PERIYAR UNIVERSITY

NAAC 'A++' Grade with CGPA 3.61 (Cycle - 3)
State University - NIRF Rank 56 - State Public University Rank 25
Salem - 636011, Tamilnadu, India.

CENTRE FOR DISTANCE AND ONLINE EDUCATION (CDOE)

MASTER OF BUSINESS ADMINISTRATION (MBA)

SEMESTER –II

CORE – : OPERATIONS MANAGEMENT

(Candidates admitted from 2024 onwards)

PERIYAR UNIIVERSITY

CENTRE FOR DISTANCE AND ONLINE EDUCATION (CDOE)

2024 admission onwards

Core: operations Management

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Centre for Distance and Online Education (CDOE)

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1.1 INTRODUCTION:

Operations are that part of a business organization that is responsible for producing goods and services. Goods are physical items that include raw materials, parts, subassemblies such as motherboards that go into computers, and final products such

as cell phones and automobiles Services are activities that provide some combination of time location, form or psychological value. Examples of goods and services are found all around you every book you read, every video you watch, every email or test message you send, every telephone conversation you have, and every medical treatment you receive involves the operations function of one or more organizations. So does everything you wear, eat, travel in, sit on and access the Internet. The operations function in business can also be viewed from a more far reaching perspective: The collective success or failure of companies' operations functions has an impact on the ability of a nation to compete with other nations, and on the nation's economy.

The ideal situation for a business organization is to achieve an economic match of supply and demand. Having excess supply or excess capacity is wasteful and costly; having too little means lost opportunity and possible customer dissatisfaction. The key functions on the supply side are operations and supply chains, and sales and marketing on the demand side.

While the operations function is responsible for producing products and/or delivering services, it needs the support and input from other areas of the organization. Business organizations have four basic functional areas, Human Resources, finance, marketing, and operations. It doesn't matter whether the business is a retail store, a hospital, a manufacturing firm, a car wash, or some other type of business, all business organizations have these three basic functions.

Finance is responsible for securing financial resources at favorable prices and allocating those resources throughout the organization, as well as budgeting, analyzing investment proposals, and providing funds for operations. Marketing is responsible for assessing consumer wants and needs, and selling and promoting the organization's goods or services. Operations is responsible for producing the goods or providing the services offered by the organization. To put this into perspective, if a business organization were a car, operations would be its engine. And just as the engine is the core of what a car does, in a business organization, operations is the core of what the organization does. Operations management is responsible for managing that core.

Hence operations management is the management of systems or processes that create goods and/or provide services Operations and supply chains are intrinsically linked, and no business organization couldexist without both. A supply chain is the sequence of organizations their facilities, functions, and activities that are involved in producing and delivering a product or service. The sequence begins with basic suppliers of raw materials and extends all the way to thefinal customer. See Figure 1.2. Facilities might include warehouses, factories, processingcenters, offices, distribution centers, and retail outlets. Functions and activities include forecasting, purchasing, inventory management, information management, quality assurance, scheduling, production, distribution, delivery, and customer service.

One way to think of a supply chain is that it is like a chain, as its name implies. That isshown in Figure 1.2. The links of the chain would represent various production and product or service

ORGANIZATION

FIGURE 1.1

FIGURE 1.2

Operationssuch as factories, storage facilities, activities, and modes of transportation (trains, railroads, ships, planes, cars, and people). The chain illustrates both the

sequential nature of a supply chain and the Interconnectedness of the elements of the supply chain. Each link is a customer of the previous link and a supplier to the following link. It also helps to understand that if any one of the links fails for any reason (quality or delivery issues, weather problems, or some other problems), that can interrupt the flow in the supply chain for the following portion of the chain.

It provides another illustration of a supply chain: a chain that extends from wheat growing on a farm and ends with a customer buying a loaf of bread in a supermarket. The value of the product increases as it moves through the supply chain.

Another way to think of a supply chain is as a tree with many branches. The main branches of the tree represent key suppliers and transporters (e.g., trucking companies). That view is helpful in grasping the size and complexity that often exists in supply chains. Notice that the main branches of the tree have side branches (their own keysuppliers), and those side branches also have their own side branches (their own key suppliers. In fact, an extension of the tree view of a supply chain is that each supplier (branch) has its own supply tree. Referring to, the farm, mill, and bakery of the trucking companies would have their own “tree” of suppliers Supply chains are both external and internal to the organization.

The external parts of aSupply chain provide raw materials, parts, equipment, suppliers, and/or other inputs to the organization, and they deliver outputs that are goods to the organization’s customers. The internal parts of a supply chain are part of the operations function itself, supplying operations with parts and materials, performing work on products, and/or performing services.

1.2 MEANING:

The creation of goods or services involves transforming of converting inputs into outputs Various inputs such as capital, labor, and information are used to create goods or services using one or more transformation processes (e.g.. storing, transporting, repairing). To ensure that the desired outputs are obtained, an organization takes measurements at various points in the transformation process (feedback) and then

compares them with previously established standards to determine whether corrective action is needed (control) to the depicts the conversion system.

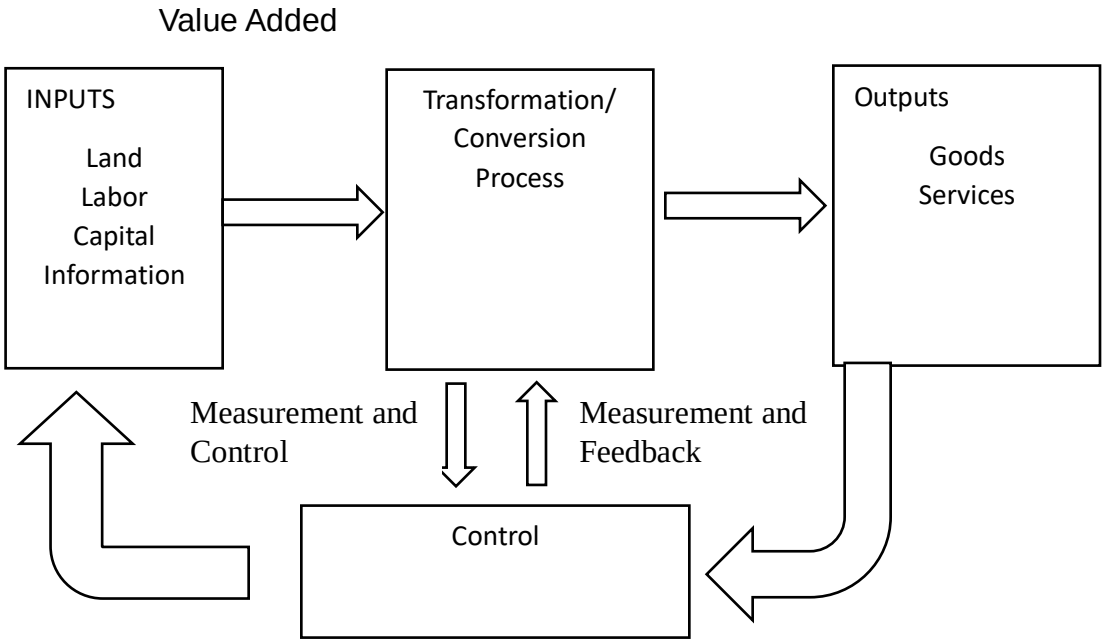
It provides some examples of inputs, transformation processes, and outputs. For example, having the oil changed in your car is a service, but the oil that is delivered is a good. Similarly, house painting is a service, but the paint is a good. The goods-service combination is a continum. It can range from primarily goods, with little service, to primarily service, with few goods. Because there are relatively few pure goods or pure services, companies usually sell product packages, which are a combination of goods and services. There are elements of both goods production and service delivery in these product packages. This makes managingOperations more interesting, and also more challenging.

The essence of the operations function is to add value during the transformation process: Value-added is the term used to describe the difference between the cost of inputs and the value or price of outputs. In nonprofit organizations, the value of outputs (e.g., highway construction, police and fire protection) is their value to society, the greater the value-added, the greater the effectiveness of these operations. In the profit organizations, the value of outputs is measured by the prices that customers are willing to pay for those goods or services. Firms use the money generated by value-added for research and development, investment in new facilities and equipment, worker salaries, and profits. Consequently, the greater the value- added, the greater the amount of funds available for these purposes. Value can also be psychological, as in branding.

Many factors affect the design and management of operations systems. Among them are the degree of involvement of customers in the process and the degree to which technology is used to produce and/or deliver a product or service. The greater the degree of customer involvement, the more challenging it can be to design and manage the operation. Technology choices can have a major impact on productivity, costs, flexibility, and quality and customer satisfaction

1.3 DEFINITION:

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



In simple words, the main aim of Operations Management is to augment the number of processes which add value to a given procedure. This value adding events should be designed, keeping in mind the market conditions.

In other words, operations management is a process that is responsible for transforming the inputs like labour, capital, equipment, land, buildings, materials and information into such outputs that provide added value to customers like the final goods and services. Thus, operations management can be referred to as an input-process-output system

1.4 NEED OF OPERATIONS MANAGEMENT

1) For having improved efficiency in the production and distribution of products and service, organizations require operations management.

2) Having better management of material stock for production process.

3) Planning budgets for various plans.

4) Logistic management for product supply.

5) Addressing the problems of customers rapidly and effectively.

6) Performing interviews of different candidates and monitoring the manpower.

1.5. OBJECTIVES OF OPERATIONS MANAGEMENT:

There are various strategies for achieving the objectives of operations management, but the most important ones can be categorised into four key areas:

EFFICIENCY

Operations managers strive to make the best use of all resources, including labour, materials, technology, and time. The goal here is to cultivate the expected output with the least amount of inputs or waste. This can be achieved through streamlining processes, eliminating bottlenecks, and reducing waste. Efficiency is the key to meeting objectives related to cost, productivity, and profitability.

QUALITY

Operations managers also aim to produce products and services that meet or exceed customer expectations. This requires designing processes that result in consistent quality and implementing quality control measures to ensure that products and services meet these standards. Without adequate quality, operations management is of zero use. It is one of the crucial strategies to meet the dynamic objectives of operations management.

INNOVATION

While efficiency and quality are essential objectives, operations managers must also be able to adapt to change and innovate. It will entail always looking for ways to improve processes and products and being open to new ideas. Every product/service requires distinctive innovations that will bring more value. Hence, it becomes imperative

to deploy brand new innovations to achieve different objectives of operations management.

CUSTOMER SATISFACTION

Ultimately, operations management aims to produce products and services that customers are satisfied with. A company cannot imagine a successful product without ensuring their customers are 100% satisfied. This requires understanding customer needs and desires and designing processes and products that meet these needs. It also involves ensuring that customers are kept informed throughout the process and that their concerns are addressed promptly.

1.6. SCOPE OF OPERATIONS MANAGEMENT:

Operations management people are involved in product and service design, process selection, selection and management of technology, design of work systems, location planning, facilities planning and quality improvement of the organization's products or services.

The operations function includes many interrelated activities, such as forecasting, capacity planning, scheduling, managing inventories, assuring quality, motivating employees, deciding where to locate facilities, and more.

We can use an airline company to illustrate a service organization's operations system. The system consists of the airplanes, airport facilities, and maintenance facilities, sometimes spread out over a wide territory. The activities include:

Forecasting such things as weather and landing conditions, seat demand for flights, and the growth in air travel.

Capacity planning,essential for the airline to maintain cash flow and make a reasonable profit. (Too few or too many planes, or even the right number of planes but in the wrong places, will hurt profits.)

Locating facilitiesaccording to managers' decisions on which cities to provide service for, where to locate maintenance facilities, and where to locate major and minor hubs. Facilities and layout, important in achieving effective use of workers and equipment.

Scheduling of planes for flights and for routine maintenance; scheduling of pilots and flight attendants; and scheduling of ground crews, counter staff, and baggage handlers.

Managing inventoriesof such items as foods and beverages, first-aid equipment, in-flight magazines, pillows and blankets, and life preservers.

Assuring quality, essential in flying and maintenance operations, where the emphasis is on safety, and important in dealing with customers at ticket counters, check-in, telephone and electronic reservations, and curb service, where the emphasis is on efficiency and courtesy.

Motivating and training employees in all phases of operations.

1.7. MANAGING THE SUPPLY CHAIN TO ACHIEVE SCHEDULE, COST, AND QUALITY GOALS:

Consider a bicycle factory. This might be primarily an assembly operation: buying components such as frames, tires, wheels, gears, and other items from suppliers, and then assembling bicycles. The factory also might do some of the fabrication work itself, forming frames, making the gears and chains, and it might buy mainly raw materials and a few parts and materials such as paint, nuts and bolts, and tires. Among the key management tasks in either case are scheduling production, deciding which components to make and which to buy, ordering parts and materials, deciding on the style of bicycle to produce and how many, purchasing new equipment to replace old or worn-out equipment, maintaining equipment, motivating workers, and ensuring that quality standards are met.

Obviously, an airline company and a bicycle factory are completely different types of operations. One is primarily a service operation, the other a producer of goods. Nonetheless, these two operations have much in common. Both involve scheduling

activities, motivating employees, ordering and managing supplies, selecting and maintaining equipment, satisfying quality standards and above all satisfying customers. And in both businesses, the success of the business depends on short and long-term planning. A primary function of an operations manager is to guide the system by decision making.

Certain decisions affect the design of the system, and others affect the operation of the system. System design involves decisions that relate to system capacity, the geographic location of facilities, arrangement of departments and placement of equipment within physical structures, product and service planning, and acquisition of equipment. These decisions usually, but not always, require long-term commitments. Moreover, they are typically strategic decisions. System creation involves management of personnel, inventory planning and control, scheduling, project management, and quality assurance. These are generally tactical and operational decisions. Feedback on these decisions involves measurement and control. In many instances, the operations manager is more involved in day-to-day operating decisions than with decisions relating to system design. However, the operations manager has a vital stake in system design because system design essentially determines many of the parameters of system operation. For example, costs, space, capacities, and quality are directly affected by design decisions. Even though the operations manager is not responsible for making all design decisions, he or she can provide those decision makers with a wide range of information that will have a bearing on their decision.. A number of other areas are part of, or support, the operations function. They include purchasing, industrial engineering, distribution, and maintenance.

Purchasing has responsibility for procurement of materials, supplies, and equipment. Close contact with operations is necessary to ensure correct quantities and timing of purchases. The purchasing department is often called on to evaluate vendors for quality, reliability, service, price, and ability to adjust to changing demand. Purchasing is also involved in receiving and inspecting the purchased goods.

Industrial engineering is often concerned with scheduling, performance standards, work methods, quality control, and material handling.

Distribution involves the shipping of goods to warehouses, retail outlets, or final customers.

Maintenance is responsible for general upkeep and repair of equipment, buildings and grounds, heating and air-conditioning, removing toxic wastes, parking, and perhaps security.

The operations manager is the key figure in the system: He or she has the ultimate responsibility for the creation of goods or provision of services.

The kinds of jobs that operations managers oversee vary tremendously from organization to organization largely because of the different products or services involved. Thus, managing a banking operation obviously requires a different kind of expertise than managing a steelmaking operation. However, in a very important respect, the jobs are the same: They are both essentially managerial. The same thing can be said for the job of any operations manager regardless of the kinds of goods or services being created.

The service sector and the manufacturing sector are both important to the economy. The service sector now accounts for more than 70 percent of jobs in the United States, and it is growing in other countries as well. Moreover, the number of people working in services is increasing, while the number of people working in manufacturing is not. The reason for the decline in manufacturing jobs is twofold: As the operations function in manufacturing companies finds more productive ways of producing goods, the companies are able to maintain or even increase their output using fewer workers. Furthermore, some manufacturing work has been outsourced to more productive companies, many in other countries, which are able to produce goods at lower costs.

1.8.NATURE OF OPERATIONS MANAGEMENT:

Operations Management is a field that focuses on the management of resources and processes to create and deliver goods or services. It is a relatively new domain, only emerging as a different discipline in the early 20th century. Operations management is concerned with all aspects of an organization's operations, including the design, planning, control, and execution of processes.

1) **Transformational Process:** The transformation of raw material is the main task of production management.

2)**Offers Value Addition**: Every succeeding level adds some value to the preceding one. As an instance, construction process leads to value addition to inputs such as sand.

3) **System Itself:** It entails a comprehensive logical process which requires following a definitive sequence ofactivities.

4**) Exists for Certain Objectives:** The first step is to set an objective and for meeting that specific objective, the whole procedure needs to be tracked.

5) **Carried out in Part of Organisation**: It shows that production is not the sole function executed by theorganisation. It performs other functions such as research and development, finance, etc.

6**) Interrelationship among the System**: A system cannot work in seclusion and its success depends on its interaction with other systems. Various systems co-exist.

7) **Stratum Formulation:** A production system exists through various levels of hierarchy in an organisation. Each level of the organisation benefits from it.

8) **Specialisation of Function:** Various functions may be executed separately and the individuals may attain specialisation in them as they perform them repeatedly.

9) **Increase in Entropy:** This entails dilapidation of the matter and energy existing in the universe until it reaches the final stage. For slowing down the momentum of the degradation, new methods need to be introduced.

10) **Increase in Productivity**: With specialization, the time required to complete the work decreases.

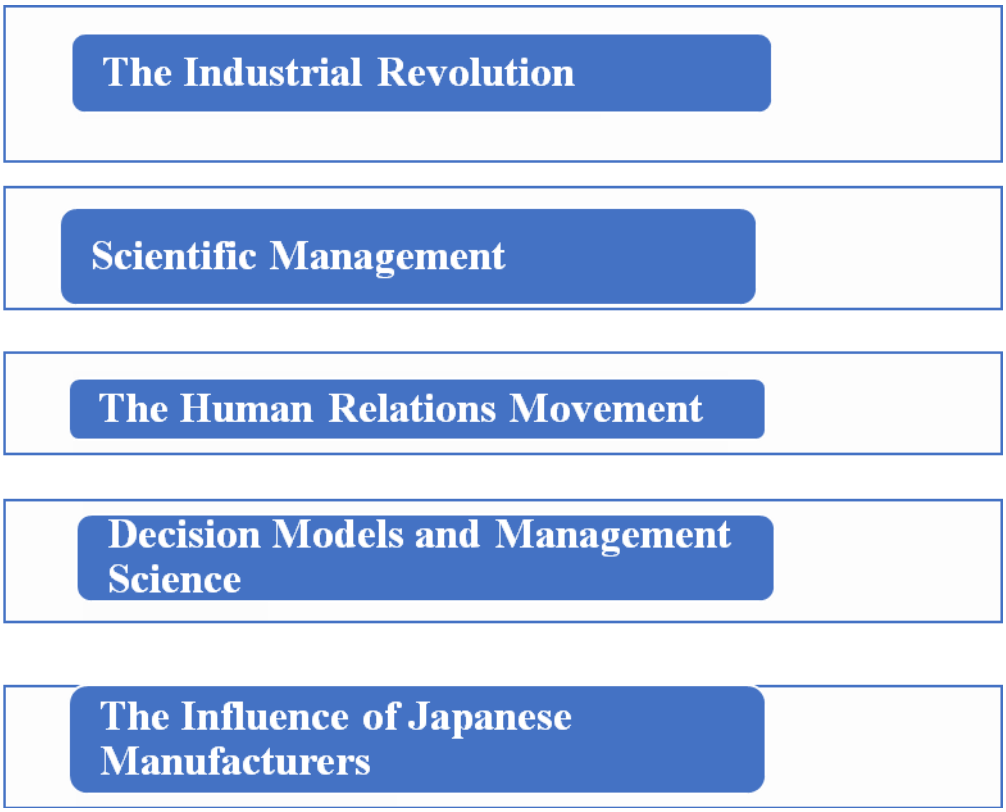
1.9 THE HISTORICAL EVOLUTION OF OPERATIONS MANAGEMENT:

Systems for production have existed since ancient times. For example, the construction of pyramids and Roman aqueducts involved operations management skills. The production of goods for sale, at least in the modern sense, and the modern factory system had their roots in the Industrial Revolution.

The Industrial Revolution:

The Industrial Revolution began in the 1770s in England and spread to the rest of Europe and to the United States during the 19th century. Prior to that time, goods were produced in small shops by craftsmen and their apprentices. Under that system, it was common for one person to be responsible for making a product, such as a horse-drawn wagon or a piece of furniture, from start to finish. Only simple tools were available; the machines in use today had not been invented.

Then, a number of innovations in the 18th century changed the face of production forever by substituting machine power for human power. Perhaps the most significant of these was the steam engine, because it provided a source of power to operate machines in factories. The supplies of coal and iron ore provided materials for generating power and making machinery. The new machines, made of iron, were much stronger and more durable than the simple wooden machines they replaced.



In the earliest days of manufacturing, goods were produced using craft production: highly skilled workers using simple, flexible tools produced goods according to customer specifications.

Craft production had major shortcomings. Because products were made by skilled crafts-men who custom-fitted parts, production was slow and costly. And when parts failed, the replacements also had to be custom made, which was also slow and costly. Another shortcoming was that production costs did not decrease as volume increased; there were no economies of scale, which would have provided a major incentive for companies to expand. Instead. Many small companies emerged, each with its own set of standards.

A major change occurred that gave the Industrial Revolution a boost: the development of standard gauging systems. This greatly reduced the need for custom-

made goods. Factories began to spring up and grow rapidly, providing jobs for countless people who were attracted in large numbers from rural areas.

Despite the major changes that were taking place, management theory and practice had not progressed much from early days. What was needed was an enlightened and more systematic approach to management.

Scientific Management:

The scientific management era brought widespread changes to the management of factories. The movement was spearheaded by the efficiency engineer and inventor Frederick Winslow Taylor, who is often referred to as the father of scientific management. Taylor believed in a "science of management" based on observation, measurement, analysis and improvement of work methods, and economic incentives. He studied work methods in great detail to identify the best method for doing each job. Taylor also believed that management should be responsible for planning, carefully selecting and training workers, finding the best way to perform each job, achieving cooperation between management and workers, and separating management activities from work activities

Taylor’s methods emphasized maximizing output. They were not always popular with workers, who sometimes thought the methods were used to unfairly increase output without a corresponding increase in compensation. Certainly some companies did abuse workers in their quest for efficiency. Eventually, the public outcry reached the halls of Congress, and hearings were held on the matter. Taylor himself was called to testify in 1911, the same year in which his classic book, The Principles of Scientific Management, was published. The publicity from those hearings actually helped scientific management principles to achieve wide acceptance in industry.

A number of other pioneers also contributed heavily to this movement, including the Following:

Frank Gilbreth was an industrial engineer who is often referred to as the father of motion study. He developed principles of motion economy that could be applied to incredibly small portions of a task.

Henry Gantt recognized the value of nonmonetary rewards to motivate workers, and developed a widely used system for scheduling, called Gantt charts

Harrington Emerson applied Taylor's ideas to organization structure and encouraged the use of experts to improve organizational efficiency. He testified in a congressional hearing that railroads could save a million dollars a day by applying principles of scientific management.

Henry Ford, the great industrialist, employed scientific management techniques in his factories.

During the early part of the 20th century, automobiles were just coming into vogue in the United States. Ford's Model was such a success that the company had trouble keeping up with orders for the cars. In an effort to improve the efficiency of operations. Ford adopted the scientific management principles espoused by Frederick Winslow Taylor. He also introduced the moving assembly line, which had a tremendous impact on production methods in many industries.

Among Ford's many contributions was the introduction of mass production to the automotive industry, a system of production in which large volumes of standardized goods are produced by low-skilled or semiskilled workers using highly specialized, and often costly, equipment. Ford was able to do this by taking advantage of a number of important concepts. Perhaps the key concept that launched mass production was interchangeable parts, sometimes attributed to Eli Whitney, an American inventor who applied the concept to assembling muskets in the late 1700s. The basis for interchangeable parts was to standardize parts so that any part in a batch of parts would fit any automobile coming down the assembly line. This meant that parts did not have to be custom fitted, as they were in craft production. The standardized parts could also be used for replacement parts. The result was a tremendous decrease in assembly time

and cost. Ford accomplished this by standardizing the gauges used to measure parts during production and by using newly developed processes to produce uniform parts.

A second concept used by Ford was the division of labor, which Adam Smith wrote about Division in The Wealth of Nations (1776). Division of labor means that an operation, such as assembling up of an automobile, is divided up into a series of many small tasks, and individual workers are assigned to one of those tasks. Unlike craft production, where each worker was responsible worker for doing many tasks, and thus required skill, with division of labor the tasks were so narrow that virtually no skill was required.

Together, these concepts enabled Ford to tremendously increase the production rate at his factories using readily available inexpensive labor. Both Taylor and Ford were despised by many workers, because they held workers in such low regard, expecting them to perform like robots. This paved the way for the human relations movement.

