be started and completed.

A. time study

B. schedule

C. loading

D. none of these

20. Which of the following is an objective of quality control?

A. to produce qualitative items

B. to reduce companies cost through reduction of losses due to defects.

C. to produce optimal quality at reduced price.

D. all of these

21. ___________ is that aspect of operation management function, which is concerned with the acquisition, control, and use of materials needed and flow of goods and services connected with the production process.

A. materials management

B. division of labour

C. mass production

D. craft production

22. _____________is the art and science of ensuring that all which occurs is in accordance with the rules established and the instructions issued in the case of operations.

A. operational attack

B. operational control

C. operational summary

D. none of these

23. _________ is concerned with deciding in advance what is to be produced, when to be produced, where to be produced and how to be produced.

A. operational planning

B. operational control

C. (a) and (b)

D. none of these

24. The differences between the actual demand for a period and the demand forecast for that period is called:

A. forecast error

B. weighted arithmetic mean

C. decision process

D. mean square error

25. _____________can be defined as the measurements that detect the onset of a degradation mechanism, thereby allowing causal stressors to be eliminated or controlled prior to any significant deterioration in the component physical state

A. break down maintenance

B. predictive maintenance

C. past maintenance

D. none of these

26. _____________is defined as the combination of tasks that are required to keep a machine or part of a machine in the desirable condition.

A. substitution

B. maintenance

C. reduction

D. induction

27. _____________involves systematically recording, analyzing and synthesizing the times required to perform a motion.

A. method study

B. motion study

C. time study

D. all of these

28. _____________refers to the manufacturing of large volume of a single or a very few varieties of products with a standard set of processes.

A. continuous production

B. intermittent production

C. project production

D. none of these

29. _______________ is the process of predicting and defining the long-term and the short-term capacity needs of an organization and determining how those needs will be satisfied.

A. capacity planning

B. capacity control

C. staff fixation

D. instrumentalisation

30. _____________is a measure the actual level of output for a process or activity over a period of time.

A. actual capacity

B. design capacity

C. maximum capacity

D. none of these

Answers

1	2	3	4	5	6	7	8	9	10
B	**C**	**A**	**A**	**D**	**D**	**A**	**A**	**B**	**C**

1	12	13	14	15	16	17	18	19	20
C	**D**	**C**	**B**	**A**	**B**	**B**	**C**	**B**	**D**

21	22	23	24	25	26	27	28	29	30
A	**B**	**A**	**A**	**B**	**B**	**C**	**A**	**A**	**A**

STATE TRUE (T) OR FALSE (F)

1. By turning raw materials into finished goods, production creates form utility.
2. Services are more tangible, more customized, and less storable than most products.
3. Services are typically characterized by a high degree of un-storability.
4. In a product layout, equipment and people are set up to produce one type of good in a fixed sequence of steps and are arranged according to its production requirements
5. A process flow chart identifies the sequence of production activities, movements of materials, and work performed at each stage of the process.
6. Staff schedules identify who and how many employees will be working, and when.
7. Materials management involves the flow of materials inside of the production facility only.
8. JIT production systems normally require large amounts of "safety stock" to be maintained in a firm's warehouse.
9. ISO 9000 originally was an attempt to standardize materials received from suppliers in such high-technology industries as electronics, chemicals, and aviation.
10. The goal of supply chain management is to reduce the number of links in the channel.
11. The relationship between business strategy and operations tends to vary widely between manufacturing companies and service firms.
12. All of the following types of operations resources, if selected, should be compatible with a chosen operations capability: equipment, human resources, and production processes.
13. Long-range capacity planning considers both current and future capacity requirements.
14. Quality planning involves a push toward the continued improvement of both products and production methods.
15. A detailed schedule will indicate how many employees will be working on a given shift.
16. The biggest challenge of TQM is motivating employees throughout the company to achieve quality goals.
17. Value-added analysis might focus on both the elimination of waste and cost minimization.
18. A value chain includes an entire network of firms with the exception of those responsible for transportation.
19. Because supply chain strategy is based on the collective effort of a number of firms, no one firm in the chain gains a competitive advantage.
20. The goal of supply chain management is better value for customers.