The Human Relations Movement

Whereas the scientific management movement heavily emphasized the technical aspects of work design, the human relations movement emphasized the importance of the human element in job design. Lillian Gilbreth, a psychologist and the wife of Frank Gilbreth, worked with her husband, focusing on the human factor in work. (The Gilbreths were the subject of a classic film, Cheaper by the Dozen.) Many of her studies dealt with worker fatigue.

In the following decades, there was much emphasis on motivation. Elton Mayo conducted studies at the Hawthorne division of Western Electric. His studies revealed that in addition to the physical and technical aspects of work, worker motivation is critical for improving productivity. Abraham Maslow developed motivational theories, which Frederick Hertzberg refined. Douglas McGregor added Theory X and Theory Y. These theories represented the two ends of the spectrum of how employees view work.

Theory X, on the negative end, assumed that workers do not like to work, and have to be controlled rewarded and punished to get them to do good work. This attitude was quite common in the automobile industry and in some other industries, until the threat of global competition forced them to rethink that approach.

Theory Y, on the other end of the spectrum, assumed that workers enjoy the physical and mental aspects of work and become committed to work. The Theory X approach resulted in an adversarial environment, whereas the Theory Y approach resulted in empowered workers and a more cooperative spirit. William Ouchi added Theory Z, which combined the Japanese approach with such features as lifetime employment, employee problem solving, and consensus building, and the traditional Western approach that features short-term employment, specialists, and individual decision making and responsibility,

Decision Models and Management Science

The factory movement was accompanied by the development of several quantitative techniques. F. W. Harris developed one of the first models in 1915: a mathematical model forInventory order size. In the 1930s, three coworkers at Bell Telephone Labs-H. F. Dodge,H. G. Romig, and W. Shewhart-developed statistical procedures for sampling and qualityControl. In 1935, L.H.C. Tippett conducted studies that provided the groundwork for statistical sampling theory.

At first, these quantitative models were not widely used in industry. However, the onset of World War II changed that. The war generated tremendous pressures on manufacturing output, and specialists from many disciplines combined efforts to achieve advancements in the military and in manufacturing. After the war, efforts to develop and refine quantitative tools for decision making continued, resulting in decision models for forecasting, inventory management, project management, and other areas of operations management.

During the 1960s and 1970s, management science techniques were highly regarded; in the 1980s, they lost some favor. However, the widespread use of personal

computers and user-friendly software in the workplace contributed to a resurgence in the popularity of these techniques.

The Influence of Japanese Manufacturers

A number of Japanese manufacturers developed or refined management practices that increased the productivity of their operations and the quality of their products, due in part to the influence of Americans W. Edwards Deming and Joseph Juran. This made them very competitive, sparking interest in their approaches by companies outside Japan. Their approaches emphasized quality and continual improvement, worker teams and empowerment, and achieving customer satisfaction. The Japanese can be credited with spawning the “quality revolution” that occurred in industrialized countries, and with generating widespread interest in lean production.

The Influence of the Japanese on U.S. manufacturing and service companies has been enormous and promises to continue for the foreseeable future.

1.10. FUNCTIONSOF PRODUCTION DEPARTMENT

The activities of production department of an organization are grouped into two broad categories.

1. The activities that convert the available capital in to physical resources required for production
2. The activities that convert the physical resources in to saleable goods and services.

In carrying out the above activities, the production department must perform the following activities.

a. Production of goods at the right time and in sufficient quantity to meet the demand
b. Production of goods at minimum possible cost.
c. Production of goods of acceptable quality.

Thus , the functions of production personnel are:

- Forecasting the demand for the products and using the forecast to determine the requirements of various factors of production.
- Arranging for the procurement of required factors of production.
- Arranging for the services such as maintenance, store keeping material handling, inspection and quality control etc. that would be required to attain the targeted level of production.
- Utilizing effectively the factors of production and service facilities available to produce the product.

1.11. SYSTEM PERSPECTIVES OF OPERATIONS MANAGEMENT:

A System is a group of interrelated items in which no item studied in isolation will act in the same way as it would in the system. A system is divided into a series of parts or subsystems, and any system is a part of a larger system. The system's boundary defines what is inside the system and what isoutside. A system's environment is everything outside the system boundary that may have an impact on the behaviour of the system. A system's inputs are the physical objects of information that enter it from the environment and its outputs are the same which leave it for the environment.

Systems view of operations management states that activities in an operations system can be classified as inputs, transformation process and output. Inputs are classified into three general categories-external, market and primary resources.

Transformation resources are the elements that act on, or carry out, the transformation process on other elements. These include such elements as labor, equipment/plant and energy. The nature and mix of these resources will differ between operations. The transformed resources are the elements which give the operations system its purpose and goal. The operations system is concerned with converting the transformed resources from inputs into outputs in the form of goods and services. There are three main types of transformed resource of materials which can be transformed

either physically (e.g. manufacturing), by location (e.g. transportation), by ownership (e.g. retail) or by storage(e.g. Warehousing)

These sub systems are present in all the 4 major sections. They are centrally controlled by the Plant Management Office (PMO).The PMO controls the central decision making and is responsible for running all the departments in sync. The PMO ensures that the decisions made by the departments do not contradict and a healthy harmony is maintained so that all of them work together as a part of a system.

Thus we see how systems view in operations can be put to a practical use. The idea behind systems model is that the operations function can concentrate solely on transforming input of raw material into goods and services without considering the external environment. The systems view gives a very simplified view of the company and thus helps us in understanding the basic processes in a company. We can see what arethe major areas of attention in a company and helps us in understanding the hierarchy and layout of an organization.

1.12. THE OPERATIONS FUNCTION:

Activities in operations management (OM) include organizing work, selecting process, arranging layouts, locating facilities, designing jobs, measuring performance, controlling quality, scheduling work, managing inventory, and planning production. Operations managers deal with people, technology, and deadlines. These managers need good technical, conceptual, and behavioral skills. Their activities are closely intertwined with other functional areas of a firm.

The four primary functional areas of a firm are marketing, finance, operations, and human resources. For most firms, operations is the technical core or “hub” of the organization, Interacting with the other functional areas and suppliers to produce goods and provide services for customers. For example, to obtain monetary resources for production, operations provides finance and accounting with production and inventory data, capital had getting requests, and capacity expansion and technology plans. Finance pays workers and suppliers, performs cost analyses, approves capital

investments, and communicates requirements of shareholders and financial markets. Marketing provides operations with sales forecasts, customer orders, customer feedback, and information on promotions and product development. Operations, in turn, provides marketing with information on product or service availability, leadare estimates, order status, and delivery schedules. For personnel needs, operations relies on human resources to recited, train, evaluate, and compensate workers and to assist with legal issues, job design, and union activities. Outside the organization, operations interacts with suppliers to order materials or services, communicate production and delivery

1.13. LONG-TERM VERSUS SHORT-TERM ISSUES:

Another useful approach to understanding the various operations management functions is to view them from the planning horizon perspective. Certain operations decisions are made once every five to ten years. For example, the decision to locate a manufacturing or service delivery facility is made as and when a new facility is to be introduced. Similarly, product line decisions and capacity augmentation decisions are made once every three to five years. Typically, a majority of design decisions are made with a planning horizon of five to ten years. Such decisions usually require a long lead time, multiple levels of decision-making and huge capital outlay. Therefore, they tend to be made at less frequent intervals.

Some other decisions are made in fixed cycles of one year. Every organization makes a business plan coinciding with its financial year, wherein specific targets for sales are established. The annual business planning exercise leads to aggregate production planning. Once the aggregate production planning is done, master production scheduling and material and capacity requirements planning are done for the next quarter or three months. These are medium-term decisions. Finally, several operations management decisions are made for a short run of a week or less. These decisions include detailed scheduling of operations, quality management and control, and reacting to disruptions and changes in plans.

Long term :

i) Product design
ii) Quality policy
iii) Technology to be employed
iv) Process selection
v) Site selection
vi) Machinery and plant / facility selection
vii) Plant/facility size selection-phased addition
viii) Man power training and development-phased programme
ix) Long – gestation periodic raw material supply projects- phased development
x) Warehousing arrangements
xi) Insurance spares
xii) Design of jobs
xiii) Setting up work standards
xiv) Safety and maintenance system
xv) Supply chain and outsourcing

Short term:

i) Production/operation scheduling
ii) Available materials allocation
iii) Scheduling of manpower
iv) Breakdown maintenance
v) Progress check and change in priorities in production/ operation scheduling
vi) Temporary manpower
vii) Supervision and inmate attention to problem areas in labour, materials, machines etc.,

1.14. OPERATIONS TODAY:

Advances in information technology and global competition have had a major influence on operations management. While the Internet offers great potential for business organizations, the potential as well as the risks must be clearly understood in

order to determine if and how to exploit this potential. In many cases, the Internet has altered the way companies compete in the marketplace.

Electronic business, or e-business, involves the use of the Internet to transact business. E-business is changing the way business organizations interact with their customers and their suppliers. Most familiar to the general public is e-commerce, consumer-business transactions such as buying online or requesting information. However, business-to-business transactions such as e-procurement represent an increasing share of e-business. E-business is receiving increased attention from business owners and managers in developing strategies, planning, and decision making

The word technology has several definitions, depending on the context. Generally, ire Technology The application of technology refers to the application of scientific knowledge to the development and improve of scientific knowledge to mean of goods and services. It can involve knowledge, materials, methods, and equipment, development and improve The term high technology refers to the most advanced and developed machines and methods meant of products and service Operations management is primarily concerned with three kinds of technology: product and service technology, process technology, and information technology (IT). All three can have a major impact on costs, productivity, and competitiveness, and operations processed.

Product and service technology refers to the discovery and development of new products and services. This is done mainly by researchers and engineers, who use the scientific approach to develop new knowledge and translate that into commercial applications. Process technology refers to methods, procedures, and equipment used to produce goods and provide services. They include not only processes within an organization but also supply chain processes, Information technology (IT) refers to the science and use of computers and other electronic equipment to store, process, and send information. Information technology is heavily ingrained in today's business operations. This includes electronic data processing, the use of bar codes to identify and track goods, obtaining point-of-sale information, data transmission, the Internet, e-commerce, e-mail, and more.

Management of technology is high on the list of major trends, and it promises to be high well into the future. For example, computers have had a tremendous impact on businesses in many ways, including new product and service features, process management, medical diagnosis, production planning and scheduling, data processing, and communication. Advances in materials, methods, and equipment also have had an impact on competition and productivity Advances in information technology also have had a major impact on businesses. Obviously there have been and will continue to he many benefits from technological advances. How- ever, technological advance also places a burden on management. For example, management must keep abreast of changes and quickly assess both their benefits and risks. Predicting advances can be tricky at best, and new technologies often carry a high price tag and usually a high cost to operate or repair. And in the case of computer operating systems, as new systems are introduced, support for older versions is discontinued, making periodic upgrades necessary. Conflicting technologies can exist that make technological choices even more difficult Technological innovations in both products and processes will continue to change the way businesses operate, and hence require continuing attention.

1.15. KEY ISSUES FOR TODAY'S BUSINESS OPERATIONS

There are a number of issues that are high priorities for many business organizations. Although not every business is faced with these issues. Chief among the issues are the following

Economic conditions: The lingering recession and slow recovery in various sectors of the economy has made managers cautious about investment and rehiring workers who had been laid off during the recession

Innovating: Finding new or improved products or services are only two of the many possibilities that can provide value to an organization, Innovations can be made in processes, the use of the Internet, or the supply chain that reduce costs, increase productivity. Expand markets, or improve customer service

Quality problems: The numerous operations failures mentioned at the beginning of the chapter underscore the need to improve the way operations are managed. That relates to product design and testing, oversight of suppliers, risk assessment, and timely spouse to potential problems.

Risk management: The need for managing risk is underscored by recent events that include financial crises, product recalls, accidents, natural and man-made disasters, and economic ups and downs. Managing risks starts with identifying risks, assessing ability and potential damage (liability cost, reputation, demand), and taking steps to reduce or share risks

Cyber-security: The need to guard against intrusions from hackers whose goal is to steal personal information of employees and customers is becoming increasingly necessary. Moreover, interconnected systems increase intrusion risks in the form of industrial espionage

Competing in a global economy, Low labor costs in third-world countries have increased pressure to reduce labor costs. Companies must carefully weigh their options, which include outsourcing some or all of their operations to low-wage areas, reducing costs internally, changing designs, and working to improve productivity.

Three other key areas require more in-depth discussion: environmental concerns, ethical conduct, and managing the supply chain.

1.16. OPERATIONS MANAGEMENT CHALLENGES:

The speed of business and the pace of developing technologies seem only to quicken. Add to that the ongoing fallout from the COVID-19 pandemic, such as the continued supply chain gridlock, shifting attitudes about how employees prefer to work, and the ever-present challenge of becoming more agile, and you have an operations management landscape rife with the possibility of change and innovation. The current trends in operations management also reveal some challenges the industry is facing.

1.17. CURRENT TRENDS IN OPERATIONS MANAGEMENT:

Many leaders in the operations management industry would argue it is imperative to initiate significant changes to address current trends and mitigate an unprecedented collection of challenges, all while remaining competitive. How well leaders address issues such as incorporating cutting-edge technology, committing to sustainability, and managing both the Great Resignation, and the needs of remote workers, may dictate how long they stay in business. Operations managers across industries are grappling with innovating around these trends and challenges.

Technology

Innovative technology is continuing to change the way we work, shop, and live at a breakneck pace. In 2023, companies across industries will need to embrace these new technologies to stay competitive. One of the most exciting trends in technology is artificial intelligence (AI) and machine learning. Here are examples of three companies and how they are innovating their business with this technology.

Artificial Intelligence and Machine Learning

Artificial intelligence (AI) is the ability of a computer, or machine, to perform tasks usually requiring human intelligence such as learning, problem-solving, and decision-making. Machine learning is a subset of AI involving the use of algorithms and statistical models to enable computers to “learn” from data without being explicitly programmed to do so. AI and machine learning have had a transformative effect for businesses poised to take advantage of these technological innovations. While this technology has been used for some time, it is always improving and now more companies are undertaking initiatives to incorporate it into their overall operations. Consider the following three companies and how they continue to innovate with AI and machine learning.

Yelp – Yelp is a website that allows people to search for all manner of local business such as restaurants, hotels, doctors, gyms, and spas. “Yelp uses machine

learning to figure out what the most popular dishes are at a restaurant based on what gets photographed and written about the most" (Firebolt, 2022).

Amazon –Amazon relies heavily on AI and machine learning. "Amazon uses machine learning for many of its retail-oriented tasks, such as product recommendations, forecasting, data cleansing, and capacity planning" (Brewster, 2022).

Alibaba – This Chinese company, is the world's largest e-commerce platform selling more than Amazon and ebay combined. In addition to using AI for customer preferences and predictions, Alibaba uses AI for it's City Brain project to create smart cities. "The project uses AI algorithms to help reduce traffic jams by monitoring every vehicle in the city. Additionally, Alibaba, through its cloud computing division called Alibaba Cloud, is helping farmers monitor crops to improve yield and cuts costs with artificial intelligence" (Mar, 2021).

Sustainability:

Reducing our individual and collective carbon footprint is essential for protecting our environment and ensuring natural resources for future generations. From a business perspective, incorporating sustainability is also important for reducing operating costs and improving their reputation and relationship with consumers. Consumers are becoming increasingly concerned about the state of the environment and are using their dollars to support companies who consider the environmental and social impact of how they manufacture, sell, and deliver products and services. Consider these two examples of companies committing to sustainable practices.

Honda, GM, and Ford – In order to reduce carbon emissions, these car manufacturers continue to widen their ability to manufacture electric vehicles. "In April of 2022, Honda and GM expanded a manufacturing partnership to develop affordable electric vehicles in 2027. GM has also stated their ambition to sell only zero-emissions cars and trucks by 2035, while Ford and Volkswagen have announced a similar partnership to jointly manufacture a state of new electric vehicles in the coming years" (Wework, 2022).

Amcor – Amcor is a global leader in developing and producing responsible packaging for a range of products including: food, beverage, pharmaceutical, medical and personal-care products. Amcor is committed to “develop all packaging to be recyclable or reusable by 2025. They also pledged to significantly increase their use of recyclable materials and drive more recycling od packaging around the world” (Absorb Tech, 2022).

The Great Resignation

Texas A&M University Mays Business School management professor, Anthony Klotz, coined the Great Resignation to describe the mass exodus of employees across industries who were, and are, leaving their jobs. A record 4.5 million workers quit their jobs in March 2022 (U.S. Department of Labor, 2022). Although national resignations have been on the rise for several years, the COVID-19 crisis exacerbated this issue. Professionals are now re-evaluating their employers and how, when and where they prefer to work.

The Great Resignation is still happening, and operations managers feel pressure to do more with fewer people. Training, coaching, and motivating employees to improve retention and operational efficiency initiatives is challenging. This confluence of factors can lead to managerial burnout. Executives are under pressure to figure out how to innovate to support retention and performance for both their managers and front-line workers.

“Some employees are tired and want a renewed sense of purpose, belonging, and connection with people. Others want better pay, benefits, and perks. Meanwhile, the entrepreneurial among us want to take control, strike out on their own, and put newfound skills to work. As an employer, understanding what employees are running from can provide answers to stem the “Great Resignation” and help attract new talent” Wolterskluwer, 2022.

In an effort to stop employees from leaving, employers are trying to think differently about what their workers need and what might make them stay. Some of these initiatives include offering:

- Free food and/or free gym memberships.
- The ability to flex time or work a shorter week.
- A culture supportive of working from home
- Access to more and better health and mental health benefits
- Professional development opportunities
- Before offering new initiatives, it is incumbent upon employers to find out what their employees' value, need, and/or want so they can help them to reset and recommit to their organization.

Remote Work

The pandemic forced many people to work from home, and after doing so for almost two years, many are resistant to returning to office life. To maintain a competitive advantage, companies must figure out how to support their operations more efficiently and effectively when relying on remote workers. Some of the challenges or concerns for employers with remote workers are:

- Lack of face-to-face supervision
- Lack of effective communication
- Employee isolation
- Boundary blurring between work life and home life

There are several initiatives employers can take to mitigate some of their worries about using remote workers. Here are some ideas:

- Encourage regular communication and collaboration by making sure all remote employees have access to the tools and technologies to stay in touch with their colleagues and supervisors; this can include video calls and sharing project management tools.

- Offer opportunities for social interaction such as virtual happy hours and/or team-building activities which can help in reducing isolation and loneliness.
- Help remote workers stay focused and motivated by providing support, guidance, and frequent opportunities for feedback.
- Model a healthy work-life balance by taking frequent breaks, keeping regular hours, and setting clear boundaries between work time and home time.

1.18.PRODUCTION DESIGN AND PROCESS PLANNING:

Production processes are designed to produce the required quantity of goods of the desired quality, at the right time, and at minimal costs. Process design helps develop a detailed plan for manufacturing products or services, and provides the foundation and structure for production operations. Decisions regarding the selection of a process design for producing a product or a service are influenced by many factors such as the nature of demand for the product, the degree of vertical integration, product and volume flexibility, the degree of automation, the quality level required, and the degree of customer contact involved.

Process designs are basically of three types: product-focused, process-focused, and group technology. In product-focused production systems, the material flow is linear without any backtracking or sidetracking. They are

Organized by the type of product or service being produced. They are primarily designed for high-volume and standardized products. Process-focused systems are designed for low-volume, small batch and customized products and are used mostly by processing industries. In a group technology layout, dissimilar machines are grouped into work centers to work on products similar in shape and processing requirements. It also identifies families of parts with common characteristics that are produced in larger batches and gives them a common code.

1.19. TYPES OF PRODUCTION

The production system (facility, equipment's and operating methods) that a company use depends upon the type of the product that is offered to the customer and the strategy that it employs to serve its customers.

Basically, production system can be categorized as:

Make to Stock Production

In this system, manufacturer stocks the finished goods (products) in inventory for immediate shipment. This system ensures intermediate delivery of good quality, reasonably priced, off the shelf standard products. For example, automobile bearings, ready to wear garments, nuts and bolts, motors, televisions etc. Normally, the customer does not accept delay in delivery and the management is required to maintain adequate stock of finished products. This system implies the manufacture of products based on a well-known and predictable demand pattern. Operations management focuses entirely on replenishment of inventory, actual customer orders cannot be identified in the production process. The production volume of each sales units tends to be high and customer's delivery time is usually determined by the availability of finished goods inventory. The finished goods inventory acts as a buffer against uncertain demand and stock out situations. The main advantage of this system being the short delivery time and the limitations being high costs of inventory and inability to express customer preference for the design of the product.

Situations for Make to Stock Production are:

1. Fairly constant and predictable demand.
2. Products are few and they are standardised.
3. Shorter delivery time expected by the customers
4. Products having higher shelf life.

Information needed to make a production plan is as follows:

5. Forecasted demand for the planning period.
6. Starting inventory level.

7. Desired ending inventory level.
8. Any previous orders to be fulfilled (back orders).

Total Production=Forecasted demand+Backorders+Endinginventory-OpeningInventory

Make to stock items are generally mass consumed and pass through multiple channels before reaching the end user. Most of the data about customers is not known and hence, feed back from distribution channel will act as an important source of information. Demand is also calculated from these channel members and aggregated for production purpose.

This system is characterized by less complex production, process and product standardization and fairly constant production rate. Distribution system is critical and integration of production and distribution is essential to keep a stable flow of products at the point of consumption and should be responsive to any change. As there is no one to one contact between producer and the customer, distribution system acts as eyes and ears of organization to support demand forecasting and demand analysis

Make to Order

Some companies make or manufacture products after the receipt of the firm order from the customer. Here the production activities will be initiated only after the confirmation of the orders and the products are not supplied from the stock and hence the lead time (the time between ordering theProduct and delivery) is long.

Make to order production system describes a manufacturing facility in which their Product order already designed but may include some custom designally made to parts of the base components available along with the engineering designs component not completely specified. The order processing cycle begins when the customer specters his requirements of the product. The manufacturer also sometimes assists the customers to prepare product specifications.

Made to order is a demand responsive strategy, and only the product and component designs and scene standard raw material and components are held in stock.

Examples are, custom tailored clothing special purpose machinery and product made to customer specifications. Very expensive products are usually made to order.

Situations for make to order productions are,

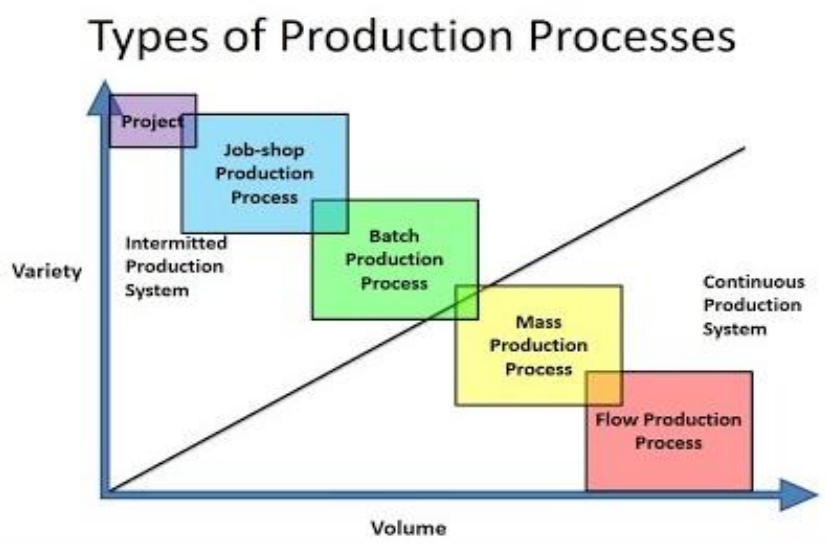
1. Products are manufactured to customer specifications
2. Customer can wait till the order is being processed (longer delivery schedule).
3. Product is nonstandard and expensive to store.
4. When there are several product options available to store.

In make to order production system, there is a direct interaction with customers during all the stages but it is extensive during engineering phase. Manufacturer quotes delivery schedule and price and there is a discussion among the customer and producer regarding alternatives to reduce cost, reduce time to deliver.

In make to order situations, production schedule changes with changes in customer orders from one period to another. In this system, producers build large capacities in anticipation and capacity utilization is lower as compared to make to stock situation. Capacity requirements planning and shop floor control are critical and distribution is less complicated.

Assemble-to-Order Production System

When number of alternative combinations or options is available to customers as in automobiles, consumer electronics and computers and customer is not ready to wait until product is made, manufacturers produce and stock standard component parts. When the customer places the order, the customer does the assembly from the parts/ components selected. Since the components are manufactured and stocked, the only the time to assemble is needed before delivering product to the customer. The modular parts approach strategy is normally used here. The assemble to order system aims to combine product customization/ variety of make to order system with low cost and shorter lead-time.



1.20. CLASSIFICATION OF PRODUCTION SYSTEM:

JOB SHOP PRODUCTION:

Job shop production arecharacterized by manufacturing of one or few quantity of products designed and produced as per the specification of customers within prefixed time and cost. The distinguishing feature of this is low volume and high variety of products. A job shop comprises of general purpose machines arranged into different departments. Each job demands unique technological requirements, demands processing on machines in a certain sequence.

Characteristics of the Job-shop production system is followed when there is:

1. High variety of products and low volume.

2. Use of general purpose machines and facilities.

3. Highly skilled operators who can take up each job as a challenge because of uniqueness.

4. Large inventory of materials, tools, parts.

5. Detailed planning is essential for sequencing the requirements of each product, capacities for each work center and order priorities.

Following are the advantages of job shop production:

1. Because of general purpose machines and facilities variety of products can be produced.

2. Operators will become more skilled and competent, as each job gives them learning opportunities

. 3. Full potential of operators can be utilized.

4. Opportunity exists for creative methods and innovative ideas.

Following are the limitations of job shop production:

1. Higher cost due to frequent set up changes.

2. Higher level of inventory at all levels and hence higher inventory cost.

3. Production planning is complicated.

4. Larger space requirements

BATCH OR INTERMITTENT PRODUCTION:

Batch production is defined by American Production and Inventory Control Society (APICS) "as a form of manufacturing in which the job passes through the functional departments in lots or batches and each lot may have a different routing." It is characterized by the manufacture of limited number of products produced at regular intervals and stocked awaiting sales.

Characteristics of Batch production system is used under the following circumstances:

1. When there is shorter production runs.

2. When plant and machinery are flexible.

3. When plant and machinery set up is used for the production of item in a batch and change of set up is required for processing the next batch.

4. When manufacturing lead time and cost are lower as compared to job order production.

Following are the advantages of batch production:

1. Better utilization of plant and machinery.
2. Promotes functional specialization.
3. Cost per unit is lower as compared to job order production.
4. Lower investment in plant and machinery.
5. Flexibility to accommodate and process number of products.
6. Job satisfaction exists for operators.

Following are the limitations of batch production:

1. Material handling is complex because of irregular and longer flows.
2. Production planning and control is complex.

MASS PRODUCTION:

Manufacture of discrete parts or assemblies using a continuous process are called mass production. This production system is justified by very large volume of production. The machines are arrangedin a line or product layout. Product and process standardization exists and all outputs follow thesame path.

Characteristics of Mass production is used under the following circumstances:

1. Standardization of product and process sequence.
2. Dedicated special purpose machines having higher production capacities and output rates.
3. Large volume of products.
4. Shorter cycle time of production.

5. Lower in process inventory.

6. Perfectly balanced production lines.

7. Flow of materials, components and parts is continuous and without any back tracking.

8. Production planning and control is easy

. 9. Material handling can be completely automatic.

Following are the advantages of mass production:

1. Higher rate of production with reduced cycle time.

2. Higher capacity utilisation due to line balancing.

3. Less skilled operators are required.

4. Low process inventory.

5. Manufacturing cost per unit is low.

Following are the limitations of mass production:

1. Breakdown of one machine will stop an entire production line.

2. Line layout needs major change with the changes in the product design.

3. High investment in production facilities.

4. The cycle time is determined by the slowest operation

CONTINUOUS PROCESS OR FLOWPRODUCTION:

Production facilities are arranged as per the sequence of production operations from the first operations to the finished product. The items are made to flow through the sequence of operations through material handling devices such as conveyors, transfer devices, etc.

Characteristics of Continuous production are used under the following circumstances:

1. Dedicated plant and equipment with zero flexibility.
2. Material handling is fully automated.
3. Process follows a predetermined sequence of operations.
4. Component materials cannot be readily identified with final product.
5. Planning and scheduling is a routine action.

Following are the advantages of continuous production:

1. Standardisation of product and process sequence.
2. Higher rate of production with reduced cycle time.
3. Higher capacity utilisation due to line balancing.
4. Manpower is not required for material handling as it is completely automatic.
5. Person with limited skills can be used on the production line.
6. Unit cost is lower due to high volume of production.

Following are the limitations of continuous production:

1. Flexibility to accommodate and process number of products does not exist.
2. Very high investment for setting flow lines.
3. Product differentiation is limited.

The Project

A project refers to the process of creating a complex one-of-a-kind product or service with a set of well-defined tasks in terms of resources required and time phasing. Some

examples of projects are:dam constructions, starting new industries, fabricating boilers, Aircraft , ship building and so on.

1.21. PLANT CAPACITY:

Plant capacity also referred to as production capacity refers to the volume or number of units that can be manufactured during a given period. Several factors have a bearing on the capacity decision.

Technological requirement: For many industrial projects, particularly in process type industries, there is certain minimum economic size determined by the technological factor.

Input constraints: In a developing country like India, there may be constraints on the availability of certain inputs. Power supply may be limited, basic raw materials may be scarce, foreign exchange available for imports may be inadequate. Constraints of these kinds should be borne in mind while choosing the plant capacity.

Investment cost :when serious input constrains does not obtain the relationship between capacity and investment cost is an important consideration. Typically, the investment cost per unit of capacity decreases as the plant capacity increases. This relationship may be expressed as follows

Examples suppose the known investment cost for 5,000 units of capacity for the manufacture of a certain item is Rs 10, 00,000. What will be the investment cost for 10,000 units of capacity if the capacity – cost factor is 0.6.

The derived investment cost for 10,000 units of capacity may be obtained as follows:

- C1 = 10, 00,000 * (10,000/5,000)0.6 = Rs 15, 16,000

Marketconditions: The anticipated market for the product or service has an important bearing on plant capacity. If the market for the product is likely to be very strong, a plant of higher capacity is preferable. If the market is likely to be uncertain, it

might be advantageous to start with a smaller capacity. If the market, starting from a small base, is expected to grow rapidly, the initial capacity may be higher than the initial level of demand- further additions to capacity may be affected with the growth of market.

Resourcesof the firm: The resources, managerial and financial, available to a firm define a limit on its capacity decision. Obviously, a firm cannot choose a scale of operations beyond its financial resources and managerial capacity.

Government policy: The capacity level may be influenced by the policy of the government.

1.22. CAPACITY PLANNING:

Capacity planning is the process of evaluating all available production resources, including machinery, staffing, and work centers to understand if the manufacturer will be able to meet customer demand now and in the future.

An important subset of capacity planning is resource capacity planning, which is the process of deciding how to optimize the function of existing resources, which resources to add, and which resources to downgrade or remove.

There are many key factors directly affecting capacity planning in operations management. We'll cover those in more detail below, but first, we'll look at why capacity planning is so important.

Importance of Capacity Planning

Capacity planning is important in making sure that everybody is working to their full potential.What you also need to understand is that capacity planning works in estimates too, not actuals. By this we mean, a capacity plan not only looks at where your business is right now in terms of the workload you are facing but also where it is likely to be in the future. This is important because business managers might look at

their actual workload and reduce the workforce because there seem to be too many outgoing expenses in terms of wages, and not enough income in terms of orders from customers. The problem with this approach is that it can often turn out to be a rash decision that will cost the business in the long term. With a smaller workforce, you may be unable to handle more work when it eventually comes your way again. Capacity planning can help you there.

Factors Affecting Capacity Planning

Just about every element of your production environment needs to be taken into account for effective capacity planning. Even factors that don't seem important can impact operational efficiency. For example, many manufacturers have discovered that seemingly irrelevant factors like office decor and layout can impact worker productivity. This means that a factory with offices or breakrooms that are decorated in an attractive matter and laid out in a way that facilities effective communication can actually inspire the workforce to be more productive and improve capacity across the board.

Away from your business facilities, you'll also need to consider the product or service you offer. Variety is the spice of life, but too much in terms of what your business offers and output will be slowed down. How streamlined your business is in terms of what you offer customers will directly affect how quickly and how efficiently you can get things done.

One challenge that production schedulers have is keeping track of all the factors that impact capacity planning. This can be readily remedied with a next generation scheduling software like Optessa. Optessa allows schedulers to configure all capacity constraint factors in seconds, without custom coding. This advanced planning and scheduling system will then consider all these constraints when creating the production schedule and optimize operational capacity with patented algorithms.

Types of Capacity Planning:

Capacity planning determines the production capacity needed by an organisation to meet changing demands for its products or services. The purpose of capacity planning is to ensure that the necessary resources are available when they are needed.

Resource Capacity Planning

Resource capacity planning determines the number of resources (e.g. machines, labour, materials) required to meet future demand. It is a crucial part of operations management as it ensures that the necessary resources are available when they are needed. With resource capacity planning, organisations can avoid over-utilisation or under-utilisation of resources, leading to inefficiencies and higher costs. Most organisations use capacity planning operations management to calculate future production capacity needs.

Benefits of Resources Capacity Planning:

Avoid over-utilisation or under-utilisation of resources: Capacity planning helps organisations avoid over-utilisation or under-utilisation of resources, leading to inefficiencies and higher costs.

Improve decision making: Capacity planning helps in creating a clear and concise understanding of production capacity needs. Organisations can invest in the right resources by understanding future capacity requirements and better using their existing resources.

Reduces production costs: Capacity planning assists in reducing production costs by ensuring that the necessary resources are available when they are needed. By avoiding over-utilisation or under-utilisation of resources, organisations can save on costs such as labour, materials, and energy.

Helps to meet future demand: Capacity planning helps to ensure that the necessary resources are available when they are needed. Organisations can invest in the right resources by understanding future capacity requirements and better using their existing resources.

Project Capacity Planning:

Project capacity planning is determining the amount of work a team can complete within a specific time frame. This process includes estimating the number and type of resources required and the amount of time needed to complete the project.

Operations management capacity planning is the process of determining the amount of work that an organisation can complete within a specific time frame. This process includes estimating the number and type of resources required and the amount of time needed to complete the project.

With capacity planning, organisations can better understand the resources required to complete a project and plan for future projects accordingly. This process can also help identify potential bottlenecks and capacity constraints within the organisation.

Overall, capacity planning is a critical process in operations management that can help organisations optimise their resources and better plan for future projects

Benefits of Project Capacity Planning

Improved resource utilisation: By understanding the resources required to complete a project, organisations can better utilise their resources and avoid over- or under-utilisation.

Increased efficiency: Capacity planning can help identify potential bottlenecks and capacity constraints within the organisation, leading to increased efficiency.

Better project planning: With capacity planning, organisations can better plan for future projects by understanding the resources and time required to complete the project

Team Capacity Planning

Team capacity planning is the process of matching your team's capacity to the amount of work that needs to be done. This planning ensures that you have the right number of people with the right skills to work on different objectives.

Operations management capacity planning is a bit different. In operations capacity planning, you are trying to match the capacity of your resources to the demand for your product or service. This includes things like machines, materials, and labour. The goal is always looking for the right amount of capacity to meet customer demand without overproducing or underproducing.

There are a few different capacity planning methods, but they all have the same goal: to ensure you're meeting customer demand without overspending on capacity. The most common forms are capacity utilisation, bottleneck analysis, and capacity planning tools.

Benefits of Team Capacity Planning

Improved communication between managers and employees: Capacity planning helps ensure everyone is on the same page regarding capacity. This can help to avoid miscommunication and misunderstanding.

Better utilisation of resources: Capacity planning can help ensure you're using your resources in the most efficient way possible. It is beneficial to expedite your growth towards success.

More clarity on the work: Capacity planning can help to give you a clear picture of work to be done to meet customer demand. This can help you to prioritise and stay organised.

HR Capacity Planning:

` HR capacity planning is the process of forecasting future demand for human resources and designing a plan to meet that demand. HR capacity planning aims to

ensure that an organisation has an adequate number of employees with the right skills to reach the business objectives.

Operations management capacity planning is critical, as it helps organisations avoid both understaffing and overstaffing. Understaffing can lead to decreased productivity and quality while overstaffing can lead to increased costs.

The first step in HR capacity planning is forecasting future human resource demand. It can be done using different methods, including trend analysis, market research, and customer surveys. Once the future demand has been forecasted, the next step is to design a plan to meet that demand.The plan should consider the number of employees needed, the skills they will need to possess, and the locations they will need to be in. The goal is to have the right number of employees with the right skills in the right place at the right time.

Benefits of HR Capacity Planning:

- **Helps organizations avoid understaffing and overstaffing:** As mentioned above, capacity planning helps organizations avoid the negative consequences of both understaffing and overstaffing.
- **Increases productivity and quality:** By ensuring that the right number of employees with the right skills are in the right place at the right time, capacity planning can help increase productivity and quality.
- **Decreases costs:** By avoiding the need to hire and train new employees, capacity planning can help decrease costs.
- **Ensures the right workforce:** By forecasting future demand and designing a plan to meet that demand, capacity planning can help ensure that an organization has the right workforce.

Capacity Planning Process:

Operations managers use capacity planning to forecast future demand for a company's products or services and ensure the necessary resources are available when demand increases.

Step One: Determine Current Capacity

The first step is to determine the current capacity of the company's resources. It is about determining how much output the company can currently produce with its existing resources. Current capacity will be affected by factors such as the number of employees, available space, and the type of equipment being used.

Step Two: Forecast Future Demand

The second step is forecasting future demand for the company's products or services. This includes estimating how much demand will increase in the future and what new products or services the company will need to meet this demand.

Step Three: Identify Gaps in Capacity

The third step is to identify any gaps in capacity. It is about identifying any areas where the company's resources will be unable to meet future demand. The gaps may be due to a lack of employees, space, or equipment. With capacity planning, operations managers can identify these gaps and take steps to address them.

Step Four: Develop a Plan to Fill the Gaps

The fourth step is to develop a plan to fill the gaps in capacity. It involves hiring new employees, renting additional space, or purchasing new equipment. By creating a plan to address the capacity needs of the company, operations managers can ensure that the company is prepared for future demand.

Step Five: Implement the Plan

The final step is to implement the capacity planning process. It puts the plan into action and ensures all the necessary resources are in place. By following the capacity planning process, operations managers can ensure that their company is prepared for future growth.

Capacity Planning Help in Operations Management

Capacity planning help operations management is a crucial part of operations management. It ensures that an organisation has the necessary resources to meet its demand. By understanding the capacity of both the organisation and its resources, capacity planning can help avoid problems such as overproduction or underutilisation of resources.

There are two main types of capacity planning: strategic and tactical. Strategic capacity planning is long-term and looks at an organisation's overall direction and goals. Tactical capacity planning is shorter-term and looks at how to best use an organisation's resources.

Both types of capacity planning are essential for ensuring that an organisation's resources are best used to meet its goals. Capacity planning can help avoid problems such as overproduction or underutilisation of resources.

When planning capacity, it is essential to consider the organisation's short-term and long-term needs. By considering the big picture and the specifics, capacity planning can help ensure that an organisation possesses all the resources to meet its goals.

The absence of capacity planning can lead to a number of problems, such as:

- **Overproduction:** This occurs when capacity exceeds demand. This can lead to wasted resources and excess inventory.
- **Underutilization:** It is a situation where capacity is less than demand leading to lost sales and unhappy customers.
- **Poor utilization:** This occurs when capacity is not used efficiently leading to wasted resources and inefficient operations.

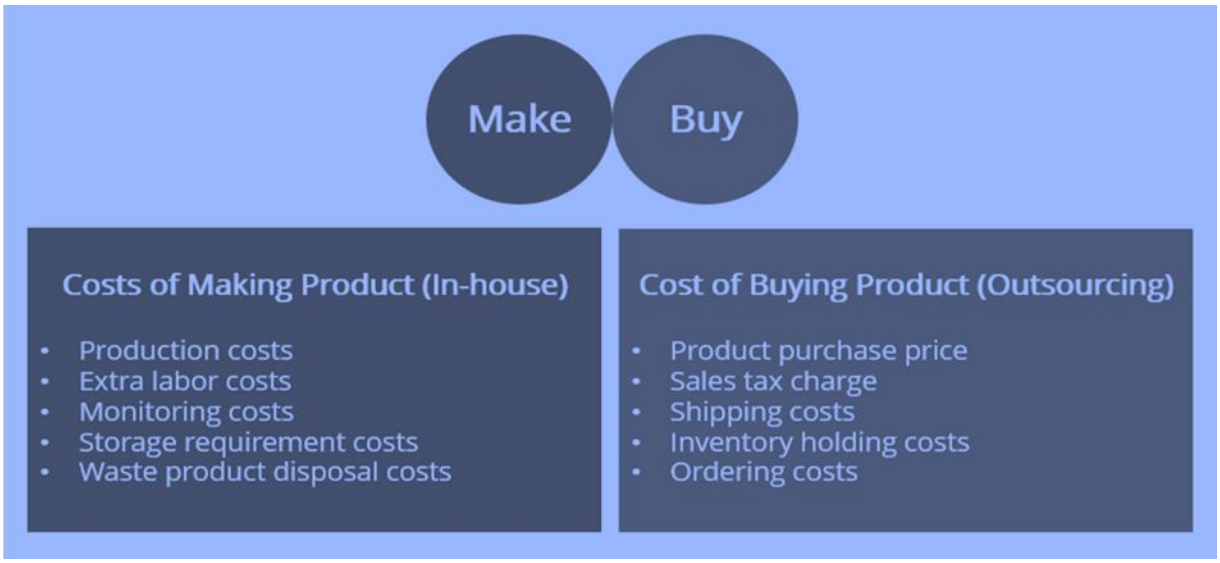
The Bottom Line

Operations capacity planning is the process of determining the number of resources required to meet future demand. It is a vital part of ensuring that an organisation can meet its goals and objectives. By understanding capacity requirements, organisations can better utilise their resources and avoid problems associated with over or under capacity.

1.23.MAKE OR BUY DECISION:

A Make or Buy Decision refers to a decision made to either manufacture a product/ service in house or buy it from outside suppliers (outsourcing) based on cost-benefit analysis. This decision is made using quantitative or qualitative research and most of the time, the results of quantitative analysis (cost-benefit analysis) are enough to decide on whether to make the product in-house or buy (outsource) from outside suppliers.

Whether an entity or economy decides to buy a product or service from external sources or manufacture it at its own unit completely depends on the expenses involved. If the manufacturing costs involved seem fine with respect to the benefits the products offer, the entities agree to manufacture it, else they prefer buying it from other entities or nations.



The Make or Buy decision applies to both goods and services. Businesses compare the cost and benefits of producing the goods or services within the company and the cost and benefits of getting an outside supplier to supply the goods and services into consideration. The value here must include all the fees associated with manufacturing (including material, labor, cost of machinery and space), storing, moving,

taxes, etc. and the corresponding benefits must include benefits in terms of increased margins (for in-house production) or low capital requirement (for outsourcing).

The analysis of make or buy decisions:

Under quantitative analysis, businesses consider all the costs associated with producing the product or service in-house. These costs include buying and maintaining equipment, cost of the premises (lease, etc.), raw material cost, conversion cost, cost of fuel and electricity, labor cost, warehousing or storage cost, shipping cost, and the cost of capital. The benefits include higher margins from in-house production.

The cost associated with outsourced production includes the product and service, transportation, warehousing, and storage and labor costs for managing the logistics.

The decision becomes a little straightforward if the company does not have an idle capacity to produce the product or service. In this case, the management can opt to hire an outside supplier considering that it is not of critical importance, and the firm's intellectual property is not endangered.

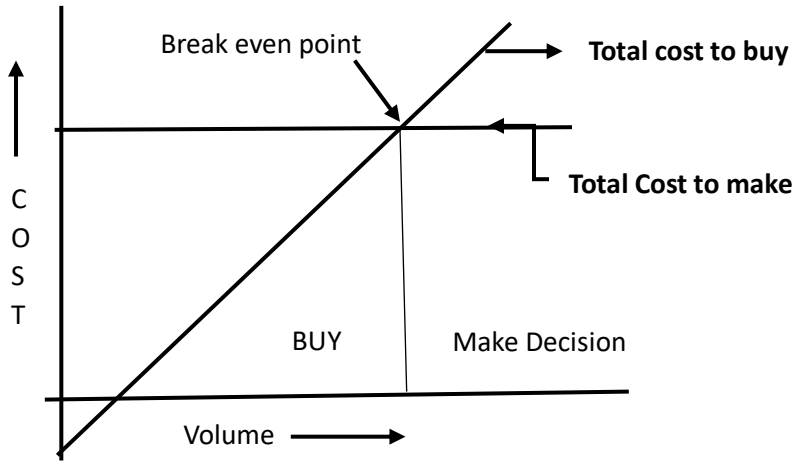
Considering the company has the idle capacity, and it is already incurring a large part of fixed expenses, it can choose to manufacture in the house if the marginal cost of manufacturing is less than what it will cost to buy from outside suppliers.

The make or buy decision should be taken with utmost care keeping the long-term and short-term benefits into consideration. There are pros and cons to both making and purchasing; however, generally, businesses tend to outsource functions where they do not have a core competency or when the cost of procuring the components or services from outside suppliers is significantly cheaper.

There are multiple factors that make individuals, entities, and economies assess what option would be better for them – to make themselves or to buy from other manufacturers. When the entities decide to make a product or offer a service

themselves, they inspect various aspects and assess the cost involved in conducting the manufacturing or production procedure. If the expenditure seems worthy of the benefits and usage frequency of items, the countries decide to do it by themselves.

On the other hand, if entities or nations find out that the benefits and usage frequency do not require them to invest so much into the production or manufacturing of items, they find it better to have an external source hired for the items.



Make Decision:

The following are the major factors considered while deciding to make the good or service in-house.

Cost concerns are one of the most important factors. If the businesses find it too expensive to outsource the manufacturing or production activities, they skip the buy idea and manufacture the products themselves.

Their desire to enhance the manufacturing focus inspires them to manufacture their own products.

Most businesses fear their intellectual belongings being roped. Such concerns disallow them to outsource processes.

Many times, businesses are not sure of the quality the outsourcing company would offer. Any tampering with the quality directly hampers a business' image or a nation's image. The quality concerns, therefore, forbid them to buy from others.

Not all suppliers are reliable. This is a reason enough to not trust a third party.

The need for direct quality control over the product. When there is another unit working on the manufacturing of the products, the main business loses supervision control, which may affect the quality of the products and services offered.

The absence/shortage of competent suppliers can be yet another reason.

The volume of product required might not be significant enough for a prospective supplier to take orders.

When the shipping and transportation costs are reasonable enough to handle, companies prefer making products rather than buying them from an external business.

Besides the above-mentioned major reasons, there can be other factors too affecting the make or buy decision. Such factors include environmental determinants, political reasons, etc.

Buy Decision

The following are the major factors considered when deciding to buy the goods or service from an outside supplier.

- The first and foremost reason that makes a business or nation opt for buying products and services from external sources is their own lack of expertise in manufacturing those categories of products and services. They know they cannot yield the best. Hence, they connect with the best providers for their consumers.
- When companies decide to outsource their manufacturing process, they do thorough research to check who's the best provider of the required products and

services. The research and specialized know-how of the supplier better than the buyer is what inspires them to delegate their manufacturing service to other brands.

- Cost considerations are always one of the main concerns. If the businesses or nations find that it is less costly for them to buy the products and services from an external source than to produce themselves, they consider the former option and hire a third-party service.
- There are situations where a business is incapable of manufacturing an item itself. This is when they have to look for some other entity that could look after its manufacturing obligations.
- When the goods are not required in large numbers, the businesses find it worth having an external source of production of the products. This is because there is no use in devoting much time and effort to arranging everything from scratch for producing an insignificant volume of goods. Hence, they prefer outsourcing services.

Besides the above-mentioned reasons to consider buying products from external sources, the company may also think that a particular product category is not much important to the firm's strategy. Hence, they prefer outsourcing the production of the same. Plus, they may have a personal liking for the brand that inspires them to outsource the manufacturing to that particular external brand.

Advantages and Disadvantages

Make or Buy decision has many benefits to offer to businesses as it gives them a chance to decide to either buy or make products and services, given the various factors or situations. However, at the same time, there are certain limitations to this process. Thus, companies and economies must understand which option would be fruitful for

them in the future. To achieve this, they must consider all the factors mentioned above for making the right choice.

Let us have a look at both the advantages and disadvantages of the process below:

Pros

- The finding helps choose the most efficient option to go about in-house production or outsourcing.
- The decision helps in the strategic manoeuvring of the business.
- The decision helps save the cost for many businesses.
- Businesses benefit from the lower cost of mistakes if they think strategically about this decision.