ANSWERS

1	2	3	4	5	6	7	8	9	10
T	**F**	**T**	**T**	**T**	**F**	**F**	**F**	**T**	**F**

11	12	13	14	15	16	17	18	19	20
F	**T**	**T**	**T**	**F**	**T**	**T**	**F**	**F**	**T**

MCQs FOR PRACTICE

1. When a company turns out costumes in time for Halloween, it creates _____ utility.

a. ownership

b. time

c. form

d. place

2. When a company makes products available where they are convenient for consumers, it creates _____ utility.

a. time

b. form

c. place

d. possession

3. Which of the following is NOT one of the kinds of utility goods and services provide to customers?

a. time

b. form

c. place

d. leisure

4. _____ draws up plans to transform resources into products, and they must bring together basic resources, such as knowledge, physical materials, equipment, and labor.

a. CEOs

b. Operations managers

c. Quality managers

d. Floor foremen

5. Which of the following statements is not true

a. Both service and manufacturing operations transform raw materials into finished products.

b. Consumers use different measures to judge services and goods because services include intangibles, not just physical objects.

c. A high-contact service system exists when the customer is not part of the system.

d. In service operations, finished products or outputs are people with needs met and possessions serviced.

6. _____ is ensuring that a manufacturing firm's capacity slightly exceeds the normal demand for its product.

a. Measurement

b. Determination

c. Capacity planning

d. Plant restructure

7. When considering a location for a manufacturing facility, which of the following do managers NOT necessarily have to consider?

a. proximity to raw materials and markets

b. availability of labor

c. energy and transportation costs

d. proximity to customers

8. The spatial arrangement of production activities designed to move resources through a smooth, fixed sequence of steps is _____.

a. product

b. location planning

c. forecasting

d. quality planning

9. _____ is defined as the combination of “characteristics of a product or service that bear on its ability to satisfy stated or implied needs.”

a. Quality

b. Production

c. Satisfaction

d. Clarification

10. Performance refers to _____.

a. the principle that quality belongs to each person who creates it while performing a job

b. the consistency of a product’s quality from unit to unit

c. how well the product does what it is supposed to do

d. the process by which a company analyzes a competitor’s products to identify desirable improvement

11. Managers can work to reduce waste, inefficiency, and poor performance by examining procedures on a step-by-step basis through _____.

a. advance planning

b. materials management

c. methods improvement

d. quality planning

12. Which of the following is NOT one of the areas of materials management?

a. transportation

b. warehousing

c. purchasing

d. customer service

13. In a _____ production system, all the needed materials and parts arrive at the precise moment they are required for each production stage.

a. quality control

b. process control

c. just-in-time

d. standardized

14. Total quality management is _____.

a. the principle that quality belongs to each person who creates it while performing a job

b. the consistency of a product's quality from unit to unit

c. the sum of all activities involved in getting high-quality products into the marketplace

d. the process by which a company analyzes a competitor's products to identify desirable improvements

15. Which of the following best describes total quality management?

a. the principle that quality belongs to everyone on the job

b. the consistency of a product's quality from unit to unit

c. all activities involved in getting high-quality products into the marketplace

d. the performance features offered by a product

16. Quality ownership is _____.

a. the principle that quality belongs to each person who creates it while performing a job

b. the consistency of a product's quality from unit to unit

c. the sum of all activities involved in getting high-quality products into the marketplace

d. the process by which a company analyzes a competitor's products to identify desirable improvements

17. Which of the following best describes competitive product analysis?

a. the principle that quality belongs to each person who creates it while performing a job

b. the consistency of a product's quality from unit to unit

c. the process by which a company analyzes a competitor's products to identify desirable improvements

d. the sum of all activities involved in getting a high-quality product into the marketplace.

18. Which of the following best describes value-added analysis?

a TQM tool in which groups of employees work together to improve quality

b. the process of evaluating all work activities, materials flows, and paperwork to determine the value they add for customers

c. the process by which a company implements the best practices from its own past performance, and those of other companies to improve its own products

d. none of the above

19. Which of the following best describes ISO 9000?

a. the concept that all employees are valuable contributors to a firm's business, and should be entrusted with decisions regarding their work

b. the redesigning of business processes to improve performance, quality, and productivity

c. a program certifying that a factory, laboratory, or office has met the quality management standards of the International Organization for Standardization

d. a certification program attesting to the fact that a factory, laboratory, or office has improved environmental performance

20. Which of the following best describes ISO 14000?

a. the concept that all employees are valuable contributors to a firm's business, and should be entrusted with decisions regarding their work

b. a certification program attesting to the fact that a factory, laboratory, or office has improved environmental performance

c. a certification program attesting to the fact that a factory, laboratory, or office has met the quality management standards of the International Organization for Standardization

d. none of the above

21. _____ is the fundamental rethinking and radical redesign of business practice to achieve dramatic improvements in performance.

a. Supply chain management

b. Business process reengineering

c. Total quality management

d. Quality ownership

22. Which of the following best describes business process reengineering?

a. the redesigning of business processes to improve performance, quality, and productivity

b. as program certifying that a factory, laboratory, or office has met the quality management standards of the International Organization for Standardization

c. the principle of looking at the supply chain as a whole in order to improve the overall flow through the system

d. a program certifying that a factory, laboratory, or office has developed pollution control standards

23. Supply chain management is _____.

a. the principle of looking at the supply chain as a whole in order to improve the overall flow through the system

b. a limitation on the number of suppliers allowed to supply a particular company

c. complete movement of raw materials throughout a manufacturing or service facility

d. a cost-reduction program in which wholesalers and retailers are eliminated in an effort to entice consumers to purchase directly from manufacturers

24. Which of the following best describes supply chain management?

a. the principle of looking at the supply chain as a whole in order to improve the overall flow through the system

b. limiting the number of a company's suppliers

c. removing wholesalers

d. none of the above

25. A _____ identifies the sequence of production activities, movements of materials, and work performed at each stage.

a. methods plan

b. production plan

c. MPS

d. process flowchart

26. Which of the following is true regarding quality management?

a. TQM focuses on production to ensure that products are produced according to specifications.

b. In controlling for quality, managers should establish specific standards and measurements.

c. Because it sets the tone for everything that follows, planning for quality is the most important stage in quality management.

d. TQM is sometimes called quality insurance.

27. _____ is the evaluation of all work activities, materials flows, and paperwork to determine the value that they add for customers.

a. Value-added analysis 7

b. Benchmarking

c. Groupware

d. Quality management

28. _____ refers to a collaborative group of employees from various work areas who meet regularly to define, analyze, and solve common production problems..

a. Supply chain management

b. Business process reengineering

c. Total quality management

d. A quality circle

29. The _____ is the flow of information, materials, and services from raw-materials suppliers through stages in the operations process until the product reaches the end customer.

a. distribution chain

b. supply chain

c. service channel

d. distribution channel

30. The process by which a company analyzes a competitor's product to identify desirable improvements in its own is called _____.

a. competitive product analysis

b. benchmarking

c. performance quality analysis

d. quality reliability analysis

POM GLOSSARY

5s: 5S is a system for organizing spaces so work can be performed efficiently, effectively, and safely. 5S stands for the 5 steps of this methodology: Sort, Set in Order, Shine, Standardize, and Sustain.

ABC Analysis: ABC analysis is an approach for classifying inventory items based on the items' consumption values. Consumption value is the total value of an item consumed over a specified time period, for example a year.

Actual Demand: Actual demand is composed of customer orders. Actual demand nets against or "consumes" the forecast, depending upon the rules chosen over a time horizon.

Aggregate Plan: A plan that includes budgeted levels of finished goods, inventory, production backlogs, and changes in the workforce to support the production strategy. Aggregated information rather than product information is used, hence the name aggregate plan.

Aggregate planning: This strategy uses demand forecasts to manage scheduling and planning for project activities between three and 18 months in advance, so that the necessary resources and personnel can be efficiently acquired or assigned.

Agile Manufacturing: Agile manufacturing is a term applied to an organization that has created the processes, tools, and training to enable it to respond quickly to customer needs and market changes while still controlling costs and quality.

Appraisal Costs: These are the costs associated with the formal evaluation and audit of quality in the firm. Typical costs include inspection, quality audits, testing, calibration, and checking time.