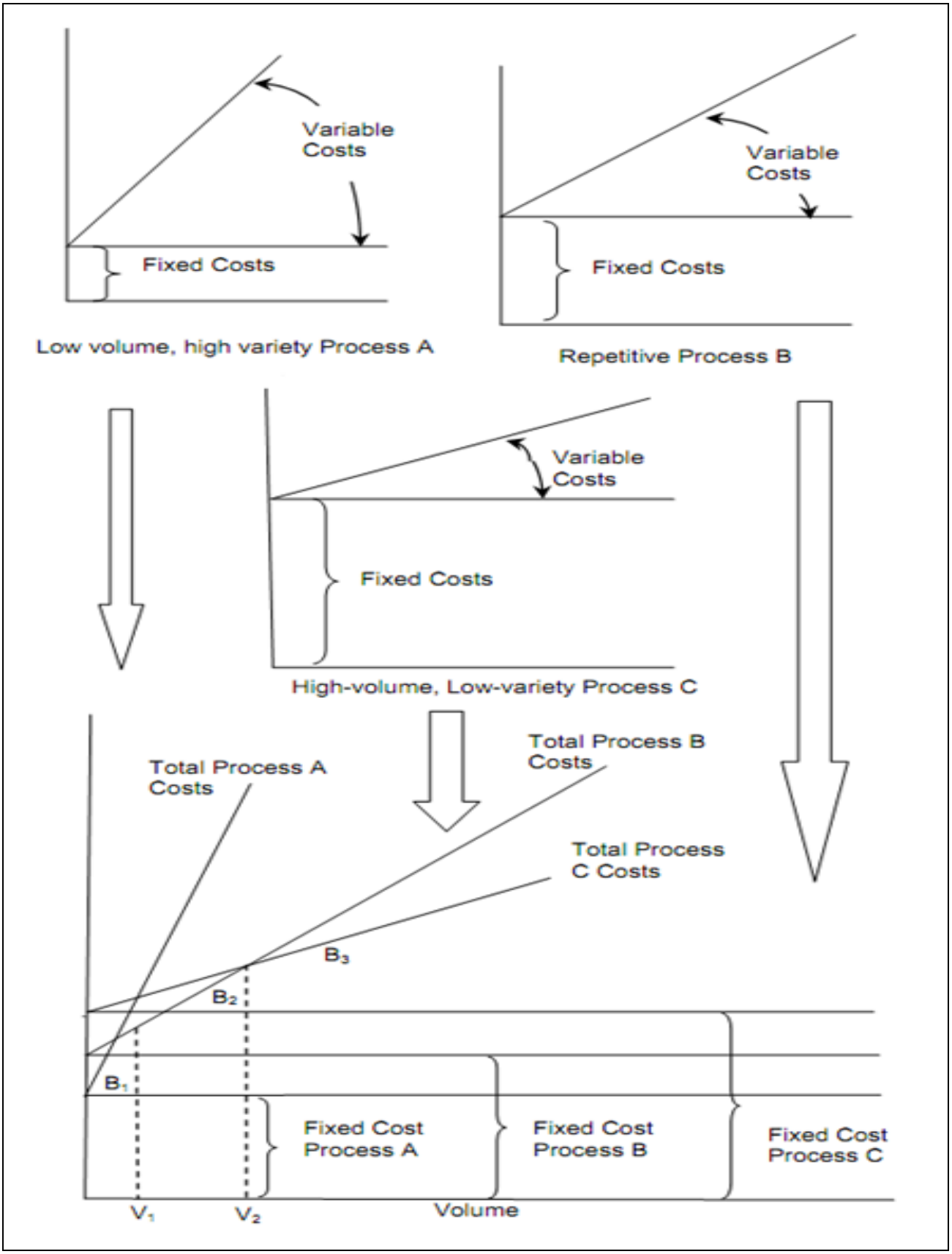
Cons

- In case the companies make a wrong choice, they have to bear huge losses. For example, if they are not an expert in producing something and still opt for it out of pride or emotional bent, they have to bear costly repercussions.
- They lose supervision control of products when an external source is handling the production.

1.24. USE OF CROSSOVER CHART FOR SELECTION PROCESS

While alternate processes are compared on a single chart, the chart thus produced is called crossover chart. Crossover chart therefore refers to the chart formed by plotting alternate processes on a single chart. It aids in the comparison of many processes. It is depicted in Figure. Break even analysis identifies the processes with

lowest total cost for the expected volume and thus helps in process selection. Break-even point also mentioned the region of highest profit. In Figure, procedure A has lowest cost below the volume V_1, process B has lowest cost for volumes between volumes V_1 and V_2, and the lowest cost for the procedure C is for volumes above V_2.


Variable Costs
Fixed Costs
Low volume, high variety Process A
Variable Costs
Fixed Costs
Repetitive Process B
Variable Costs
Fixed Costs
High-volume, Low-variety Process C
Total Process A Costs
Total Process B Costs
Total Process C Costs
B3
B2
B1
Fixed Cost Process A
Fixed Cost Process B
Fixed Cost Process C
V1
V2
Volume

1.25. TYPES OF CHARTS IN OPERATIONS MANAGEMENT

(a) Charts

1. Outline process chart: Principle operations and inspection of the process

2. Flow process chart: Activities of men, material or equipment are analysed into five events, operation, transport, inspection, delay and storage.

3. Two-handed process chart: Movement of two hands or limbs of the operator

4. Multiple activity chart: Simultaneous/interrelated activities of operators and machines on a common time scale.

5. Simultaneous motion cycle (SIMO) Chart: Movement of body members of the perator, expressed in terms of therbligs on a common time scale.

(b) Diagrams and Models

1. Flow diagram:Path of men, materials and equipments on a scale model Same as above except for the variation that it uses string to trace the path

2. String diagram: Same as above expect for the variation that it uses string to trace the path.

(c) Photographic Aids

1. Cyclegraph :Movement of hand obtained by exposing a photographic plate to the light emitted from small bulbs attached to the operator's fingers.

2. Chrono-cyclegraphs :Modification of cyclegraph in which recording is mate using flash lights.

1.26. Symbols used in Process Chart

Symbol	Activity	Purpose for which it is used
	Operation	It indicates the main steps in a process, method of procedure, usually the part, material or product concerned which is modified or changed during the operation.
	Transport	It indicates movement of workers, material or equipment from place to place.

	Inspection	It indicates any type of inspection, check, measurement, visual scrutiny for quality and/or quantity
	Temporary Storage or delay	It indicates a delay in the sequence of events.
	Storage	It indicates a controlled storage in which material is received into or issued from stores under some form of authorization or an item is retained for reference purposes

Let's Sum-Up:

Dear Learners, in this Module we learn ,nature- scope, Evolution, function a system perspective, challenges and trends , production design and process planning- types of production process, plant capacity, make or buy decisions, use and types of charts used in operations management.

Assignment Questions:

PART-A

1. _____ takes care of production and services.

(a) Production management

(b) Operations management

(c) Systems management

(d) None of the above

2. _____ manufacturing facility produces some intermediate varieties of products with intermediate volumes.

(a) Job shop

(b) Project

(c) Batch manufacturing

(d) Flow shop

3. _____ is a conversion process in which successive units of output undergo the same sequence of operations, using specialised equipment usually positioned along a production line.

(a) Flow shop

(b) Job shop

(c) Project

(d) None of the above

4._____ is a process of converting an invention into some useful product which can satisfy human wants either directly or indirectly.

(a) Manufacture

(b) Design

(c) Innovation

(d) None of the above

5. _____ is a complete determination of the specific technological process steps and their sequence to be followed to produce at the desired quality, quantity and cost.

(a) Process planning

(b) Process selection

(c) Process cost estimation

(d) None of the above

6._____ is the design of the equipment required for the production of a product according to a pre-determined process.

(a) Product design

(b) Process improvement

(c) Process design

(d) None of the above

7. The production volume of a product line is the _____ of the production quantities of different stations in the product line.

(a) Maximum

(b) Minimum

(c) Average

(d) None of the above

8. _____ strategy is the planning for the next model even when the present model is moving well.

(a) Phase-out

(b) Phase-in

(c) Both (a) and (b)

(d) None of the above

9. _____ is a prediction of the future characteristics of useful machines, products,process, procedures or techniques.

(a) Economic forecast

(b) Demand forecast

(c) Technology forecast

(d) None of the above

10.Multiple regression uses more than one _____ variable.

(a) Dependent

(b) Independent

(c) Semi

(d) None of the above

PART-B

1. Define Operations Management.
2. What is the Scope of Operations Management?
3. How Production and process design are useful for organizations?
4. Write short not on Capacity Planning

PART-C

1. Explain the Nature and scope of Operations Management.
2. Describe the types and concept of Production Process.
3. Discuss about Evolution of Operations Management.
4. Find out the limitations of manufacturing Trends in India.
5. Explain the Types of Charts used in Operation Management.

UNIT- 2

FACILITY DESIGN

PLANT LOCATION: FACTORS TO BE CONSIDERED IN PLANT LOCATION- LOCATION ANALYSIS TECHNIQUES- CHOICE OF GENERAL REGION, PARTCULAR COMMUNITY AND SITE- MULTIPLE PLANT LOCATION DECISION- PLANT LOCATION TRENDS, LAYOUT OF MANUFACTURING FACILITIES: PRINCIPLES OF A GOOD LAYOUT- LAYOUT FACTORS – BASIC TYPES OF LAYOUT- PRINCIPLES OF MATERIAL HANDLING- MATERIALS HANDLING EQUIPMENT- ROLE OF ERGONOMICS IN JOB DESIGN.

Unit module structuring

6. **Plant location.**
7. **Choice of general region**
8. **Layout**
9. **Types of layout**
10. **Materials handling systems**
11. **Ergonomics**

Self- Learning Material Development – STAGE- I

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2.1.INTRODUCTION:

Plant location is all about deciding the place where the plant is to be installed and the ‘placing’ of machines in the factory in such way that they doing the place where deciding about the ‘plant location’ is the first step of plant planning”. The location of plant is significant because the costs involved in installation of plant and mass regards high and it is not possible to change the location, frequently. Hence, any wrong decision taken in this regard may results in waste of the investment done in the installation and loss to the organization.

Plant location refers to selecting an ideal location for establishing a plant so that it could bring maximum economies to scale, efficiency and effectiveness in the operations. Thus, plant location is the physical location, where the plant of the company is located. An entrepreneur, while in the process of establishing a plant encounters this depends upon major problems and the same needs to be resolved quickly. The decision for the plant location depends upon availability of uninterrupted raw material and labour,

efficient utilisation of the production capacity, plant layout, and the cost of the production. Considering all these factors and setting up of the plant does not guarantee the success of the project. The same needs to be backed up by the efficient management also. However, if the location it is that a poor one, the management is also not left with many alternatives. So, proper care needs to be taken, to ensure that proper location is selected for the plant.

2.2. MEANING AND DEFINITION OF FACILITY/PLANT LOCATION:

According to Prof. R. C. Davis, “The function of determining where the plant should be located for maximum Operating economy and effectiveness”.

According to Bethel Smith and Alwater, “Facility location stands for that spot where in consideration of business as a whole, the total cost of production and delivering goods to all the consumers is the lowest.”

2.3. NEED FOR SELECTION OF LOCATION

There are three situations that affect the selection of the location:

1) **Selecting a Location for the First Time for New Organizations:** When selecting a plant location for a newly established organization, the cost factor needs to be considered.One should consider that the business is going to operate for indefinitely long period of time. Layout should be made after considering the present and the future requirements:

Identification of Region: Some key factors like availability of technology, marketing, internal management, regional resources availability, social and legal environment, geographical positioning, operating facilities etc., influences the decision about the location.

Choosing a Site in a Region: After the region has been duly selected, the next step is the identification of the site within that particular region. Selection of the site is remotely related with the long-term strategy of the organisation. Various alternate sites may be

considered and evaluated in terms of both tangible as well as intangible costs. This problem of site selection can be best answered by adopting cost oriented non-interactive model, also popularly termed as the dimensional analysis.

Dimensional Analysis: It would be better and easy if the costs can be quantified and were tangible in nature. The answer would have been straightforward and the location having minimum cost would have automatically been selected. In majority of cases, intangible costs expressed in relative terms over the absolute terms are considered. The benefits and the limitations could have also been compared easily.

2) **Selecting Location for Existing Organisations:** Here an existing set up requires multiple plant locations or wishes to shift from the existing location to extract economies to scale. The new location may be well within the existing location itself or may require a distinct location. The following factors are considered in this case:

Plant Manufacturing Different Products: Ideally a plant should be able to cater the requirement of the total market of the organization. This strategy holds the key while satisfying the technological and other needs for the alternate product lines and channels. For example, a product line that demands high degree of efficiency and control cannot be set-up allied with the other product line that requires very little control or less precision.Contradictions should be avoided in terms of the use of the machinery, requirement of the skilled and semi- skilled labour, supervisory staff, and use of other resources. If such contradictions appear, then presence of both the production lines will not be justified as either one of them will not get the adequate resources. Where the market is characterized by presence of high competition, product specialization holds the key. The resources that are available in a respective geographical region must be exploited to the maximum extent. Decentralization is preferred in management and location of the plant which assists in better control of the resources

Manufacturing Plants supplying to a Specific Market Area: In this case, every plant of the companymanufactures all the products that the company deals in. However, the set-up requires a very high degree of co-ordination between the corporate office and the

manufacturing unit. The same is best experienced in the case of bottling plants of the soft drinks.

Plants Divided on the Basis of the Process or Stages in Manufacturing: Sometimes the product may passthrough several stages before final completion and all the stages or processes may not even be completed in one plant set-up different processes are carried out in different plant layouts. Such may be made to factors like availability of the equipment, labour, technology or even the management's policies. Since the output of one plant is the input for the other plant, extreme co-ordination is required in this case and the control by the head office should also be exercised.

Plants Emphasising Flexibility: The layout demands co-ordination among various plants to cater to the change in the requirement while managing the usage of various resources and the facilities. If regular changes are made in the long-term strategies of the company, the same may not be a healthy sign for an organisation.While finalising a particular location for a plant its long-term sustainability and ability to incorporate the change in the requirement should be judged beforehand. Following methods may be adoptedto increase the capacity of an existing organisation:

Expanding the Facilities in the Existing Site: The facilities may be expanded only if it does not ultra- vires the philosophies, strategies, purpose of the organisation. i.e., while expanding, no compromise should be made with quality or the customer service.

Relocation/Closing Down of the Facilities: This is a major decision for the organisation. In case of some extreme circumstances that require strategic decisions, only then the relocation is preferred. The valid reasons may be technology, availability of the resources, etc.

The above factors are mainly applicable to the service units where the strategies, priorties and objectives may be different from the manufacturing units.

3) Case of Global Location: Since the inception of globalisation, many multi-national companies have opened their units in India and similarly Indian companies have also established their units in foreign countries. In such circumstances, there is:

Virtual Proximity: The advancement that is made in the telecommunication sector has brought the concept of virtual proximity into the picture. In firms that are into the line of providing the software services, majority of work takes place only through this route. High end communicating devices are used to share the information through long distances. The cost and the time involved in the logistics have certainly reduced and these are also considerable factors in finalising the location. The market reach has increased and thus there is also increase in the customer base.

Virtual Factory: Especially in U.S.A. and U.K. majority of the large-sized service or the manufacturing units outsource a part of their work to locations like India, where the technology and the labour force is available and the work can be carried out at a lesser cost. Thus, investing and developing own operations are substituted by utilising the facilities of others by paying a nominal cost. The outsourcing firm in India, procuring orders from outside is termed as the virtual service factory of the foreign-based unit.

While selecting a location, there is a need of thinking about a large number of factors which may influence the decision. It is almost impossible to finalize a location which possesses all the essential characteristics that are needed for the initiation of the process. But an attempt is made to ensure that maximum possible facilities are available and alternative actions are sought for those that are unavailable. Foremost importance is given to the location where the raw material is easily available and ease of doing business exists.

2.4. FACTORS AFFECTING FACILITY LOCATION DECISION

Apart from the different factors that are studied, some of the physical factors can also significantly impact the operations and the cost structure of the organisation. Such factors may be quantitative or even qualitative. Quantitative factors can be material,

manpower, land, machinery, transportation, etc., while the qualitative factors can be measured in terms of significance, superiority, adequacy, etc.

Factors Affecting Location in Manufacturing Operations

Following are the factors that may affect the location in the manufacturing operations:

Dominant Factors: There are certain factors that may dominate the location decision for establishing the new plant and can be classified into some groups. They are discussed as below:

i. **Availability of the Raw Material:** Those areas where the procurement of the raw material can be easily done are better than the other areas. Much emphasis is given to these areas. It may bring the following advantages:
    a) Reduction in the transportation cost,
    b) Continuous and efficient supply of the material, and
    c) Reduced carrying and storing costs.

ii. **FavourableLabour Working Environment:** In those companies or the manufacturing units that require more labour like furniture, textiles, cement, consumer goods and electronics, working environment of the labour is quite significant. The environment comprises of worker training, wage rates, labour unions, amenities, productivity requirement, etc.

iii. **Integration with Other Parts of Organisation**: The newly established unit should be adequately connected with the rest of the establishment. Initially, there may be some hurdle in the growth that needs to be taken care of and it is possible if the unit is closely connected with the rest of organisation.

iv. **Proximity to the Market:** The local demand and the potential growth should also be considered while selecting the ideal location of the plant. Normally, the market, where the demand is maximum is selected so that the goods may reach the consumer in no time and the transportation cost can also be saved. For example, the concept is adopted by the manufacturers of the bricks and the plastic pipes.

v. **Quality of Life:** Presence of other facilities like schools, hospitals, society and culture, recreational activities, etc., also attract the project (the whole concept of quality life) in a good way.

vi. **Proximity to the Suppliers and the Resources**: parts to their other manufacturing units. Or outside source. Many organisations are themselves suppliers of the main in some instances, the same may also be procured from an In both the cases, preference is given to the place where both the suppliers and the are located close to the set-up.

vii. **Safety Requirements:** Few plants may not only be themselves exposed to certain threats hut the neighborhood may also be exposed to the same. For example, nuclear power reactors, chemical and the explosives factory, etc. In such cases, normally a remote locality is preferred for the set-up.

viii. **Availability of Useful Services:** Following are the services, the presence of which is highly crucial, likeas gas, Electricity, Water, Drainage, Disposal of wastes, Communication

ix. Few industries may require significant amount of water as in the case of laundries, food processing, chemical, etc., while some other may require electricity or gas in abundance while setting up a unit, requirement of the plant should be carefully considered.

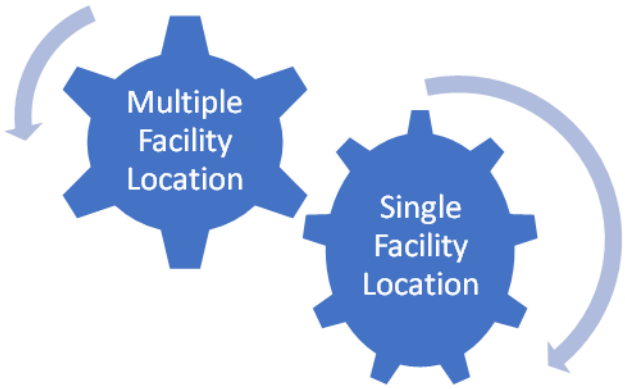
x. **Utilities, Taxes, and Real Estate Costs:** Some more significant factors including the basic utility, local administration and taxes, land costs, relocation costs are also to be accounted for.

2) **Secondary Factors:** Apart from the basic primary factors, certain other factors like scope for expansion, total cost of construction, access to the alternate modes of the transport, cost of shifting labour and the material between two sites, competitive environment, response of the society and the community, etc. are vital. If the firm is planning to expand globally, then employee education and training, infrastructure development need to be considered

2.5.STEPS IN SELECTION OF FACILITY LOCATION

The decision about the location is initiallydriven by the geographical location that has been selected .There may be one location wherein all the different facilities are available and all the activities are done under one roof.

On the other instance, the same may not be ableto serve the purpose and other location also need to establish located close to a particular market to ensure easy access to the customer. Each type of location has distinct characteristics of its own and same are to be duly considered while selecting the one.



1.SINGLE FACILITY LOCATION

The following steps should be considered while selecting a single facility location:

1)**Defining the location objective and the Associated Constraints**: After considering the need and opinion of the owners, promoters, suppliers, employees and the customers of the form, the objectives of the location and the associated constraints are defined.

2)**Identifying Relevant Decision makingCriteria:** Location should be selected after considering different factors that influence the decision. The factors may be economic, social, political or other and may relate to material or the labour cost which have an overall impact on the location.

3)Relating the objectives to Criteria by Using Various Appropriate Models: Different models may be used like that of linear programming (LPP),breakeven analysis, or qualitative factor analysis for taking relevant decisions. It is important to quantity the decision process of the location but the same is managerial opinion is sought on the matter before arriving at a conclusion hard to do. So, the managerial opinion is sought on the matter before arriving at a conclusion.

4)Evaluating Alternative Locations: Data should be collected and analysed to the maximum possible extent from the primary an well as the secondary sources while deciding the location. Primary data refers collected for the first time for the underlying study and the secondary data means the as a result of the study that is conducted by the others to the one that is one that is already available as a result of the study that is conducted by the others.

Various trade journals and magazines are available that contain good volume of data to carry out the research.Both the secondary and the primary data are compiled together to arrive at the optimum solution.

5)Selecting the Location that Best Suits Criteria: Finally a location is selected after carrying out all the necessary tasks to out the criteria and are which is in the favour of the society.

2. **MULTI-FACILITY LOCATION**

The following steps should be considered while selecting a multi-facility location.

1) **Separate Facilities for Different Products/Services:** Those companies that produce more than one type of products, prefers separate facilities for their different products and the services. Each facility is responsible to satisfy the requirement of the entire population residing in a particular geographic region. This eliminates confusion and conflicts that may arise while trying to achieve the economies to scale. Companies like Tata have different plants for manufacturing

vehicles, food products, watches and so on. Godrej has different plants for manufacturing washing machine, air-conditioners, etc.

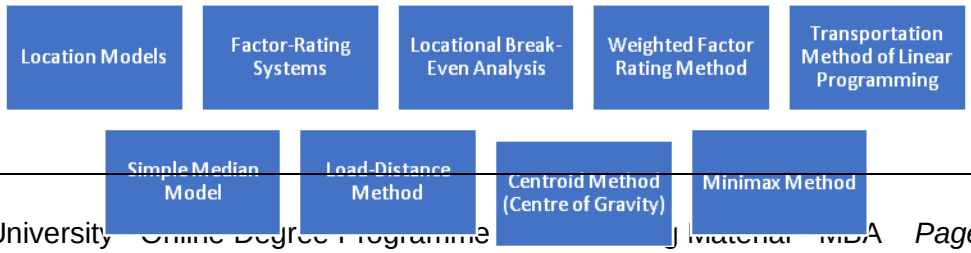
2) **Separate Facilities to Serve Different Geographical Areas:** The most suitable example for this category is the strategy adopted by Coca-Cola and Pepsi. This strategy features reduction in the overall cost of transportation and also uninterrupted supply of the product in the market. Any fluctuation in the demand can also be duly taken into consideration. In addition to this, various service sector organisation like insurance companies, banks hospitals, etc. have several offices that provide services in different localities and regions.
3) **Separate Facilities for Different Processes:** The best example for this can be automobile or the electronic industry. In certain manufacturing units of the cars, some parts are manufactured at a distant location and assembly is done at some other location. Facility that requires more labour is located in the region that has abundance of labour and the technical part is carried-out in the location where the technology is available.

2.6. LOCATION MODELS

Some of the location models are discussed as below:

Factor-Rating System

While selecting an appropriate location, factor rating system is the most widely adopted technique. Under this system, a wide range of factors are analysed in a very simple manner. A list of factors is prepared, which the company believes are most important in selecting a location and the weights are allotted accordingly. Each of the alternate site is rated and the costs and the benefits associated are made the base and then the same is multiplied with the respective weight.



The total weights allotted are then summed up to arrive at the final score. In a similar way. Rating of all the sites is carried out. Finally, the site getting the highest score is selected. Because of its simplicity and wide coverage, the technique is highly popular when it comes to selection of the site. Mostly all the factors that are supposed to have an impact are taken into the consideration and the rating is done using the weighted rates.

Steps that are involved in Factor Rating

There exist six steps in factor rating. They are:

1) Developing a list of the critical success factors which may have an impact.
2) Assigning weight to all the factors depending upon their significance to the company.
3) Developing scale for all the factors (for example, 1 to 10).
4) Allotting score to each location of each factor after using the scale.
5) Multiplying the score and the weights to arrive at the total score.
6) Analysing the score and making a recommendation for the site selection. Normally, the site which scores maximum is selected.

Weighted Factor Rating Method/Qualitative Factor Analysis Method

In case the location cannot be selected on the basis of economic criteria, then it requires systematic weighing of the criteria while finalizing the location. The approach is termed as the qualitative factor analysis. Under this method, both the quantitative as well as qualitative factors are merged together and then the weights are assigned on the basis of their significance by adopting a preference matrix. The location that attains the maximum weighted score becomes the obvious choice.