Approved Vendor List (AVL): List of the suppliers approved for doing business. The AVL is usually created by procurement or sourcing and engineering personnel using a variety of criteria such as technology, functional fit of the product, financial stability, and past performance of the supplier.

Arrow diagram: A planning tool to diagram a sequence of events or activities (nodes) and the interconnectivity of such nodes. It is used for scheduling and especially for determining the critical path through nodes.

Artificial intelligence: Artificial intelligence (AI) is the ability of a computer or a robot controlled by a computer to do tasks that are usually done by humans because they require human intelligence and discernment.

Automated Guided Vehicle System (AGVS): A transportation network that automatically routes one or more material handling devices, such as carts or pallet trucks, and positions them at predetermined destinations without operator intervention.

Automated Storage/Retrieval System (AS/RS): A high-density rack inventory storage system with un-manned vehicles automatically loading and unloading products to/from the racks.

Automation: Automation is the use of technology to perform tasks with reduced human assistance.

Back Scheduling: A technique for calculating operation start dates and due dates. The schedule is computed starting with the due date for the order and working backward to determine the required start date and/or due dates for each operation.

Batch Manufacturing: Batch manufacturing is a style of manufacturing that compiles the different components of a product through step-by-step processes..

Bill of Material (BOM): A structured list of all the materials or parts and quantities needed to produce a particular finished product, assembly, subassembly, or manufactured part, whether purchased or not.

Break-even analysis: A break-even analysis is a financial calculation that weighs the costs of a new business, service or product against the unit sell price to determine the point at which you will break even.

Break-Even Point: The level of production or the volume of sales at which operations are neither profitable nor unprofitable. The break-even point is the intersection of the total revenue and total cost curves.

Breakdown maintenance: Breakdown maintenance is the continuous use of a part, machine, unit, or device until it breaks down and needs to be repaired or replaced.

Business Process Reengineering (BPR): The fundamental rethinking and oftentimes, radical redesign of business processes to achieve dramatic organizational improvements.

Capacity: A facility's maximum productive capability, usually expressed as the volume of output per period of time.

Capacity Management: Capacity management refers to the act of ensuring a business maximizes its potential activities and production output at all times, under all conditions.

Capacity Planning: Capacity planning is a technique used to identify and measure overall capacity of the production. It assures that needed resources will be available at the right time and place to meet logistics and supply chain needs.

Cellular manufacturing: Cellular Manufacturing is a lean manufacturing approach that helps companies builds a variety of products for their customers with as little waste as possible. In cellular manufacturing, equipment and workstations are arranged in a sequence that supports a smooth flow of materials and components through the process, with minimal transport or delay.

Combination Layout: A combination layout is possible where an item is being made in different types and sizes. In such cases machinery is arranged in a process layout but the process grouping is then arranged in a sequence to manufacture various types and sizes of products.

Computer-aided design (CAD): Computer-aided design (CAD) is the use of computers (or workstations) to aid in the creation, modification, analysis, or optimization of a design.

Computer-Aided Manufacturing (CAM): Computerized systems in which manufacturing instructions are downloaded to automated equipment or to operator workstations.

Computer-Integrated Manufacturing (CIM): CIM is the integration of the total manufacturing enterprise through the use of integrated systems and data communications coupled with new managerial philosophies that improve organizational and personnel efficiency.

Concurrent Engineering: A product development approach where design and development are carried out at the same time. It is used to shorten the development life cycle and to release products more quickly. The simultaneous execution of design and development can help to improve design practicality.

Continuous Process Improvement (CPI): A never-ending effort to expose and eliminate root causes of problems; small-step improvement as opposed to big-step improvement.

Control chart: Control charts compare process results with historical averages and process control limits to show whether a process meets results expectations. If a process's results are inconsistent or fall outside process control limits, it may need to be examined and adjusted.

Cost of quality: Cost of quality is a method for calculating the costs companies incur ensuring that products meet quality standards, as well as the costs of producing goods that fail to meet quality standards..

Critical Success Factors (CSF): Critical Success Factors, or CSFs, are indicators for opportunities, activities or conditions required to achieve an objective within a project or mission.