Location Break-Even Analysis

The various alternatives for the location are compared in terms of cost and the volume and also an economic comparison is made. The fixed and the variable costs for each of the location are identified and the same are plotted on a graph. The same comparison can be made mathematically also. The location having the least cost is selected. While comparing graphic approach is preferred over the mathematical as it has a range of volume.

Following are the three steps that are followed for such analysis:

- Determination of the fixed and the variable costs for all the location
- Plotting of cost on the vertical axis anal volume as the horizontal axis of graph
- The location having the least cost is selected.

Simple Median Model

Under this method, the best location is finalizedfrom the short-listed ones. In case of Facility location planning, the quantum of the transportation cost in the main aspect. Under this, a new facility is created, so as to reduce the transportation cost between the new establishment and the existing ones. Since the model is quite simple and easy to operate thus is known as the Simple Median Model. In this, median means the statistical median of loads that is to be transported between the new and the existing channel. This model is based upon an assumption that the movement of the goods can take place either on the X axis or on the Y axis. Any diagonal movement is prohibited.

Transportation Method of Linear Programming :

While carrying out evaluation of facility location, this model is the most effective model. Under this model, the varying demands are considered and is correlated with the capacity so as to reduce the transportation cost. Location which is characterized by the least transportation cost is the ideal location where the plant can be set-up, Using the transportation model, the supplies from the various factories to the markets can be managed in a cost effective manner. No value addition is made to any of the product

under this method, only the place utility is defined. The cost of transportation involved in transporting the material and the finished goods is of the prime importance before finalizing the location of the plant. The management should evaluate the location in terms of the cost of transporting the material to the market and receiving the same front the warehouse. The demand is also very crucial. It should be measured in terms of the opportunity cost if the demand is not satisfied.

Load Distance Method

This method is a mathematical technique in deciding the location of the plant after giving due consideration to the proximity factors. An attempt is made to reduce the weighted load movement inwards and outwards of facility, Grids are used on the maps to measure the distance between the two locations and alternatives are sought.

Centroid Method (Centre of Gravity)

This method is derived from the cost considerations. It aids the managers in maintaining the balance in cost and the service objectives. The location of the plant and that of the market is given due consideration along with the quantum of the goods that is to be transported. Then the transportation cost is calculated and alternatives are looked upon with a view to reduce the same. Thus, the center of gravity is established, where the distance between the warehouses and the processing unit and then towards the distribution channel is minimized. Firstly, under this, the locations are identified and co-ordination is developed among them. If the relative distances are presented in an accurate manner. The scale and the origin of co-ordination can be at the discretion of the management. The following formula represents the center of gravity:

Minimax Location Model

For selecting a location, the minimax location model serves a solution as it minimizes the distance between the facility and for future existing location. It takes into consideration the worst cases assuming the distance to be the largest. For example, locating the ambulance, fire extinguishers, helicopter service, etc. to respond in case of

critical accidents. Apart from this, there can be bomb disposal team and the fire stations, etc.

On the basis of the distance among the facilities, this technique can be classified into two types. They are:

1) **Minimax Location Problem for Rectilinear Distances:** Under this technique, the emphasis is to find a location.

2) **Minimax Location Problem for Euclidean Distance:** When this technique is applied, it reflects that the solution of the Euclidean minimax MFLP will arrive when the continuous differentiable conclave is maximized subject to the condition that there should be smaller number of constraints that are linear. This results in getting the optimum solution for the problem.

Euclidean Distance Problem

In case of Euclidian problem, the transportation cost of pair of the facilities is assumed to be proportionate to shortest route between them. Now, let's assume that there are existing facilities at P_{1s} P P_{1_{1}}…,P_{m} with coordinates (a, b), (a 2,b_{2}) (a_{3},b_{3}),…,(a_{n},b_{n}) Now, there is a need make an addition of the new facility so that the total material handling cost is minimized. Let n=no. Of existing facilities

If further, it Is assumed that the material handling cost is proportional to the total amount of the material, then in such case, the Euclidean distance among the source, destination and the total cost i.e. Z is expressed.

After solving the Euclidean problem, the derivatives are further squared to nil to calculate the most optimum values for x and y. It may happen that the new location coincides with some of the present facilities, then in such circumstance the derivatives need not to bedefined. So, before solving further, it should be ensured that such a situation does not arise.

2.7. MEANING OF FACILITY/PLANT LAYOUT

The literal meaning of "layout" is to arrange various things in the planned manner. In the context of facilityespecially with reference to a manufacturing entrepreneur, it relates to the set-up of different machineries, equipment and other facilities incidental to the core manufacturing activity, viz. department for receiving (raw materials),department for dispatching (finished goods), tool rooms, maintenance department, department looking after the workrelating to employees welfare, etc. The purpose of having such plant layout in place is to ensure a prompt, hassle-freeand uninterrupted process of production at the lowest possible cost.

2.8.DEFINITION OF FACILITY/PLANT LAYOUT

According to Shubin, "Plant layout is the arrangement and location of production machinery, work centers and auxiliary facilities and activities (Expectation, handling of material storage and shipping) for the purpose of achieving efficiency in manufacturing products or supplying consumer services".

According to Keith and Gubellini, "Plant layout deals with the arrangement of the physical facilities and the manpower which are required to manufacture a product or perform a service".

According to J. Lundy, "Plant layout ideally involves the allocation of space and the arrangement of equipment in such a manner that overall operations costs be minimized".

2.9.CHARACTERISTICS OF FACILITY LAYOUT

The characteristics of 'facility layout' can be discussed as under.

1. It refers to the positioning of the factors of production like plant, machinery, material, human resource etc. in an organisation or at factory.
2. It starts with designing the building of a factory and continues to the selection of location and the movementof work.
3. It involves the new layout for the organisation and all sort of improvements in it are also mentioned.

4. It involves the decision regarding the space required and the space is utilised in such a manner that the functioning of the process is performed with minimum cost.
5. It involves proper arrangement of material handling, storage of work in progress, storage of scraps and storage oftools and fixtures at the work area.
6. Facility layout helps in proper flow of the materials that increases the productivity and morale of the employees.

2.10. OBJECTIVES OF FACILITY LAYOUT

The basic objective of having plant layout in a manufacturing unit is to cut the cost of production and bring it to the minimum possible level. Other objectives, which may not be considered so important and may be referred to as thesubsidiary objectives, are as follows:

1) Handling and transportation of materials are facilitated, which leads to handling of such materials in a costeffective manner.

2) Available floor space is put to use in the most optimal way.

3) Various resources, viz. plants, machineries, equipment and even the human resources are utilized economically.

4) As the production activity is smoothened due to reduction in delays and other hurdles to a great extent, the work in process (WIP) inventory remains at the minimum level. The final outcome is maximum inventory turnover. The entire process of production may be planned and monitored efficiently.

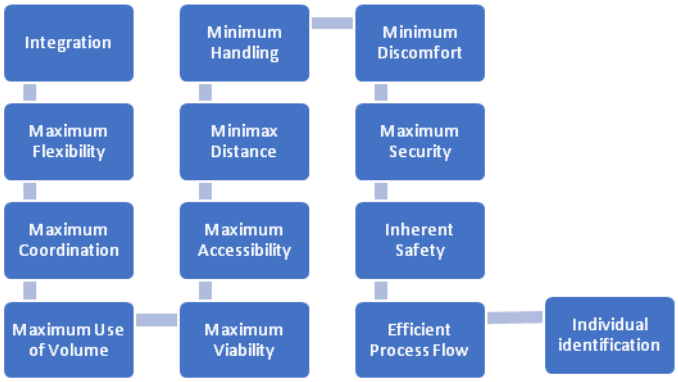
6) Manpower involved in production process develops high moral because of the security and facilities made available to them under a good plant layout.

7) It provides service centers in abundance at appropriate locations.

2.11. PRINCIPLES OF FACILITY/PLANT LAYOUT

The principles, on the basis of which a good facility/plant layout it founded, are as follows:

1) **Integration**: An efficient facility layout is one in which all resources, such as men, materials, machines and auxiliary services are integrated, so that the resources are utilised optimally, and maximum effectiveness at minimum cost is ensured.



2) Maximum Flexibility: An ideal facility/plant layout needs to be completely flexible to any changes, as and when they take place. In this regard supply of services in abundance is of paramount importance.

3)**Maximum Coordination:** Layout needs to be viewed in a broader and holistic perspective and not in a fragmented way. Entry into any functional area or exit therefrom must be a smooth one, without causing any disruption in its working.

4)**Maximum Use of Volume:** Optimum utilisation of the available volume should be made. For example, cables, pipelines, conveyor belts, etc, may be considered for running above head height and used as moving WIP stores. Similarly, tools and equipment, wherever possible, may be considered for being suspended from the ceiling.

5)**Maximum Visibility:** All the resources, viz, human resources and other materials should be strategically planned to be placed in such a manner, that they remain within the visible limits, so that the movements may be monitored. Such a condition is rather difficult to meet, especially if this is being introduced for the first time as a new system.

6)**Maximum Accessibility:** All the plants, machineries, equipment, etc. need to be placed in such a manner that they are accessible from all the sides for the purpose of servicing, maintenance, repairs, etc. They should be specifically avoided to be placed against the wall.

7)**Minimum Distance**: Movement of materials should be need based and the shortest possible route should be taken for the purpose. The underlying principle that "movements are an addition to the cost, without value- addition in many of the cases" needs to be kept in view.

8)**Minimum Handling:** The dictum that "no handling is the best handling of materials as well as that of information" should be taken as the guiding principle. However, when it becomes inevitable, it is necessary to ensure that it is kept at the minimum possible level by making use of suitable means.

9)**Minimum Discomfort:** Appropriate systems needs to be put in place to reduce and manage discomforts relating to draught, insufficient lighting, excessive sunlight, heat, noise, vibrations, obnoxious smells, etc. At times, they are the creator of bigger problems than the discomfort caused by them. Pre-emptive actions may be taken in this regard wherever possible.

10)**Inherent Safety:** Safety of various resources, including the human resources, should be accorded top priority during the finalization of layout plans.

11)**Maximum Security**: The original layout should have adequate provisions for protection against natural and man-made occurrences, like fire, theft, moisture, general deterioration, etc. A well-thought and careful planning is required in this regard, so that subsequent addition in the form of doors, barriers, etc, may be avoided.

12)**Efficient Process Flow**: A proper synchronization is required to be ensured between the process flow and any transport flow. The essence of a good layout lies in the fact that it provides unidirectional flow of paper as well as material. Absence of this may lead to problems, including extreme catastrophic situations.

13)**Individual Identification:** It is very important for an individual that they are provided with a space of the own, with which they can identify themselves. It not only inculcates the feeling of belongingness, but also acts as a morale booster. To the extent possible, this requirement may be fulfilled for a successful layout.

2.12. TYPES OF FACILITY /PLANT LAYOUT

Facility/plant layouts have been categorised into following types:

1. Product Layout
2. Process Layout
3. Fixed Position Layout
4. Flexible Manufacturing System (FMS)
5. Cellular Manufacturing Layout
6. Hybrid or Combined Layout

1. PRODUCT LAYOUT:

Product Layout is also referred to as "Straight Line Layout', 'Line Processing Layout', 'Flow Line Layout', or "Layout for Serialised Manufacture. This type of layout provides arrangement of equipment in an order to represent their sequential role in the process of production. In the sequence, one end is the entry point of the real material, while the other end is the exit point of the finished goods. In between these two points, various steps production cycle take place in a pre-decided order. This category of layout is the most appropriate for the manufacturer of standardised products, which have bulk demand. The entire manufacturing process itself is routine, monotonous and repetitive in nature. Each step production, however, requires specialisation in respect of manpower and equipment. A high level of finished under such system makes it an attractive investment choice; the decision to invest heavily is taken by a potential investor promptly. In view of the limited number of items involved, the entire layout may be arranged in tune the technological processing requirements pertaining to that product or service.

2. PROCESS LAYOUT:

Process Layout is also referred to as 'Functional Layout' or 'Job Shop Layout'. This type of layout is characterised by the following:

1) The grouping of machines and services is done on the basis of their functions; and

2) Areas are set aside for the operations of the same kind.

Departments are created on functional premise, i.e, one type of function is carried out in one department and another type of function is carried out by another department.

Such type of layout is generally used by the companies where:

- Level of production is low and
- Jobs are diversified; in other words there is no standardization.
- Order of each client is distinctive.

The sequence of operations undergoes changes with the changes in jobs , as each job involves unique sequence of operations. Due to flexibility, work areas are grouped together.

3. FIXED POSITION LAYOUT:

Under the fixed position layout, manufacturing the most important product is stable or fixed as one place. That location is the focal point of all activities; all the machineries , equipment, tools, components labour, etc. are brought to that site Such an arrangement(bring men and machinery to the place of manufacturing site of the key product) is logical in view of the fact that between the option of of moving the key product of enormous size and moving the men and machine to the site of production, the latter is convenient. This kind of layout is most suited to the manufacturers of heavy engineering goods like ships, generators, wagons, aircrafts, etc. For a small scaleindustry, it is not considered appropriate. Fixed position layout in respect of shipbuilding industry has been depicted

4. FLEXIBLE MANUFACTURING SYSTEM (FMS):

Under Flexible Manufacturing System, various machines and work are connected with each other through a robust transportation system, which ensures movement of work to respective machines in an automatic, swift and precise manner. Such a system uses pallets or other sophisticated interface units to accomplish the task.

Under FMS, there are clusters of processing work centres, which are linked with each other through an automatic system of storage and material handling. The entire system is monitored and controlled by an integrated computerised terminal. It is characterised by the following:

1)It can manufacture various parts without resorting to the exercise of re-tooling.

2)It is a measurement of the speed with which a company changes its processes from manufacturing an old line ofgoods to the production of an entirely new product

3)It is competent to (1) bring about changes in production schedule, (ii) amend a part, and (iii) manage multiple parts and

4) In a nut shell, FMS is a layout with some flexibility, which ensures that the system responds appropriately to thechanges.

5.CELLULAR MANUFACTURING/PRODUCTION LAYOUT:

Cellular Manufacturing Layout is a kind of layout wherein machines are put together in groups as per the process needs for a group of similar items, which are required to be put through the similar processing. Such groups arereferred to as Cells. Once the processing in one cell is completed, the processed end products are passed on to the next cell for further processing at their level.

A cellular layout may, thus, be considered as an equipment layout designed to facilitate cellular manufacturing. Under the cellular manufacturing, the processes are assembled into cells through group technology, which is associated with the identification of parts with same features in respect of design (size, shape and functions) and processes (category of required processing, available machinery for undertaking that kind of processing and order of processing).

According to Shri V.B. Salaja "Group technology is the realisation that many problems are similar and that by grouping similar problems, a single solution can be found to a set of problems, thus saving time and effort".

Group Technology may further be elaborated through an example of an entrepreneur specialising in computer component manufacture. An exclusive cell may be required for the processing and assembling of some of the components for the production of parts to meet the specifications of a specific customer.

6.HYBRID OR COMBINED LAYOUT:

A blend of two layouts, viz. process layout and product layout is termed as hybrid/combined layout. The advantages of both the layouts may be put to use to have a synergic benefit, provided the products manufactured have some level of similarities without any form of complexity.

2.13.MATERIALS HANDLING SYSTEMS

In addition to designing of the layout for a factory system, the development of materials handling system to move materials from one stage of production to another is very important. Materials handling includes moving, packaging and storing all the materials used by a firm. The materials handling system is judged by how well it serves the production process and how economical it is.

With thedevelopment of technology, a variety of material handling equipments has been developed to economize costs, lessen the monotony and effort of the workers, improve the safety for men and materials and improve the overall productivity. Such equipmentsrange from hand trolleys to automatic devices for handling a variety of products and materials.

The design of the plant layout and the materials handling system are clearly interlinked and the design of one affects the other.

2.14.UNIT LOAD CONCEPT

The materials are shipped from a given source to a given destination in batches consisting of certain number of pieces or certain quantity in each trip. Again, for the purpose of handling within a given work area, loading to a material handling equipment and unloading from a material handling equipment, there must be a limit on the number of pieces in the case of discrete items or a limit on the quantity (weight) of materials in the case of continuous materials to be picked and placed simultaneously while loading and unloading the materials. In this process, the batch of materials which are placed at particular destination should retain its original shape and size before picking.The optimal shape and size of the bulk of material which will retain its original shape and size even after unloading is called as unit load.

2.15.MATERIALS HANDLING PRINCIPLES

Some of the important principles of materials handling are listed below.

1. All materials to be handled mechanically from the inbound raw materials stage to the outgoing finished goods stage.

2. Heavy loads must be handled mechanically.

3. Avoid mixing materials which require future sorting

4. Transfer of materials from one container to another should be done mechanically.

5. Hot and hazardous materials must be handled mechanically.

6. Unit load concept must be followed. The larger the size of the unit load, the greater the economy.

7. Use of overhead space for conveyers and for stocking materials to be stored must be encouraged.

8. Materials are to be moved in a straight line to the extent possible. Minimum number of changes in the direction while moving materials is preferable.

9. Avoiding floor contact of materials is preferable. Pallets can be used for this purpose.
10. Gravity feed must be taken into advantage wherever feasible.

11. Pick and place of materials within operations and in transit should be infrequent

2.16.CLASSIFICATION OF MATERIALS HANDLING EQUIPMENTS

The materials handling equipments can be classified into the following categories.

1. Fixed path equipments
2. Variable path equipments
3. Auxiliary equipments

FIXED PATH EQUIPMENTS: The fixed path equipments are as listed below.

(A) CONVEYERS

1. Belt conveyor
2. Roller conveyor Screw conveyor
3. Bucket conveyor
4. Pneumatic conveyor
5. Gravity conveyor

(B) CRANES AND HOISTS

1. Overhead travelling crane
2. Gantry crane
3. Jib crane
4. Hoist
5. Stacker crane
6. Monorail

2. VARIED PATH EQUIPMENTS: The equipments that can be included in this category are listed below

1. Lift truck

2. Platform truck
3. Hand stacks
4. Tractors
5. Hand trolleys

3. AUXILIARY EQUIPMENTS :These can be classified into the following categories.

1. Pallets, skids
2. Containers
3. Lift truck attachments
4. Loaders and unloaders
5. Ramps

2.17. ERGONOMIC CONSIDERATIONS IN PRODUCT DESIGN:

In addition to the psychological aspects involved in designing equipments in industries/end user products, physical effects of working nature on the human beings (worker/ any person using end products) should be considered while designing either equipment/end user items like cars, two wheeler, control devices etc. Some of these effects are taken into account in the designing of equipments that workers we. Human factors engineering or ERGONOMIC, endeavour to apply relevant information about human characteristics and behaviour to the design of things people use the methods by which they are used and the environment in which people work and live.

Design of physical devices/products : Since, the human part of the machine, ie the worker system cannot be redesigned and reconstructed in an effort to increase its effectiveness, the machine/equipment product must be adapted to the worker. To operate a machine, a person must be able to sense the operating conditions to reach the controls and to apply on it the necessary force. An average person is capable of reaching many locations, but the speed of reach and the accuracy of adjustment are affected by the location of the object which one aims to reach. Therefore a determination of the best location requires considerable investigation and understanding of human capability and limitations.

In any product/equipment, all information displays must be located so as to ensure clear access and visibility. Switches should be located so that all the off positions are in the same direction. Thus, the operator/user of the product can quickly spot deviations from the normal. In machines, levers and hand wheels should be of proper size and located such that sufficient operating force may be applied in the appropriate direction.

In the case of some end products, like buses and cars, seating arrangements, drivers' cabins, etc. are to be designed by taking anthropometric data into considerations.

2.18. PRINCIPLES OF MOTION ECONOMY :(ERGONOMIC CONSIDERATIONS AT WORK)

The improvement of any method is generally accomplished using the leas chosen from the alternatives thrown up during the critical examination phase of the method study. Toaid critical examination, certain rules or principles may be used. These are called principles of motioneconomy.These can be classified into the following three categories:

(a) Related to the use of the human body

(b) Related to the arrangement of the work place

(c) Related to the design of tools and equipment

PRINCIPLES RELATED TO THE USE OF THE HUMAN BODY

(a) The two hands should begin as well as complete their motion at the same time

(b) The two hands should not be idle at the same time except during rest periods

(c) Motions of the arms should be made in opposite and symmetrical directions and should be made simultaneously.

d) Momentum should be employed to assist the worker, wherever possible and it should be reduced to a minimum if it must be overcome by muscular effort.

(e) Ballistic movements are faster, easier and more accurate than restricted or controlled movements

(f) Rhythm is essential to the smooth and automatic performance of an operation and the work should be arranged to permit any easy and natural rhythm wherever possible.

PRINCIPLES RELATED TO THE ARRANGEMENT OF THE WORK PLACE

(a) There should be a definite and fixed place for all tools and materials.

(b) Tools, materials and controls should be located close to the operator and directly in frontof the operator.

(c) Gravity feed bins and containers should be used to deliver materials close to the point ofuse.

(d) Drop deliveries should be used whenever possible.

(e) Materials and tools should be located to permit the best sequence of motions.

(f) The height of the work place and the chair should preferably be arranged so that alternate sitting and standing at work are easily possible.

PRINCIPLES RELATED TO THE DESIGN OF TOOLS AND EQUIPMENT

(a) The hands should be relieved of all work that can be done more advantageously to a jig. a fixture or a foot operated device.

(b) Two or more tools should be combined wherever possible.

(c) Tools and materials should be pre-positioned wherever possible.

(d) Where each finger performs some specific movements such as in typewriting, the load should be distributed in accordance with the inherent capacity of the finger.

(e) Handles such as those used on cranks and large screw drivers should be designed to permit as much of the surface of the hand to come in contact with the handle as possible.

2.19.JOB DESIGN :

Job design may be defined as the function of specifying the work activities of an individual or group in an organizational setting. The objective of the job design is the develop job structure that meet the requirements of the organisation and its technology and that satisfies the individual requirements

The various decisions involved in job design are Where, When, Why, What, Who, JobStructure

The following trends are going to influence the job design

1. Workers concern and responsibility for quality-concept of quality at source or sell-certification concept
2. Multiskilling of workers
3. Workers involvement in designing and organizing work
4. Extensive use of temporary or contract labors
5. Education of work force and ability to take challenges
6. Automation of heavy and hazardous work.

2.20.VARIOUS ASPECTS OF JOB DESIGN

A. SOCIO-TECHNICAL APPROACH

This approach attempts to develop jobs that adjust the needs of the production process technic so the needs of the worker and the workgroup. It emphasis on both technical and social variables relation to job design. This approach helps in designing the jobs that take into account the positive costs of turnover, absenteeism and boredom in relation to technology.

The individual or work group requires a logically integrated pattern of work activities the incorporates the following job design principles.

1. Task Variety: Try to provide an optimal variety of tasks within each job. Too much variety is frustrating and too little leads to monotony and boredom. Optimal level is one, which allows employee to take a rest from high level of attention or effort, while working on another jobs

2. Skill Variety: Employees derive satisfaction from applying number of skill levels

3.Feed Back:A means for informing employees regarding their achievement Fast feedback aids in learning process.

4. Task Identity:A particular set of tasks should be separated from other tasks by some clear boundary. A group or individual should have responsibility for some set of tasks that can be clearly defined, visible and meaningful

5. Task Anatomy: Employees should be able to exercise some control over their work i.e they should be involved in decision-making

B. DEGREE OF LABOUR SPECIALIZATION

Specialization of labour on one side results in high speed, low cost production and on other side has some serious adverse effects on workers as well as on production system. The problem is to determine how much specialization is to be accounted for?

The advantages of specialization include,

- Rapid training of the workforce, ease in recruiting new work force, lower wages due to case of substitutability and higher outputs
- The main limitations are limited perspective of workers, limited flexibility in workforce, repetitive nature of jobs and boredown.

C. JOB ENRICHMENT APPROACH:

Job enrichment generally entails adjusting a specialized job to make it more interesting to the job holder. A job is said to be enlarged horizontally if the worker performs a greater number of variety of tasks and it is said to be enlarged vertically if the worker involves in planning, organizing and inspecting his own work

Vertical enlargement referred to as job enrichment attempts to broaden workers influence in the transformation process by giving them certain managerial powers over their own activities. Thus, job enrichment is an approach to job design, which stresses the motivating potential in thework itself.

The organizational benefits of job enrichment occur both in quality and productivity, Quality in particular improves drastically because when individuals are responsible for their work output, they take ownership of it and simply do a better job. Productivity improvement also occurs from job enrichment

D. PHYSICAL CONSIDERATION IN JOB DESIGN

The Work Physiology-incorporates the cost of moderate to heavy work in job design. Work physiology sets work rest cycles according to energy expended in various parts of the job.