Customer Relationship Management (CRM): Customer relationship management (CRM) is a technology for managing all your company's relationships and interactions with customers and potential customers.

Cycle Time: The amount of time it takes to complete a business process.

Decision tree analysis: A diagrammatic technique used to illustrate a chain of decisions and to examine the implications of multiple decision-making or situational outcomes.

Delphi Method: The Delphi method is a process used to arrive at a group opinion or decision by surveying a panel of experts. ·

Demand Forecasting: Demand forecasting is the process of using predictive analysis of historical data to estimate and predict customers' future demand for a product or service.

Demand: Demand is the quantity of a good that consumers are willing and able to purchase at various prices during a given period of time.

Discrete Manufacturing: Discrete manufacturing processes create products by assembling unconnected distinct parts as in the production of distinct items such as automobiles, appliances, or computers.

Dispatching: Dispatching is the routine of setting productive activities in motion through the release of orders and necessary instructions according to pre-planned times and sequence of operations embodied in route sheets and loading schedules.

Economic Order Quantity (EOQ): An inventory model that determines how much to order by determining the amount that will meet customer service levels while minimizing total ordering and holding costs.

Efficiency: Performing activities at the lowest possible cost.

Enterprise Resource Planning (ERP): Enterprise resource planning (ERP) is a process used by companies to manage and integrate the important parts of their businesses.

Expediting: 1) Moving shipments through regular channels at an accelerated rate. 2) To take extraordinary action because of an increase in relative priority, perhaps due to a sudden increase in demand.

Facilities: Facilities are the physical plant, distribution centers, service centers, and related equipment.

Facility Layout: Facility layout is an arrangement of different aspects of manufacturing in an appropriate manner as to achieve desired production results.

Facility location: Facility location is the process of determining a geographic site for a firm's operations.

Fishbone diagram: A fishbone diagram is used in project management to identify and categorize the possible causes of an effect.

Fixed Costs: The term fixed cost refers to a cost that does not change with an increase or decrease in the number of goods or services produced or sold. Fixed costs include items such as depreciation on buildings and fixtures.

Fixed Interval Inventory Model: A setup wherein each time an order is placed for an item, the same (fixed) quantity is ordered.

Fixed Order Quantity: The Fixed Order Quantity is the inventory control system, wherein the maximum and minimum inventory levels are fixed, and maximum and fixed amount of inventory can be replenished at a time when the inventory level reaches the auto set reorder point or the minimum stock level.

Flow Chart: A flowchart is a picture of the separate steps of a process in sequential order.

Flow Process Charts: A flow process chart is a chart of all the activities involved in a process.

Forecasting: It is the process of predicting future events, including product demand.

Gantt chart: A Gantt chart is a type of bar chart that shows all the tasks constituting a project. Tasks are listed vertically, with the horizontal axis marking time. The lengths of task bars are to scale with tasks' durations.

Goods: Goods are things that are made to be sold.

Handling Costs: It is the cost involved in moving, transferring, preparing, and otherwise handling inventory.

House of Quality: A house of quality (HOQ) involves collecting and analyzing the "voice of the customer" and a key component of the Quality Functional Deployment technique.

Indirect Cost: Indirect costs are costs used by multiple activities, and which cannot therefore be assigned to specific cost objects.

Inspection: The process of reviewing and examining the final product to assess compliance to initial requirements and expectations.

Intermittent process: A process in which raw materials are converted into components or parts for stock and they are combined according to customer orders.

Inventory: Raw materials, work in process, finished goods and supplies required for creation of a company's goods and services.

Inventory Control: Inventory control is the process of keeping the right number of parts and products in stock to avoid shortages, overstocks, and other costly problems.

Inventory Management: It is the process of ensuring the availability of products through inventory administration.

Inventory Planning: Inventory planning is the process of determining the optimal quantity and timing of inventory for the purpose of aligning it with sales and production capacity.

ISO 14000 Series Standards: A series of generic environmental management standards under development by the International Organization of Standardization, which provide structure and systems for managing environmental compliance with legislative and regulatory requirements and affect every aspect of a company's environmental operations.

ISO 9000: A series of quality assurance standards compiled by the Geneva, Switzerland-based International Standardization Organization.

Job Design: Job design is the process of creating a job that enables the organization to achieve its goals while motivating and rewarding the employee.

Johnson's Rule: Johnson's Rule is a technique that can be used to minimise the completion time for a group of jobs that are to be processed on two machines or at two successive work centres.

Just-in-Time (JIT): An inventory control system that controls material flow into assembly and manufacturing plants by coordinating demand and supply to the point where desired materials arrive just in time for use. An inventory reduction strategy that feeds production lines with products delivered "just in time".

Kaizen: The Japanese term for improvement; continuing improvement involving everyone-managers and workers. In manufacturing, kaizen relates to finding and eliminating waste in machinery, labor, or production methods.

Kanban: Kanban is a workflow management method for defining, managing and improving services that deliver knowledge work. It aims to help the firms to visualize their work, maximize efficiency, and improve continuously..

Layout: Physical location or configuration of a department or a work station.

Lead Time: The total time that elapses between an order's placement and its receipt. It includes the time required for order transmittal, order processing, order preparation, and transit.

Lean systems: It is a philosophy that takes a total system approach to creating efficient operations through the elimination of waste.

Location analysis: It is the process of identifying the best location for facilities.

Machine Learning: Machine learning is the science of getting computers to act without being explicitly programmed.

Maintenance management: Maintenance management is defined as the process of maintaining the assets and resources of a company, which has as main objective to control and reduce costs, times, and resources

Maintenance: Maintenance refers to care or upkeep, as of machinery or property, or to the means of upkeep, support, or subsistence.

Man-machine charts: Man-machine charts allow engineers to visually compare the time that multiple machines and operators are occupied and working.

Manufacturing: A generic term used for the process of producing or assembling goods by hands or machines for sale to others.

Mass customization: The ability of a firm to highly customize its goods and services at high volumes through its operations management function.

Master Production Schedule (MPS): The master level or top level schedule used to set the production plan in a manufacturing facility.
Material Requirement Planning: A methodology that includes production scheduling that

Material Requirement Planning (MRP): MRP refers to the basic calculations used to determine component requirements from end item requirements. It also refers to a broader information system that uses the dependence relationship to plan and control manufacturing operations.

Materials Handling: The physical handling of products and materials between procurement and shipping.

Materials Management: Materials Management is a method for planning, organizing and controlling the activities that are related to the flow of materials in a company.

Mean absolute deviation (MAD): The mean absolute deviation of a dataset is the average distance between each data point and the mean.

Method Study: The systematic recording, analysis and critical examination of existing and proposed ways of doing work and the development and application of easier and more effective method

New Product Development: New product development (NPD) is the complete process of bringing a new product to market.

Operations: Operations is the work of managing the inner workings of the business so that it runs as efficiently as possible.

Operations Management: Operations management is chiefly concerned with planning, organizing and supervising in the contexts of production, manufacturing or the provision of services.

Period Order Quantity: A lot-sizing technique under which the lot size is equal to the net requirements for a given number of periods. The number of periods to order is variable, each order size equalizing the holding costs and the ordering costs for the interval.

Planned maintenance: Planned maintenance is a proactive approach to maintenance in which maintenance work is scheduled to take place on a regular basis.

Poka Yoke: Poka-Yoke is also known as mistake-proofing, is a technique for avoiding simple human errors at work.

Preventive maintenance: Preventive maintenance (PM) is the regular and routine maintenance of equipment and assets in order to keep them running and prevent any costly unplanned downtime from unexpected equipment failure.

Process Design: Process Design is concerned with the overall sequences of operations required to achieve the product specifications. It specifies the type of work stations to be used, the machines and equipments necessary to carry out the operations.

Process Layout: A process layout is a type of facility layout in which the floor plan is arranged with similar processes or machines located together.

Process Planning: Process planning refers to the way production of goods or services is organised. It is the basis for decisions regarding capacity planning, facilities layout, equipments and design of work systems.

Process selection: The process of identifying the unique features of the production process that will give the product its unique characteristics. Process selection typically goes hand in hand with product design, as we need to create a process that gives rise to the particular product design desired.