Ergonomics- is the term used to describe the study of physical arrangement of the workspace together with the tools used to perform a task. In ergonomics, attempt is made to fit the workto the body rather than forcing the body to conform to the work.

Work Method - the principal approach to the study of work methods is the construction ofcharts such as operation process chart, flow process chart, Man machine charts and multipleactivity chart with time study or standard time date. The choice of charting method depends on tasks activity level i.e, whether focus is on producing process, worker at fixed place a worker interacting with equipment and worker interacting with other workers.

Let's Sum-Up:

Dear Learners, in this Module we learn , about Plant location ,factors selection,Location Models,Layout, meaning & Definition , objectives, principles of layout, Types, Material handling, principles,Equipments, Egronomics, Job Desgin.

Assignment Questions:

PART-A

1) A _____ location is defined to be a location such that no more than one half theitem movement is to the left (below) of the new facility location and no more than one halfthe item movement is to the right (above) of the new facility location.

(a) Centroid

(b) Mode

(c) Median

(d) None of the above

2) Facility location problem with quantitative and qualitative data will have _____solution.

(a) Definite

(b) A range of

(c) Infeasible

(d) None of the above

3. Emergency facility location problem is alternately called as _____ location problem.

(a) Minimax

(b) Maxmini

(c) Max-max

(d) None of the above

4. _____ layout is used when machines and auxiliary services are located according tothe processing sequence of the product.

(a) Process

(b) Product

(c) Group technology

(d) Fixed position

5) The optimal shape and size of the bulk of material which will retain its original shape and sizeeven after unloading is called as _____.

(a) Cubical load

(b) Rectangular load

(c) Unit load

(d) None of the above

6) Plant layout is a _____ of the physical facilities which are used in production.

(a) Boundary

(b) Floor plan

(c) Three-dimensional object

(d) None of the above

7) _____ layout combines the benefits of two popular basic layouts.

(a) Process

(b) Product

(c) Group technology

(d) Fixed position

8. In _____, the total score is evaluated using the sum of “Closeness rating × Length ofshortest path” for all the pairs of the departments.

(a) SLP

(b) CORELA

(c) CRAFT

(d) ALDEP

9) The optimal shape and size of the bulk of material which will retain its original shape and sizeeven after unloading is called as _____.

(a) Cubical load

(b) Rectangular load

(c) Unit load

(d) None of the above

10) In total covering problem, the objective of covering a given customer by more than one facility is called _____.

(a) Backup coverage

(b) Partial coverage

(c) Instant coverage

(d) None of the above**.**

PART-B

1. Define Plant Layout.
2. What is the Need of Plant location?
3. How material handling equipments are useful for organizations?
4. Write short note on Egronomics.

PART-C

1. Explain the steps involved selection of facility location.
2. Discuss about Material handling equipments in Operations Management.
3. Describe the different types of plant Layout.
4. Explain the principles of Good layout.
5. Explain the Types of Charts used in Operation Management.

UNIT- 3

INVENTORY CONTROL AND MAINTENANCE

BASIC INVENTORY MODELS- ECONOMIC ORDER QUANTITY, ECONOMIC BATCH QUANTITY,REORDER POINT-SAFETY STOCK-INVENTORY COSTS-CLASSIFICATION AND CODIFICATION OF STOCK- ABC CLASSIFICATION-MATERIALS REQUIREMENT PLANNING (MRP)- JIT- IMPLICATIONS OF SUPPLY CHAIN MANAGEMENT, MAINTENANCE: PREVENTIVE VS BREAKDOWN MAINTENANCE, GROUP REPLACEMENT VS INDIVIDUAL REPLACEMENT-BREAKDOWN TIMEDISTRIBUTION- MAINTENANCE OF COST BALANCE-PROCEDURE FOR MAINTENANCE.

Unit Module Structuring

1. **Inventory models**
2. **Inventory classifications**
3. **Materials requirement planning (mrp)**
4. **Just in time (jit)**
5. **Maintenance**

SELF- LEARNING MATERIAL DEVELOPMENT – STAGE- I

TABLE OF CONTENTS FOR THE UNIT

3.1.INTEGRATED MATERIALS MANAGEMENT

The main activity of production system is to convert raw materials into useful products by value addition process. Just to aid this activity, we use various other resources. If we closely examine the various elements of prime cost, materials cost would dominate other costs. The materials which are required for the production purposes are normally procured and stored in raw materials warehouses and then they are shifted to manufacturing plants if an organization has number of plants. Even otherwise, the raw materials are to be purchased in advance and stocked in stores mainly to smoothen the production process.

Each functional head of materials department will try to optimize the operation of his own function. But, all of them should aim for a common goal of providing materials with minimum total cost (cost of carrying, ordering cost, purchase cost, etc.) for better functioning of the organization. For example, let us assume that the purchasing function plans to buy huge quantity of raw materials, just to exploit seasonal availability of the material. If the rent paid on the storage is abnormal in a place like Mumbai, then the purchasing function and the stores function will have conflicting objectives. This can be resolved if a proper trade-off analysis is done by taking the objectives together. This is possible if these two functions are integrated together. This is only a small example involving two functions. In reality, all the functions of materials management are to be integrated. The different functions of materials management are materials planning, purchasing, receiving, Stores, inventory control, scrap and surplus disposal.

If these systems are designed to function independently, there won't be close coordination among them. But we need complete integration of these functions for better operation of the system. The integrated materials management will result in the following advantages:

- Better accountability.
- Better coordination.
- Better performance.
- Adaptability to computerized systems.

3.2. COMPONENTS OF INTEGRATED MATERIALS MANAGEMENT

The components of the integrated materials management can be classified into the following modules.

- Materials planning
- Inventory control
- Purchase management
- Stores management

Materials Planning

Sales forecasting and aggregate planning are the basic inputs for materials planning. The tasks under planning are listed below:

- Estimating the individual requirements of parts.
- Preparing materials budget.
- Forecasting the levels of inventories.
- Scheduling the orders and
- Monitoring the performance in relation to production and sales.

Inventory Control

This includes the following:

- ABC analysis.
- Fixing economical order quantity.
- Lead time analysis.
- Setting safety stock and reorder level.

Purchase Management

The tasks under purchasing are listed below:

- Evaluating and rating suppliers.
- Selection of suppliers.
- Finalization of terms of purchase.
- Placement of purchase orders.
- Follow-up.
- Approval of payments to suppliers.

Stores Management

The different tasks under stores are listed below:

- Physical control of materials.

- Preservation of stores.
- Minimization of obsolescence and damage through handling.
- Disposal and efficient handling.
- Maintenance of stores records.
- Proper location and stocking of materials, and more
- Reconciling the materials with book figures.

3.3. INVENTORY CONTROL

INTRODUCTION

In majority of the organizations, the cost of material forms a substantial trans for the selling price of the product. The interval between the receiving the purchased parts and transforming them final products varies from industries to industries depending upon the cycle time of manufacture. Materials are procured and held on the shape of inventories. It is therefore necessary to hold inventories of various kinds to act as a buffer between supply and demand for efficient Operation of the system. Thus an effective control on inventory becomes a must for smooth and efficient running of the production cycle with least interruptions. The stocking of anything that is tangible in order to meet the future demand is the subject matter of inventory theory.

MEANING OF INVENTORY

Inventory generally refers to the materials in stock. It is also called the idle resource of an enterprise. Inventories represent those items which are either stocked for sale or they are in the process of manufacturing or they are in the form of materials which are yet to be utilized.

Inventory control is a planned approach of determining what to order, when to order and how much to order and how much to stock so that costs associated with buying and storing are optimal without interrupting production and sales. Inventory control basically deals with two problems,

(1) When should an order be placed? (Order level)

(2) How much should be ordered? (Order quantity)

These questions are answered by the use of inventory models. The scientific inventory control system strikes the balance between the loss due to non-availability of an item and cost of carrying the stock of an item. Scientific inventory control aims at maintaining optimum level of stock of goods required by the company at minimum cost to the company.

3.4. TYPES OF INVENTORIES:

A manufacturing firm generally carries the following types of inventories.

1. **Raw Materials:**

Raw materials are those basic fabricated materials which have not undergone any operation since they are received from the suppliers. E.g. Round bars, angles, channels pipes etc.

2. **Bought Out parts:**

These parts refer to those finished parts, subassemblies which are purchased from outside as per the company's specifications.

3. **Work in Process Inventories (WIP):**

These refer to the items or materials in partially completed condition of manufacturing. E.g. Semi-finished products at the various stages of manufacture.

4. **Finished Goods Inventories:**

These refer to the completed products ready for dispatch.

5. **Maintenance, repair and operating stores:**

Normally these inventories refer to those items which do not form the part of the final product but are consumed in the production process. Example: Machine spares, Oil, Grease.

6. Tools inventory:

Includes both standard tools and special tools.

INVENTORIES CAN ALSO BE CLASSIFIED AS:

Fluctuation inventories have to be product cannot be always predicted with accuracy. There are variations in demand and lead times for reserve stock or safety stock to account for carried for the reason that sales and production times for the Thus there is a need the fluctuations in demand and lead time.

Anticipation Inventories are built up in advance for big selling season, promotion programme or anticipation of likely change in demand suddenly and in case of plant shutdown period. It is the inventory for the future need

Lot size inventory refers to producing and storing at the rate higher than the current consumption rate. The production in lots is going to help the advantage of price discounts for quantities purchased in bulk and fewer set ups and hence the lower set-up cost.

The transportation inventories exist because materials must be moved from one place to another. When transportation requires a long time, the items in transport represent the inventory. Thus transportation inventory is a result of extended or longer transportation time.

OBJECTIVES OF INVENTORY CONTROL:

1. To ensure adequate supply of products to customer and avoid shortages as far as possible.
2. To make sure that the financial investment in inventories is minimum (ie. To see that the working capital is blocked to the minimum possible extent)
3. Efficient purchasing, storing, consumption and accounting for materials is an important objective.
4. To maintain timely record of inventories of all the items and to maintain the stock within the desired limits.

5. To ensure timely action for replenishment
6. To provide a reserve stock for variations in lead times of delivery of materials.
7. To provide a scientific base for both short term and long term planning of materials

Benefits of Inventory Control:

It is an established fact that through the practice of scientific inventory control, the stocks can be reduced anywhere between 10% to 40%. The benefits of inventory control are:

1. Improvement in customers relationship because of the timely delivery of goods and services
2. Smooth and uninterrupted production and hence no stock out.
3. Efficient utilization of working capital.
4. Helps in minimizing loss due to deterioration, obsolescence damage and prolifeage.
5. Economy in purchasing.
6. Eliminates the possibility of duplicate ordering.

3.5.COSTS ASSOCIATED WITH INVENTORY:

1. **Purchase (or production) Cost:** The value of an item is its unit purchasing (production) cost. This cost becomes significant when availing the price discounts. This cost is expressed as R unit.
2. **Capital cost:** The amount invested in an item, (capital cost) is an amount of capital not available for other purchases. If the money were invested somewhere else, a return on the investment is expected. A charge to inventory expenses is made to account for this unreceived return. The amount of the charge reflects the percentage return expected from other investment.
3. **Ordering Cost:** It is also known by the name procurement cost or replenishment cost or acquisition cost. Cost of ordering is the amount of money expended to get

an item into inventory. This takes in to account all the costs incurred from calling the quotations to the point at which the items are taken to stock.

There are two types of costs –

- Fixed costs and
- Variable costs.

Fixed costs do not depend on the number of orders whereas variable costs change with respect to the number of orders placed.

The salaries and wages of permanent employees involved in purchase function and control of inventory purchasing incoming inspection, accounting for purchase orders constitute the major part of the fixed costs.

The cost of placing an order varies from one organization to another. They are generally classified under the following heads:

(1) Purchasing: The clerical and administrative cost associated with the purchasing, the cost of requisitioning material, placing the order, follow-up, receiving and evaluating quotations.
(2) Inspection: The cost of checking material after they are received by the supplier for quantity and quality and maintaining records of the receipts.
(3) Accounting: The cost of checking supply against each order, making payments and maintaining records of purchases.
(4) Transportation costs.

4. **Inventory carrying costs (Holding costs):** These are the costs associated with holding a given level of inventory on hand and this cost vary in direct proportion to the amount of holding and period of holding the stock in stores.

The holding costs include,

(1) Storage costs (rent, heating, lighting etc.)
(2) Handling Costs: Costs associated with moving the items such as cost of labour, equipment
(3) Depreciation , Taxes and insurance

(4) Product deterioration and obsolescence.

(5) Spoilage, breakage ,pilferage and loss due to perishable nature

5. **Shortage Cost:** When there is a demand for the product and the item needed is not in stock, then we incur a shortage cost or cost associated with stock out

The shortage costs include:

- Backorder costs.
- Loss of future sales
- Loss of consumer goodwill
- Extra cost associated with urgent, small quantity ordering costs
- Loss of profit contribution by lost sales revenue

The unsatisfied demand can be satisfied at a later stage (by means of hack orders) of unfulfilled demand is lost completely (no back ordering, the shortage costs become proportional to only the shortage quantity)

INVENTORY CONTROL TERMINOLOGY:

1. **Demand -**It is the number of items (products) required per unit of time. The demand may either deterministic of probabilistic in nature
2. **Order Cycle**- The time period between two successive orders is called order cycle.
3. **Lead time** – The length of time between placing an order and receipt of items is called lead time
4. **Safety stock**-It is also called Buffer stock or Minimum stock. It is the stock of inventory needed to account for delays in materials supply and to account for sudden increase in demand due to rush orders.
5. **Inventory turnover** – If the company maintains inventories equal to 3 months consumption. It means that inventory turnover is 4 times a year, in the entire inventory is used up and replaced 4 times a year
6. **Re-order Level (ROL)**- It is the point at which the replenishment action in initiated. When the stock level reaches R.O.L., the order is placed for the item

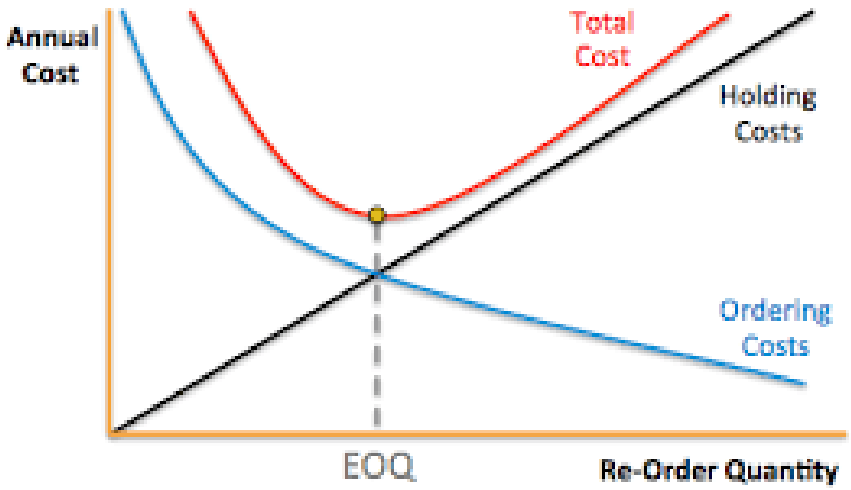
7. **Re-order quantity**- This is the quantity of material (items) to be ordered at the re-order level. Normally this quantity equals the economic order quantity

INVENTORY COST RELATIONSHIPS:

There are two major cost associated with inventory Procurement cost (ordering cost) and inventory carrying cost. Annual procurement cost varies with the number of orders. This implies that the procurement cost will be high, if the item is procured frequently in small lots. The procurement cost is expressed as Reorder.

The annual Inventory carrying cost (Product of Average inventory carrying cost) is directlyproportional to the quantity in stock. The inventory carrying cost decreases. If the quantity ordered per order is small.

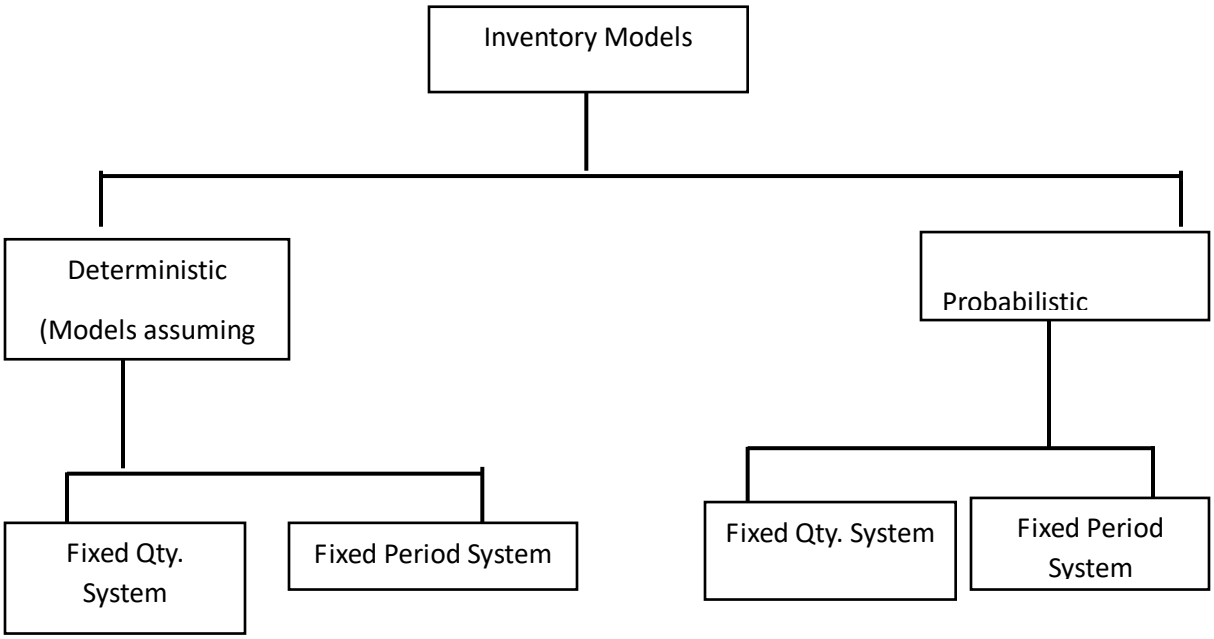
The two costs are diametrically opposite to each other. The right quantity to be ordered is one that strikes a balance between the two opposing costs. This quantity is referred to as order quantity" (EOQ). The cost relationships are shown in the figure



3.6. INVENTORY MODELS:

One of the basic problems of inventory management is to find out the order quantity so that it is most economical from overall operational point of view. Here the problem lies in

minimizing the two conflicting costs. i.e., ordering cost and inventory carrying cost. Inventory models helps to find out the order quantity which minimizes the total costs (sum of ordering costs and inventory carrying costs. Inventory models are classified as shown in the diagram



There are different models of inventory. The inventory models can be classified into determinacy models and probabilistic models. The various deterministic models are as given below:

- Purchase model with instantaneous replenishment and without shortages.

- Manufacturing model without shortages.
- Purchase model with instantaneous replenishment and with shortages.
- Manufacturing model with shortages

MODEL – I PURCHASE MODEL WITH INSTANTANEOUS REPLENISHMENT AND WITHOUT SHORTAGES:

In this model of inventory, orders of equal size are placed at periodical intervals. The items again a an order are replenished instantaneously and the items are consumed at a constant rate. The purchase price per unit is the same irrespective of order size. Let,

D be the annual demand in units.

Co be the ordering cost/order

Cc be the carrying cost/unit/year

P be the purchase price per unit

Q be the order size

$Q^*=\sqrt{2C_oD/C_c}$

Number of orders = D/Q^*

Time between orders = Q^*/D

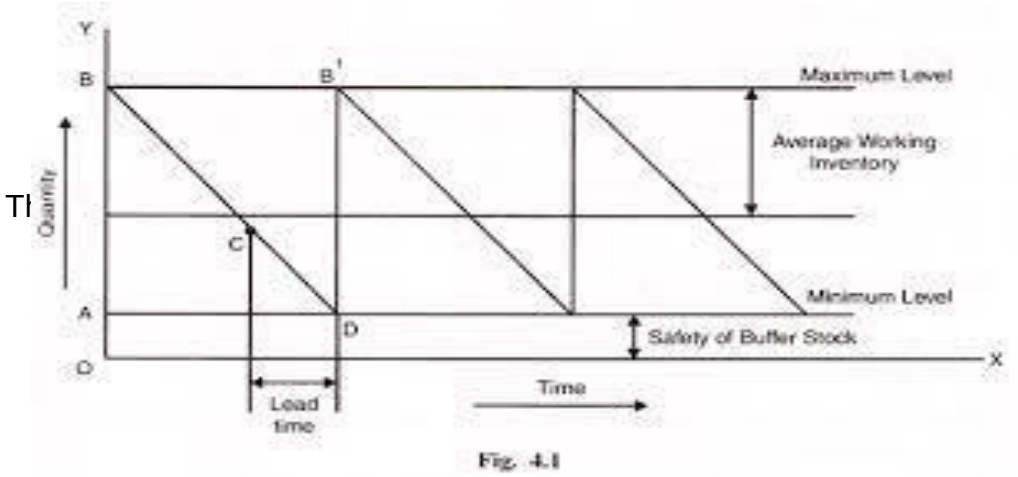


Fig. 4.1

MODEL II: MANUFACTURING MODEL WITHOUT SHORTAGES

If a company manufactures its component which is required for its main product, then the corresponding model of inventory is called “Manufacturing model”. This model will be with shortages or without shortages. The rate of consumption of items is uniform throughout the year. The cost of production per unit is same irrespective of production lot size. Let,

r = Annual demand of an item.
k = Production rate of the item (No. of units produced per year).
Co = Cost per set up.
Cc= Carrying cost per unit per period
P = Cost of production per unit.
EBQ be Economic Batch Quantity

$EBQ = \sqrt{2C_o r/C_c(1-r/k)}$

$t^*_{1=} Q^*/k$

$t_2^*=Q^*(1-r/k)/r$

Cycle time $=t^*_1+t^*_2$

During the period t1, the item is produced at the rate of k units per period and simultaneously it is consumed at the rate of r units per period. So, during this period, the inventory is built at the rate of k-r units per period. During the period t2, the production of the item is discontinued but the consumption of that item is continued. Hence, the inventory is decreased at the rate of r units per period during this period.

MODELIII:PURCHASE MODEL WITH SHORTAGES (INSTANTANEOUS SUPPLY)

In this model, the items on order will be received instantaneously and they are consumed constant rate. The purchase price per unit remains same irrespective of order size. If there is no at the time of receiving a request for the items, it is assumed that it will be satisfied at a later data with a penalty. This is called backordering. The variables which are used in this model are given below.

D =Demand/period

Cc= Carrying cost/unit/period

Co= Ordering cost/order.

Cs= Shortage cost/unit/period.

Q* = Economic order quantity,

Q1 = Maximum inventory, and

Q2 = Maximum stockout

Q * = EOQ = $\sqrt{\frac{2CoD}{Cc}\ (Cs + Cc)/Cs}$

Q1 * = EOQ = $\sqrt{\frac{2CoD}{Cc}\ (Cs/Cs + Cc)}$

Q2 = Q*-Q1*

T* = Q*/D

T1*= Q1*/D

T2*= Q2*/D

MODEL IV:MANUFACTURING MODEL WITH SHORTAGES

In this the model, the items are produced and consumed simultaneously for aportion of the cycle time . The rate of consumption of items is uniform throughout the year. The cost of production per unit is the same irrespective of production lot size. In this model, stockout is permitted. It is assumed that the stockout units will be satisfied from the units which will produced at a later date with penalty. This is called backordering. The variables which are used in this model are given below. Let,

r = Annual demand of an item

k = Production rate of the item (No. of units produced/year)

Co = Cost/set up.

Cc= Carrying cost/unit/period

Cs = Shortage cost/unit/period

P = Cost of production/unit

Q* = Economic order quantity,

Q1 = Maximum inventory, and

Q2 = Maximum stockout

$Q^* = EBQ = \sqrt{2C_o/C_c}\, kr/(k-r)\ (C_c+C_s)/C_s$

$Q1^* = \sqrt{2C_o/C_c}\, r(k-r)/K\ C_s/\ (C_c+C_s)$

$Q2^* = \sqrt{2C_oC_c/C_s(C_c+C_s)}\, r(k-r)/k$

$Q1^* = \sqrt{(k-r)/k\ Q^*)} - Q2^*$

$T^* = Q^*/r$

$T1^* = Q1^*/(k-r)$

$T2^* = Q1^*/r$

$T3^* = Q2^*/r$

$T4^* = Q2^*/(k-r)$

3.7. MATERIAL REQUIREMENT PLANNING (MRP)

Introduction

Material requirement planning (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. MRP is a technique of working backward from the scheduled quantities and needs dates for end items specified in a master production schedule to determine the requirements for components needed sheet the master production

schedule. The technique determines what components are needed, how many are needed, when they are needed and when they should be ordered so that they are likely to be available as needed. The MRP logic serves as the key component in an information system for planning and controlling production operations and purchasing. The information provided by MRP is highly useful in scheduling because it indicates the relative priorities of shop orders and purchase orders.

DEFINITION:

"Materials Requirement Planning (MRP) is a technique for determining the quantity and timing for the acquisition of dependent demand items needed to satisfy master production schedule requirements".

MRP is one of the powerful tools that, when applied properly, helps the managers in achieving effective manufacturing control.

MRP Objectives

1. **Inventory reduction-** MRP determines how many components are required, when they are required in order to meet the master schedule. It helps to procure the materials/components as and when needed and thus avoid excessive buildup of inventory.
2. **Reduction in the manufacturing and delivery lead times-** MRP identifies materials and components quantities, timings when they are needed, availabilities and procurements and actions required to meet delivery deadlines. MRP helps to avoid delays in production and priorities production activities by putting due dates on customer job orders.
3. **Realistic delivery commitments** - By using MRP, production can give marketing timely information about likely delivery times to prospective customers.
4. **Increased efficiency-** MRP provides a close co-ordination among various work centers and hence helps to achieve uninterrupted flow of materials through the production line. This increases the efficiency of production system.

FUNCTIONS SERVED BY MRP

1. Order planning and control. When to release orders and for what quantities of materials components.
2. Priority planning and control. How to expected date of availability compares to the need date for each component.
3. Provision of a basis for planning capacity requirements and developing a broad business plans.

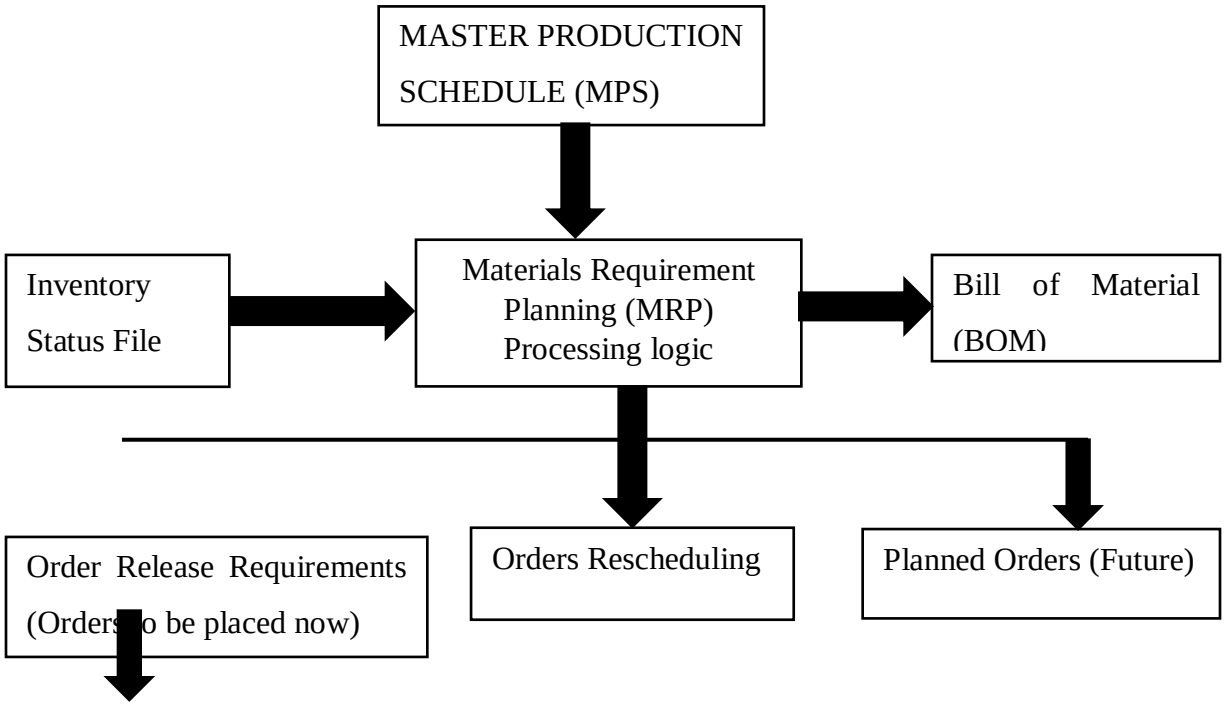
MRP TERMINOLOGY:

1) **Dependent Demand**- The demand for an item depends on another item. The demand dependency is the degree to which the demand for one item is associated with demand for another item.
2) **MRP-** A technique for determining the quantity and timing of dependent demand items
3) **Lot size-** The quantity of items required for an order.
4) **Time phasing –** Scheduling to produce or receive an appropriate amount (Lot) of material so that it will be available in the time periods when required.
5) **Time bucket –** The time period used for planning purposes in MRP.
6) **Gross Requirements** – The overall quantity of an item needed at the end of the period to meet the planned output levels.
7) **Net Requirements** – The net quantity of an item that must be acquired to meet the schedules output for the period. It is calculated as, Gross requirements minus schedules receipts for the period minus amounts available from the previous period.
8) **Requirements explosion** – The breaking down of (exploding) of parent items in to component parts that can be individually planned and scheduled.
9) **Scheduled Receipts** – The quantity of an item that will be received from suppliers as a result of orders that have been placed.

10) **Planned order receipts** – The quantity of an item that is planned to be ordered so that it will be received at the beginning of the period to meet net requirements for the period. The order has not yet been placed.
11) **Planned Order Release** – The quantity of an item that is planned to be ordered or it is a plan (quantity and date) to initiate the purchase or manufacture of materials so that they will be Received on schedule after the lead time offset.
12) **Lead time offset** - The supply time or number of time buckets between releasing an order and receiving the materials.

MRP SYSTEM:

The MRP system components.



The inputs to the MRP Systems are:

1. A master production Schedule.
2. An inventory Status file.
3. Bill of material (BOM)

Using these three information sources, the MRP processing logic (Computer Programme) provides three kinds of information (Output) for each product component: Order release requirements order rescheduling and planned orders.

MASTER PRODUCTION SCHEDULE (MPS)

MPS is a series of time phased quantities for each item that a company produces, Indicating how many are to be produced and when. MPS is initially developed from firm customer orders or from forecast of demand before MRP system begins to operate. The MRP system accepts whatever the master schedule demands and translates MPS end items in to specific component requirements. Most systems then make a simulated trial run to determine whether the proposed master satisfied.

Inventory Status File:

Every inventory item being planned must have an inventory status file which gives complete and updateinformation on the hand quantities, gross requirements, schedules receipts and planned order releases for the item. It also includes planning information such as lot sizes, lead times, safety stock levels and scrap allowances,

Basically, the job of the inventory status file is to keep data, about the projected use and receipts of each item and to determine the amount of inventory that will be available in each time bucket. If the projected available inventory is not adequate to meet the requirement in a period, the MRP a progamme will recommend that its item be ordered.

Bill of Materials (BOM):

To schedule the production of an end product, an MRP system must plan for all the materials parts and sub-assemblies that go in to the end product. The Bill of Material file in the computer provide this information. BOM file identifies each component by unique part number and helps processing by a process which ‘explodes” end item requirements in to end item requirements into component requirements.

Thus BOM identifies how each end product is manufactured, specifying all subcomponents items their sequence of buildup, their quantity in each finished unit and the work centers performing the buildup sequence. This information is obtained from product design documents, work flow analyses and other standard manufacturing information.

The BOM processor is a software package that maintains and updates the BOM listing of all components that go in to the product. It also links the BOM file with the inventory status file so that the requirements explosion correctly accounts for the current inventory levels of all components.

Product Structure – the primary information to MRP from Bill of material is the product structure The levels of components to produce an end product. End product is on level 'O'; components required for level 'O' are on level '1' and so on.

One unit of end product 'A' requires one unit each of components B and C. One unit of end Product 'D' requires one unit of component E and one unit of component F'. The component F' turn requires one unit of component B' and two units of component 'C'

To facilitate MRP processing, each component at every level of the BOM must have a unique part number for its identification. The separate identifications enable computer to find any parent item and to determine all the components needed to make it. Determining all the lower level components needed to make a parent is called exploding the requirement by the BOM.

MRP Outputs

The most visible outputs are the actual and planned order releases that go to purchasing and in house production shops.

A variety of reports can be generated from the information made available by an MRP Program

TO MPS Planners

- Simulation of proposed MPS
- Researching information for open orders (due to cancellation, delays, shortages

To Purchasing and Production

- Changes to keep priorities valid.
- Order releases (Purchase and shop orders)
- Planned order releases.

To capacity Requirements Planning

- Order release information for Load profiles, delays, shortages.

To Management

- Performance measurement (vendors, cost, forecast accuracy)
- Exception reports (on due dates BOM file etc.)

MRP Logic:

MRP processing logic accepts the master schedule and determines the components schedules for successfully low-level items of the product structures. It calculates for each item in each producer structure and for each time period (typically one week) in the planning horizon how many of that items are required (Gross requirements) how many units from inventory are already available, the net quantity that must be planned (planned order receipts) and when orders for new shipments must be planned (planned order releases) so that all material arrive when needed.

Net Requirements are calculated by adjusting for existing inventory, items already on order as recorded in inventory status file.

Order releases are planned for components in a time phased manner (using lead time data from the inventory file) so that materials will arrive precisely when needed. This is referred to as planned order receipt. When the orders are actually issued to vendors or shops the planned receipt becomes the scheduled receipt.

3.8. CLASSIFICATION OF INVENTORY:

1. ABC Analysis
2. HML(High, Low, Medium)
3. VED Analysis (Vital, Essential, Desirable)
4. SDE Analysis (Scarce, difficult, Easy)
5. FSN Analysis (Fast, Slow, Nonmoving)
6. GOLF (Govt., Ordinary, Local, Foreign)
7. SOS (Seasonal, off seasonal)
8. XYZ Analysis

1. **ABC Analysis** : The inventory of an industrial organization generally consists of thousands of items with varying prices, usage rate and lead time. It is neither desirable nor possible to pay equal attention to all the items. For example, A T.V. set has about 5% of its parts contribute to 80% of the total costs. This is true of majority of the items like car, refrigerator etc. ABC Analysis is a basic analytical tool which enables management to concentrate its efforts where efforts will be greater.

   The pare to principle (20/80) of cause and effect is a useful concept in business where it can be used to solve majority of production, quality and inventory problems. The concept applied to inventory control is called as ABC analysis.

   Statistics reveal that just a few items account for bulk of the annual consumption of the materials. These few items are called ‘A’ class items which hold the key to business. The other items known as ‘B’ and ‘C’ which are numerous in number but their contribution is less significant. ABC analysis thus tends to segregate the items into three categories A, B & C on the basis of their annual usage. The categorisation is made to pay right attention and control demanded by items.

   “A” class items – These items hardly constitute 5-10% of the total items and account for 70-75% of the total money spend on inventories. These items require rigid and strict control and need to be stocked in smaller quantities. These items are to be procured frequently and each time less quantity is procured. The inventory of ‘A’ class items is kept at minimum.

"B" class items – These items are generally 10-15% of total items and represent 10-15% of the total expenditure on materials. These are intermediate items. The control on these items should be intermediate between A and C items.

C" class items – These are about 70-80% in number and constitute only 5-10% total expenditure on materials.These items being less expensive does not require strict control. These are ordered in bulk as against infrequent ordering of A class items.

Advantages of ABC Analysis:

This approach helps the manager to exercise selective control and focus his attention only on a few items.

By exercising strict control on 'A' class items, the materials manager is able to show the results within a short period of time. It results in reduced clerical costs, saves time and effort and results in better planning and control and increased inventory turnover. ABC analysis thus tries to focus anddirect the effort based on the merit of the items and thus becomes an effective management control.

Limitations of ABC Analysis:

ABC analysis is a fundamental tool for exercising selective control over numerous inventory items but in present form permit precise consideration of all relevant problems of inventory management,

ABC analysis is not one time exercise and items are to be review and recatagorised periodically Features and Policy Guide Lines for ABC Analysis

Features and Policy Guide Lines for ABC Analysis

A Class (High Value)	B Class (Moderate Value)	C Class (Low Value)

1. Tight control on stock levels 2. Low safety stock 3. Ordered frequently 4. Individual posting in stores 5. Continuous check on schedules and revision when called for 6. Weekly control statements 7. Procured from multiple sources 8. Minimize waste, obsolete and surplus 9. Continuous effort to reduce lead time	1. Moderate control 2. Medium safety stock 3. Less frequently 4. Individual posting 5. Broad check on schedule revisions 6. Two or more reliable sources 7. Monthly control reports 8. Quarterly control over waste 9. Moderate efforts	Looses control Large safety stock Bulk ordering Collective postings Hardly any check required Two reliable sources for each time Quarterly control reports Annual review regarding waste Minimum efforts

Procedure for making ABC Analysis:

1. Calculate the total inventory value for each item held in inventory by multiplying the number of units used in a year by its unit price.
2. Tabulate these items in descending order of their values placing first the item having the highest total value and so on.
3. Prepare a table showing item No, unit cost, annual unit consumed and annual rupee value of units used.
4. Compute the running total item by item for the items and also for rupee value of consumption.
5. Compute the cumulative percentage for the item count and cumulative annual usage value
6. Classify the items as per the norms for ABC items.
7. The cumulative percentages are represented graphically.

2. **VED Analysis:** This analysis represents classification of items based on criticality. The analysis classifies the items into three groups called vital, essential and desirable.

   Vital items are those items the unavailability of which will stop the production. Essential items are those items whose stock out costs are very high.Desirable items will not cause any immediate production stoppages and their stock out costs are nominal.

   This analysis is mainly carried out to identify critical items. An item which may belong to C- category may be critical from production point of view.

   The service level for each item may be determined and the inventory can be planned accordingly.

3. **SDE Analysis:** SDE Analysis classifies the items in to three groups namely – Scarce, Difficult and Easy. These are based on the problems of procurement.

   'Scarce, classification includes items which are in short supply, imported items. Such items are procured once in a year because of effort and expenditure involved in its import.

   Difficult items are those items which are available indigenously but are difficult to procure.

   Easy classification covers those items which are readily available and easy to procure. These are mostly commercially available standard items.

4. **HML Analysis:** This analysis is similar to ABC analysis but here the criteria is 'price' instead of usage value.

   The items in this analysis are classified in to three groups i.e. high, low and medium. The management decides the cut off lines or prices for the three categories. This analysis helps to keep control over consumption as per the price and helps to assess storage and security requirements. i.e. the high priced items are to be stored in the cupboards. It helps to outline the buying policies and to delegate authorities to buyers.

5. **FSN Analysis:** All the items in the inventory are not required at the same frequency. Some are required regularly, some occasionally and some very rarely.

FSN analysis classifies items in to fast moving, slow moving and nonmoving.

6. **SOS Analysis:** This classification is based on the seasonality of the items as seasonal andoff seasonal. Seasonal items are available only for a limited period and hence they are procured to meet the demand till the next season.
7. **XYZ Analysis:** This analysis is based on the value of the stocks on hand. (i.e. capital employed to procure inventory). Items whose inventory values are high are called 'X' category and whose values are low are called 'Z' items. Usually XYZ analysis is used in association with ABC Analysis.

3.9. JUST IN TIME (JIT) MANUFACTURING:

Introduction

Most successful companies develop and implement strategies that will give them a competitive advantage. A company that improves performance on a regular and continuous basis certainly will gain the competitive edge. Companies seek competitive advantage by emphasizing on performance factors such as flexibility, quick responsiveness, cost, efficiency, quality and reliability and service.

Just in time manufacturing is a philosophy rather than a technique. By eliminating all waste and seeking continuous improvement, it aims at creating a manufacturing system that is responsive to the market needs.

The phrase just in time is used to because this system operates with very low WIP (work in process) inventory and often with very low finished goods inventory. Products are assembled just before they are sold, subassemblies are made just before they are assembled and components are made and fabricated just before sub assembly are made. This leads to lower WIP and reduced lead times. To achieve this organizations have to be excellent in other areas e.g. quality.

JIT is a manufacturing system whose goal is to optimize processes and procedures by continuously pursuing waste reduction.

According to Voss,

JIT is viewed as a “Production methodology which aims to improve overall productivity through elimination of waste and which leads to improved quality”. JIT provides for the cost efficient production in an organization and delivery of only the necessary the parts in the right quantity at the right time and place while using the minimum facilities.

JIT enables one to conceive, design, implement and operate a manufacturing and supportingsystems, as an integrated whole based on the principles of continuous improvements and elimination of all kinds of waste.

Seven Wastes: Shigeo Shingo, a Japanese JIT authority and engineer at the Toyota Motor Company identifies seven wastes as being the targets of continuous improvement in production processes. By attending to these wastes, the improvement is achieved.

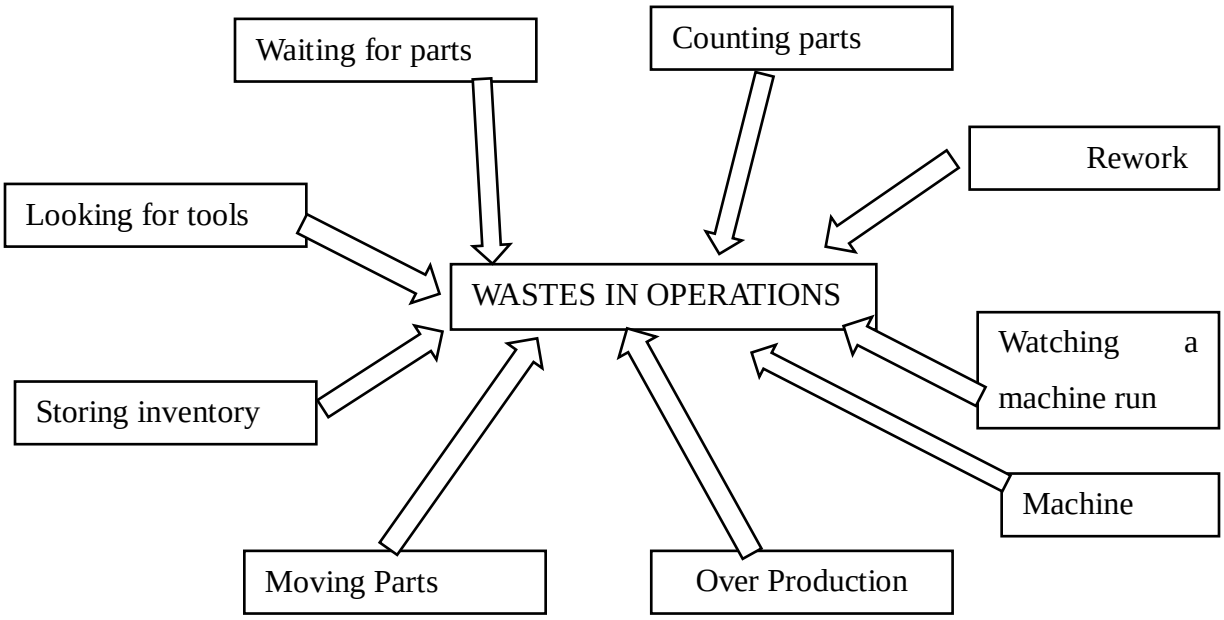
1. Waste of Overproduction Eliminate by reducing set-up times, Timing between processes, layout problems. Make only what is needed now.
2. Waste of Waiting Eliminate bottle necks and balance uneven loads by flexible work force and equipment.
3. Waste of Transportation Establish layouts and locations to make handling and easy if possible. Minimise transportation and handling if not possible to eliminate.
4. Waste of Processing Itself Question regarding the reasons for existence of the product and then why each process is necessary.
5. Waste of Stocks reducing all other wastes reduces stocks.
6. Waste of Motion Study motion for economy and consistency, Economy improves productivityand consistency improves quality. First improve the motions, then mechanize or automate. Otherwise, there is a danger of automating the waste.

7. Waste of Making Defective Products Develop the production process to be prevent defects from being produced, so as to eliminate inspection. At each process, do not accept defects and make no defects. Make the process fail safe. A quantify process always yields quality product

Waste in Operations

Basic Elements Of JIT

1. **Flow Layout-**The physical layout of production facilities is arranged, so that the process flow is streamlined i.e. for each component, the proportion of value added time should be more, there should be minimum queuing and non-value added times. Use of dedicated lines, U shaped or parallel lines, use of small machines is preferred. Flexibility of equipment is essential to adjust quickly to changing market demand



2. Smoothed Build up Rate – The buildup rate should be smooth over a monthly cycle. To achieve this, under capacity scheduling is resorted to so that they can respond to demand changes

3.Mixed Model Scheduling – JIT objective is to match the production rate to demand as closely as possible. One way of doing this is to increase the flexibility of production lines to allow concurrent assembly of different models on the same line.

4.Small Lots and Minimum Set-up Time – The objective of minimizing set-up times is to reduce the batch sizes to the minimum possible. This reduces the manufacturing cycle time and inventory. Use of SMED technique (single minute exchange of dies) is recommended.

5.Buffer Stock Removal- Constant elimination of buffer stocks isemphasized to highlight production problems scheduled by high inventory levels.

6.Kanban Card-It is a pull system of managing material movement comprising of "KanbanCard" based on information system. It helps to trigger the movements of material from one operation to another (next). Merely by alternating the frequency of the circulating Kanban, the production system can be made to adjust to demand fluctuations within limits. The number of cards in the system determine the total inventory. Hence the objective is tominimise the number ifkanbans.

7.Quality-The achievement of high quality levels is a prerequisite of successful JIT. Zero defect, statistical process control, process data collection and worker central quality are commonly used quality Programmes.

8.Product and Process Simplification

This is achieved through

i. Rationalization of product range
ii. Simplification of methods of manufacture
iii. Simplification through component item standardization.

9.Standard Container – JIT emphasize small standardized containers. This simplifies materials movement and use of M.H. equipment.

10.Preventive maintenance- JIT requires removal of causes of uncertainty and waste. Break- down is a major cause of the uncertainty. Rigours preventive maintenance attempts to remove the uncertainty.

11.Flexible Workforce – This is the critical requirements of JIT. Flexible work force is developed through cross training. It is necessary to match production rate and product rate as closely as possible.

12.Organization in Modules or Cells – Many JIT factories are organized in small autonomous modules or cells, each cell being totally responsible for its own production and supply of adjacent module. The cells are designed so that material flow between the cells is minimized.

13.Continuous Improvement – JIT is not one time effort. It is a philosophy of continuous improvement. It seeks the involvement of everyone in the continuous improvement.

14.JIT Purchasing – Materials and components are purchased in accordance with well-defined requirements in terms of quality, quantity and delivery. JIT purchasing vendor development, long term buyer-seller relationship, vendor involvement in design of products high quality if purchased material, frequent part delivery etc. Supplier JIT is a pre requisite in JIT manufacture. The key elements are represented in a table

JIT Philosophy

The roots of the IT system can probable be traced to the Japanese environment. Japan has inherent limitations of lack of space and lack of natural resources. Japanese have developed an aversion towards all kinds of wastes. They view scrap and rework as waste and hence strive for perfect quality. They strongly believe that inventory storage wastes space and results in locking up of valuable materials and capital. Anything that does not contribute value to the product is viewedas waste. Thus, it is quite natural for the JIT Philosophy to develop in Japan. Apart from eliminating wastes JIT has another important feature utilizing the full capacity of workers. Workers in JIT

system are charged with responsibility for producing quality parts just in time to support the next production process.The objective of JIT system is to improve profits and return on investment through cost reductions, inventory reduction and quality improvement. Involvement of workers and elimination of waste are the means of achieving these objectives.

So, JIT manufacturing is a broad philosophy of continuous improvement that includes mutually supportive components such as,

1. People participation and involvement
2. Total quality control
3. Just in time flow

The People Involvement

The stock less production or zero inventories has created an impression that JIT in only inventory program. JIT has a strong human resources management component that must be recognized in order to exploit the full potential of technology component. The success of JIT depends upon how the companies train their human resource to have an appropriate skill, responsibility and co-ordinate and motivate people. JIT seeks to fully utilize the creative talents of employer's suppliers, subcontractors and others who may contribute to the company's improvement. Team discipline and supplier involvement are the important components that contribute to the success of JIT.

Total Quality Control (TQC):

Total Quality Control refers to the achievement and improvement in quality in a JIT company, which involve every department and each employee in the company. All employees should seek ways to serve the final customer better so that the company can remain competitive.

Internal Customer Concept – JIT companies believe in broad definition of a customertraditional organization define that customer is a person outside the company who buys and uses the products and services. JIT companies add to this definition the

concept of immediate customer (or internal customer) who is the next person or department or process who uses or further processes them. If each worker sends only defect free items to his immediate customer, no defective in products will be produced.