Procurement: procurement comprises all activities and processes involved in acquiring needed goods and services from external parties.

Product design: The process of deciding on the unique and specific features of a product.

Product layout: Product layout has a structured arrangement of various machines that concentrate on producing a single kind of final product.

Production control: Production control is the activity of monitoring and controlling any particular production or operation.

Production planning and control: Production planning and control refers to two strategies that work cohesively throughout the manufacturing process.

Production Planning: Production planning is the planning of production and manufacturing modules in a company or industry.

Productivity: A measure of how efficiently an organization converts inputs into outputs. It is usually measured by a ratio of output divided by input. It is a scorecard of how efficiently resources are used and a measure of competitiveness.

Purchasing management: Purchasing management is the management of the purchasing process and related aspects in an organization.

Purchasing: Purchasing is one of the process of inventory management which is focused on buying the raw materials, goods, and services.

Quality Circle: A small group of people who normally work as a unit and meet frequently to uncover and solve problems concerning the quality of items produced, process capability, or process control.

Quality Control (QC): The management function that attempts to ensure that the foods or services manufactured or purchased meet the product or service specifications.

Quality Function Deployment (QFD): A structured method for translating user requirements into detailed design specifications using a continual stream of 'what-how' matrices. It links the needs of the customer with design, development, engineering, manufacturing, and service functions.

Quality management: It is the process used to ensure the quality of a product, including measuring quality and identifying quality problems.

Quality planning: Quality planning involves identifying expected quality standards and creating mechanisms to ensure these standards are met. It may also recommend corrective action if quality standards are not being met.

Reengineering: The processes of redesigning a company's processes to increase efficiency, improve quality, and reduce costs.
reflects timing and quantity of production

Robots: A robot is a type of automated machine that can execute specific tasks with little or no human intervention and with speed and precision.

Robust Design: Robust Design is a technique that reduces variation in a product by reducing the sensitivity of the design of the product to sources of variation rather than by controlling their sources

Schedule: A comprehensive list of project activities and milestones in logical order, with start and finish dates for each component.

Scheduling: The process of deciding on the timing and use of resources within an operation; it addresses questions such as who will work on what work schedule and in what sequence jobs will be processed.

Services: A service is a transaction in which no physical goods are transferred from the seller to the buyer.

SIMO Chart: SIMO chart records simultaneously the different therbligs performed by different parts of the body of one more operator on a common time scale.

Statistical Process Control (SPC): Statistical process control (SPC) is a method of quality control which employs statistical methods to monitor and control a process.

Subcontracting: It is the process of sending production work outside to another manufacturer. This can involve specialized operations such as plating metals, or complete functional operations.

Time Study: Time study is the art of observing and recording time required to do each detailed element of an individual operation.

Total Productive Maintenance (TPM): Team based maintenance process designed to maximize machine availability and performance and product quality.

Total quality management (TQM): A philosophy that seeks to improve quality by eliminating causes of product defects and by making quality the responsibility of everyone in the organization..

Unplanned Maintenance: Unplanned maintenance occurs when something is broken. often know as emergency, reactive or breakdown maintenance.

Value added: A term used to describe the net increase created during the transformation of inputs into outputs. The OM function seeks to create value added in the transformation process.

Value Analysis: It is a method to determine how features of a product or service relate to cost, functionality, appeal and utility to a customer.

Value engineering: Value engineering seeks to increase the functionality-to-cost ratio of a product by providing improved functionality at lower cost.

Voice of the customer: The expressed requirements and expectations of customers relative to products or services, as documented and disseminated to the members of the providing organization.

Work Breakdown Structure (WBS): A complete line by line breakdown of the products, services, and activities that will be required to fulfill a contractual obligation.

Work sampling: Work sampling is the statistical technique used for determining the proportion of time spent by workers in various defined categories of activity.

Work Study: A term used to embrace the techniques of method study and work measurements which are employed to ensure the best possible use of human and material resources in carrying out a specified activity.

X-Bar control charts: An x-bar control chart includes two separate charts that display the means and sample ranges for a number of periodically gathered, same-size samples. The sampled data constitute some characteristic of a product or a process.