Quality at Source – each employee is given the responsibility for quality at his workstation Employees are trained in quality principles and testing procedures. They inspect their own words ensure that the defectives are not passed onto the next process. The defective element is more easily detected by the immediate customer than by the person who is responsible for it. E.g. a part may not fit in to the assembly if it is not properly made. A procedure called “JIDOKA” is brought in to effect. Any employee who senses that a process is producing defects or is about to go out of proper specification has the authority and the responsibility to stop the process. The concept behind this that it is better to stop the production rather than producing defects.

TQC is a Culture Not a Program

The TQC philosophy aims at the culture of continuous improvement in which people always strive to do better. Companies continue to look for incremental product improvements and process refinements. The objective here is reducing variability in processes and in parts because it is the variation, which makes the product deviation from quality, Total quality efforts extend to suppliers. When supplier’s quality reaches a consistently high quality, there is no need for the supplier to go through incoming inspection.

JIT Flow

A queue in front of the work center represents the WIP. Any form of inventory is a waste as per the JIT philosophy when the queues are long, the cost of holding the WIP becomes high and the time required for a job to flow through the required work centers becomes excessive. The major objective of JIT is to have only the right item at the right place at the right time. This practice reduces the WIP and hence the working capital requirement but also the floor space and the flow through time. Thus, the important aspects that support the JIT flow are

- Uniform production rate and mixed model assembly.
- Pull method of co-coordinating work centers.
- Quick and inexpensive set ups.
- Multi skilled work force and flexible facilities.
- High quality levels with no rejects or reworks.

Benefits of JIT

The most significant benefit of JIT is to improve the responsiveness of the formto the changes in the market place thus providing an advantage in competition. The benefits are

1. Product Costis greatly reduced due to reduction of manufacturing cycle tirne, reduction waste and inventories and elimination of non value added operations.
2. Quality – is improved because of continuous quality improvement programmes. 3. Quality-Due to fast response to engineering change, alternative designs can be quickly on the shop floor.
3. Productivity improvement
4. Higher production system flexibility
5. Administrative and ease and simplicity

3.10. MAINTENANCE:

Maintenance is concerned with those actions taken by a system user to maintain an existing systems or facilities in order to restore it to an operating condition. **Maintainability** is concerned with those actions taken by a system or facility during developmentso that the system or facility when installed and operated can be maintained with eases. That is maintainability means design for ease of maintenance. It is a characteristic of system design that determines the ability of a system to be retained in (preventive maintenance) or restored to (corrective maintenance) an effective operational condition. Here the manufacturer of a facility has to take care while

designing the equipment or facility, so that the parts/components susceptible to breakdown are easily accessible for inspection and repair during maintenance. This is generally termed as design for maintenance.

Reliability is the capability of a system to achieve a standard performance and to maintain that standard for a period of time intended under the operating conditions encountered during the system's up time. Maintainability, on the other hand is concerned with the system's down time. So, reliability and maintainability are different but complementary engineering disciplines, which determine the system's operational readiness, often called availability

3.11. BASIC TYPES OF MAINTENANCE

Maintenance can be classified as:

(1) Capital Replacement,

(ii) Provision of stand-by facility,

(iii) Break down maintenance,

(iv) Scheduled maintenance,

(v) Predictive maintenance,

(vi) Planned maintenance, and

(vii) Preventive maintenance.

CAPITAL REPLACEMENT

When equipment or a facility is installed and start working on it, due to wear and tear, some of its component may loose their operating efficiency and productivity of the facility will reduce. More over the percentage of scrap or rework will also increase. This leads to increase in production cost and affects the quality of the products produced. At that time the maintenance department attends to suitable maintenance of the facility and

bring back the operating efficiency of the facility. The efficiency thus obtained maybe somewhat less than the previous efficiency. After a considerableperiod and several maintenance , a situation will arise, that the maintenance cost will increase and it will be found that efficiency of the machine deteriorate and will be better to replace the machine by similar or a better machine. e Maintenance department must workout an appropriate replacement time for each and every equipment.

Stand-by Capacity:

Sand-by capacity is often provided for the items of equipment that critical in production/service tem It is often considered as an economical maintenance practice to install, such spare capacity to put into operation, while the original unit is under repair or is over-hauled. Production; in this edition, is held up only for the period of time required to switch over from one machine to the other machine. A standby, however, ties up capital. But here criticality of production is more important that the capital tied up. This is particularly true in line production system.

Break Down Maintenance:

Here the production facility is run without much routine maintenance until it breakdown. Once the machine breakdown it is taken for repair and inspected to find out the defects. After identifying the defect, the required repair is planned and the spares are procured to repair the machine. As the breakdowns are random in nature and the machine cannot be used during the repair period, production tours are lost hence the productivity is reduced. Repair maintenance is not a recommended practice, in general, but many a time many organizations prefer this, because they do not want to keep the machine idle for maintenance. But they ignore the fact that the break down repair costs more than the regular maintenance practice. It is however, an economical way of maintaining certain non-critical items whose repair and down time costs are less this way than with any other system of maintenance.

Scheduled Maintenance:

Scheduled maintenance is a stitch-in-time procedure aimed at avoiding breakdown. Breakdowns increase the production costs, by reducing the productivity and are not desirable by management. Sometimes they are dangerous to the life of labour also. Scheduled maintenance practice incorporates inspection, lubrication, repair and overhaul of certain equipments, which if neglected can result in breakdown. Scheduled maintenance practice is generally followed for overhauling of machine, cleaning of water tanks and other tanks, whitewashing of buildings and regular lubricating of movable parts of machinery. This type of maintenance is practiced to a certain extent even in those companies, where breakdown maintenance is otherwise a rule. Pre-determination of dates of commencement of work ensures comparatively better allocation of man-power keeping in view the requirements of production and other activities of the maintenance crew. Mere scheduling however, is not sufficient. It cannot ensure completion of work in time because the nature and details of work required to be done remains unknown, It consequently leads to an increased down time due to non availability of requisite skills and material. In such situations, manpower may also remain idle

Planned Maintenance:

Planned Maintenance is an extension to scheduled maintenance practice. Briefly stated, maintenance visualizes the work contained in a future job: determines the best method to be adopted and skills required for its execution; estimates the time, material and costs involved and assign thejobs to individuals or a group of people : programs the work to specific time periods on the basis of priority and after ascertaining production requirements and for release of machine in time. Planned maintenance also provides for a system of feedback of information for necessary changes in the original plan

Preventive Maintenance:

A system of scheduled, planned or preventive maintenance tries to minimize the probable breakdown maintenance. It locates weak parts in all equipments, provides them regular inspire and minor repairs thereby reducing the danger of unanticipated

breakdowns. The underlying pr of preventive maintenance is that prevention is better than care. It involves periodic inspection equipment and machinery to uncover conditions that lead to production breakdown and ha depreciation. The system of preventive maintenance varies from plant to plant depending on te requirement of the plant. Any company, adopting the preventive maintenance should keep the re of failure of various components and equipment, which help the maintenance department to statistic analyze the failure pattern and replace the item before it fails, so that the breakdown can be eliminate This reduces the unanticipated breakdowns, increases the availability of the equipment, maintain optimum productive efficiency of equipment and machinery reduces the work content of maintenance job, increases productivity and safety of life of worker.

Production department or maintenance department depending on the size of the plant generally takes up preventive maintenance work. As the preventive maintenance is a costly affair, it is better to maintain records of cost (both labour, materials used and spares used) and a valuation of the work done by the department will show us what benefits are derived from preventive maintenance. The analytical approach to evaluate the work done by preventive maintenance is

(1) (Inspections incomplete)/ (Inspections scheduled) x 100 should be less than 10%

(2) (Hours worked for maintenance)/(Scheduled hours) × 100 = Performance of the department

(3) Down time to be given as a ratio of the available hours and to be compared against standard to be worked out for each company or against a figure of the past. The ratio is given as:- (Down time in hours) / Available hours (= working days x hours per day x number of machines). Here down time is the total time of stoppage of the machine for scheduled and unscheduled maintenance work.

(4) Frequency of break downs =(Number of break downs)/(Available machine hours) (5) Effectiveness of planning = (Labour hours on scheduled maintenance)/(Total labour

hours spent on maintenance). OR(Down time due to scheduled maintenance) / (Down time due to total maintenance work)

Advantages of preventive maintenance are (1) Reduced breakdowns and downtime, (2) Greater safety to workers, (3) Fewer large scale repairs, (4) Less standby or reserve equipment of spares (5).Lower unit cost of the product manufactured, (6) Better product quality, (7i) Increased equipment life and (8) Better industrial relations.

Predictive Maintenance:

In predictive maintenance, the user of the equipment senses that the equipment is going to give some trouble by hearing to the noise made by the equipment while in operation. For example, consider a two-wheeler. Whenever it gives some uneasy sound, the user immediately stops the vehicle and examines where from the sound is coming. If he can locate it, he takes it to a mechanic gets it repaired. In case, he neglects it, he may have to face a major repair work. Predictive maintenance makes use of human senses or other sensitive instruments such as : Audio gages, Vibration analyzers, Amplitude meters, strain gages to predict troubles before the equipment fail. Predictive maintenance extends the service life of equipment.

A best example of all the above said maintenance is our body. We take care of our body by brushing our teeth every day, taking bath every day, drink clear water and eat healthy and good food that our availability to day-to-day work is more. This we can call as preventive maintenance. We take oil bath once in a week or a fortnight to keep ourselves healthy and have regular health checkups, which may be taken as scheduled maintenance. Sometimes we feel uneasy in breathing and slight body pains, we predict that there will be some trouble in near future and hence consult a doctor and get treatment. This we may consider as predictive maintenance. If we neglect all the above, some day, we will be on bed and major medical treatment is necessary to bring us back to normal condition.

3.12.TYPES OF PLANNED AND PREVENTIVE MAINTENANCE

These types of maintenance are carried out either when the plant is running (on line) or when it is taken down as per an agreed schedule when no production is possible. These may be classified as:

Time Based

It means doing maintenance work at regular time intervals herein the deterioration is linked to time rather than usage. For example, undertaking monthly, quarterly, six-monthly or yearly maintenance work as per the time calendar. Such schedules are easy to monitor. A best example of this may be quoted from maintenance schedules followed in A.P.R.T.C., where we have schedule1, Schedule2, Schedule 3 and so on which are based on time as daily, weekly, monthly etc.

Work based

In this, maintenance work is undertaken after a set number of hours of plant working or processing of certain volume of products on the machine. It is more difficult to monitor. We have to use some kind of auto-counter. Forexample, servicing a vehicle every 2000 kilometers.

Opportunity Based

This implies doing maintenance work when the equipment is available. For example, doing maintenance work on Sunday or weekly-off days or doing maintenance work outside the normal working shifts.

Condition - based

When condition of the machine is such that if we do not maintain it, it may lead to costlybreakdown or equipment failure. Often, all these types of maintenance operate together, overlap or coincide

ORGANIZING MAINTENANCE WORK:

In order to facilitate proper control of maintenance work; we must enforce three rules as below,

Maintenance Request

This must be made in writing to a central point in the organization. No work should be carried out without the knowledge and approval of maintenance supervision - if this discipline is not followed by the organization, it leads to wastage of skilled manpower and inability of the maintenance personnel to schedule essential maintenance work.

Maintenance Stores

Non-availability of vital spare parts when required to meet an emergency like breakdown, may lead to excessive shutdown of the plant and equipment. A large number of items or materials are required to be stored and it involves investing valuable funds from the working capital. A proper stores management is essential as a backup service of good maintenance.

Records Of Maintenance Work Done

Paper work for maintenance is crucial for establishing a good maintenance organization and is often neglected. The records of maintenance work carried out from time to time have to be kept equipment wise. History cards or logbooks of all the plants and equipment must be compiled meticulously giving details of materials used, components replaced and time spent by the workforce. Creation and maintaining this database is essential for proper planning and control, which alone will lead to effective and efficient maintenance management.

TEROTECHNOLOGY

Like most management functions, maintenance work also enjoins a data based management orientation. This has given birth to a new branch of science called terotechnology, which is the application of managerial, financial, engineering and other

practice to physical assets of the organization in pursuit of total maintenance for total life cycle economy. It encompasses the concept of design to discard and focuses on improving reliability and maintainability of all physical assets so as to achieve minimum cost per unit of output and may be considered as the precursor to the modern concept of total productive maintenance system.

TOTAL PRODUCTIVE MAINTENANCE

This is a fresh way to look at our total attitude to maintenance and maintenance management. To be successful with Total Productive Management (TPM), we have to have a complete re-orientation of the roles. Just like Zero Defects Program in Quality Control, we can have Minimum Breakdown Program (MBP). This may be done by Safety Circles or Maintenance Circles, which consists of people from operator and supervisor level to the concerned managers, who meet periodically and chalk out programs to achieve the MBP goal

EQUIPMENT REPLACEMENT

Equipment replacement decisions form the other extreme of the maintenance options open to an organization. When the equipment reaches the end of its useful life, the failure rate begins to increase. Frequent breakdowns are quite likely at this stage. At some point, both preventive maintenance and breakdown maintenance may prove to be expensive. Equipment replacement may be a viable optionat this stage. However, the equipment replacement decision involves heavy capital outlay. Therefore, the cost of other methods of maintenance needs to be compared with that of the annualized cost of the new equipment before a decision is taken. In the case of maintenance related to multiple items of simple components (such as electric bulbs in a factory), group replacement policies may sometimes be more cost effective than individual replacements.

Each of the maintenance alternatives has varying implications for an organization the cost and operational impact of the various alternatives. At one end of the spectrum is routine inspection. It is the least-cost option for maintenance. At the same time, it may

not necessarily restore the working condition of the equipment to its original (new) state. At the other extreme, equipment replacement restores the equipment back to its original state, but at a much higher cost. All other alternatives fall between these two extremes

GROUP REPLACEMENT POLICIES

The logic that we have developed for determination of an optimum PM cycle can be directly applied to another commonly encountered issue in maintenance. In several industrial set- tings, maintenance planners face a classic trade-off involving replacement of just the failed item or the entire set of items even though other items are working normally. For example, in a factory having a high-rise ceiling, lights are mounted at a high point (close to the ceiling). In this case, the cost of reaching the light points (by way of making special gadgets available to reach such a high position) is so high that it is worthwhile to consider replacing all the bulbs. Similarly, if there is an electro-mechanical device having several identical transistors and capacitors that control the logic and kinematics of the device, it may be worthwhile to consider replacing all of them at a time rather than reacting to breakdowns and failures.

In several such situations, the relative costs of the item replaced to the cost of break-down maintenance will determine if a group replacement policy will be worthwhile. Furthermore, these costs will also determine how often such a replacement policy should be pursued so that the overall cost of maintenance is minimized.

Assignment Questions:

PART – A

1. Inventory is essential to _____ in operating a system.

(a) Provide flexibility

(b) Make the product intact

(c) Make employees happy

(d) None of the above

2. In the purchase model of inventory without shortages, the number of orders per year is_____.

(a) Annual demand/lead time

(b) EOQ/annual demand

(c) Annual demand/EOQ

(d) None of the above

3.In the purchase model of inventory, if the standard deviation of the annual demand of a products 100 units and the value of the standard normal statistic for a service

level of 0.9987 is 3,then the ROL is _____.

(a) 100

(b) 200

(c) 300

(d) 400

4. In _____ buying, the purchase decision for a period (say, 1 year) will be takenin advance.

(a) Forward

(b) Tender

(c) Blanket

(d) Zero stock

5. In _____ method of stock accounting, the old stock is depleted first.

(a) FIFO

(b) LIFO

(c) Average cost

(d) Market price

6. _____ is the process of finding an overall score for each of the suppliers basedon the weights of the main criteria and sub-criteria.

(a) Inventory rating

(b) Vendor rating

(c) Buyer rating

(d) None of the above

7. _____ analysis is based on the frequency of use of the items in the stores.

(a) ABC

(b) VED

(c) FSN

(d) SDE

8. In the quantity discount model of inventory, the computation of EOQ will be done only onceif the computed EOQ lies in the _____ price break.

(a) First

(b) Middle

(c) Last

(d) None of the above

9._____ stock accounts for the variation in demand.

(a) Safety

(b) Buffer

(c) Both (a) and (b)

(d) None of the above

10. The formula to determine safety stock in the purchase model of inventory is _____.

(a) Ks

(b) K/s

(c) s/K

(d) None of the above

PART – B

1.Define Integrated materials management.

2.What are the types of inventories?

3.Write a short note on Inventory models.

4.What are the objectives of Material requirement planning(MRP)?

PART – C

1.Explain the Components of Integrated materials management.

2.Discuss briefly about MRP.

3.Explain the classification of inventory

4.List out the basic elements of JIT.

5.What are the basic types of maintenance?

UNIT- 4

DESIGN OF WORK SYSTEMS AND OUALITY CONTROL

WORK STUDY OBJECTIVES PROCEDURE- METHOD STUDY AND MOTION STUDY- WORK MEASUREMENT- TIME STUDY-PERFORMANCE RATING ALLOWANCE FACTORS- STANDARD TIME WORK SAMPLING TECHNIQUES- JOB SEQUENCING AND SCHEDULING. QUALITY CONTROL: PURPOSE OF INSPECTION AND QUALITY CONTROL- DIFFERENT TYPES OF INSPECTION- ACCEPTANCE SAMPLING- THE OPERATING CHARACTERISTIC CURVE- CONTROL CHARTS FOR VARIABLES AND ATTRIBUTES: QUALITY CIRCELS, TQM ,SIX SIGMA, KAIZEN.

Unit Module structuring

12. **Work study**
13. **Method study**
14. **Motion study**
15. **Work measurement**
16. **Time study**
17. **Job sequencing**
18. **Quality control**
19. **Control charts**
20. **Quality circles**
21. **Total quality management**
22. **Six sigma**
23. **Kaizen**

Self- Learning Material Development – STAGE- I

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4.1. WORK STUDY: INTRODUCTION

Work study deals with the techniques of method study and work measurement, which are employed to ensure the best possible use of human, machine and material resources in carrying out a specified activity.

Objective: Work study is concerned with finding better ways of doing work and avoiding waste in all its forms. As such the objective of work study is to assist management to obtain the optimum use of the human, machine and material resources available to the organization for the accomplishment of the work upon which it is engaged.

The objective has three aspects:

- The most effective use of plant and equipment
- The most effective use of human effort
- The evaluation of human work.
- Work study has two broad areas
- Method study and Time study.

4.2. METHOD STUDY

Method Study is concerned with finding the facts about a situation and after a critical examination of these facts, developing a new and better method of doing that work. It is defined as the existing and proposed ways of doing work and the development and application of easier and more productive methods.

Method study must precede time study before any attempt is made to measure and set standards for the various jobs concerned.

It is the systematic recording, analysis and critical examination of existing and proposed ways of doing work and the development and application of easier and new production methods.

Areas of application of method study: It can be applied to any field of work, but the most important areas where it plays a major role in improving productivity are as follows.

- Improved layout of office, working areas of factories
- Improved design of plant and equipment
- Improved use of materials, plant, equipment and manpower
- Most effective handling of materials
- Improved flow of work
- Standardization of methods and procedures.
- Improved safety standards
- Better working conditions

STEPS IN METHOD STUDY:

Methods improvement involves systematic, orderly and scientific approach to problems. One should have an open mind, maintain a questioning attitude, collect all relevant facts, consult others including workers, list reasons/causes for various effects.
Decision must be taken after listing out all alternatives and evaluating them critically. Based on these guidelines, the steps in method study are explained below:

1. **Select:** Select the work to be studied.

2. **Record:** Record all the relevant facts of the present (or proposed) method by directObservation.
3. **Examine:** Examine the facts critically in sequence, using special critical examination sheet.
4. **Develop:** Develop the best methodize. The most practical, economic and effective method. Under prevailing circumstances.
5. **Install:** Install that method as standard practice.
6. **Maintain:** Maintain that standard practice by regular routine check.

4.3.MOTION STUDY

Motion study is the systematic study of the human motions used to perform an operation. The purpose is to eliminate unnecessary motions and to identify the best sequence of motions for the maximum efficiency. Hence, motion study can be an important avenue for productivity improvements. Present practice evolved from the work of Frank Gilbreth, who originated the concepts in the bricklaying trade in the early 20th century. Through the use of motion study techniques, Gilbreth is generally credited with increasing the average number of bricks laid per hour by a factor of 3, even though he was not a bricklayer by trade, when you stop to realize that bricklaying had been carried on for centuries, Gilbreth's accomplishment is even more remarkable.

There are a number of different techniques that motion study analysts can use to develop efficient procedures. The most-used techniques are the following:

1. Motion study principles
2. Analysis of therbligs
3. Micromotion study
4. Charts

Gilbreth's work laid the foundation for the development of **motion study principles**, which are guidelines for designing motion-efficient work procedures. The guidelines are divided into three categories: principles for use of the body, principles for arrangement

of the workplace, and principles for the design of tools and equipment. In developing work methods that are motion efficient, the analyst tries to:

1. Eliminate unnecessary motions
2. Combine activities
3. Reduce fatigue
4. Improve the arrangement of the workplace
5. Improve the design of tools and equipment

THERBLIGS are basic elemental motions. The term therblig is Gilbreth spelled backward (except for the therblig). The approach is to break jobs down into basic elements and base improvements on an analysis of these basic elements by eliminating, combining, or rearranging them.

Although a complete description of therbligs is outside the scope of this text, a list of some common ones will illustrate the nature of these basic elemental motions:

- **Search** implies hunting for an item with the hands and/or the eyes.
- **Select** means to choose from a group of objects.
- **Grasp** means to take hold of an object.
- **Hold** refers to retention of an object after it has been grasped.
- **Transport load** means movement of an object after hold.
- **Release load** means to deposit the object.

Some other therbligs are **inspect, position, plan, rest, and delay,**

Describing a job using therbligs often takes a substantial amount of work. However, for short, repetitive jobs, therbligs analysis may be justified.

Frank Gilbreth and his wife, Lillian, an industrial psychologist, were also responsible for introducing motion pictures for studying motions, called **micromotion study**. This approach is applied not only in industry but also in many other areas of human endeavor, such as sports and health care. Use of the camera and slow-motion replay

enables analysts to study motions that would otherwise be too rapid to see. In addition, the resulting films provide a permanent record that can be referred to, not only for training workers and analysts but also for settling job disputes involving work methods.

The cost of micromotion study limits its use to repetitive activities, where even minor improvements can yield substantial savings owing to the number of times an operation is repeated, or where other considerations justify its use (e.g., surgical procedures).

Motion study analysts often use charts as tools for analyzing and recording motion studies. Activity charts and process charts such as those described earlier can be quite helpful. In addition, analysts may use a **SIMO CHART**to study simultaneous motions of the hands. These charts are invaluable in studying operations such as data entry, sewing, surgical and dental procedures, and certain assembly operations.

4.4. WORK MEASUREMENT

Job design determines the content of a job, and methods analysis determines how a job is to be performed. **Work measurement** is concerned with determining the **length of time** it should w take to complete the job. Job times are vital inputs for capacity planning, workforce planning, estimating labor costs, scheduling, budgeting, and designing incentive systems. Moreoverfrom the workers' standpoint, time standards reflect the amount of time it should take to do a given job working under typical conditions. The standards include expected activity time plus allowances for probable delays.

A standard time is the amount of time it should take a qualified worker to complete a specified task, working at a sustainable rate, using given methods, tools and equipment, raw material inputs, and workplace arrangement. Whenever a time standard is developed for a job, it is essential to provide a complete description of the parameters of the job because the actual time to do the job is sensitive to all of these factors; changes in any one of the factors can materially affect time requirements. For instance, changes in product design or changes in job performance brought about by a methods study should trigger a new timety to update the standard time. As a practical matter,

though, minor changes are occasion- made that do not justify the expense of restudying the job. Consequences are occasion in many jobs may be slightly inaccurate. Periodic time studies may be used to update the standards.

Organizations develop time standards in a number of different ways. Although some small manufacturers and service organizations rely on subjective estimates of job times, the most commonly used methods of work measurement are (1) stopwatch time study, (2) historical times, (3) predetermined data, and (4) work sampling.

DEFINITION

Work measurement is also called by the name “Time study “Work measurement is a absolutely essential for both the planning and control of operations. Without measurement data, we can determine the capacity of facilities or it is not possible to quote delivery dates or costs. We are in a position to determine the rate of production and also labourutilisation and efficiency. It may not be possible to introduce incentive schemes and standard costs for budget control.

Time study has been defined by **British standard institution** as “The application of techniques designed to establish the time for a qualified worker to carryout a specified job at a defined level of performance.”

OBJECTIVES OF WORK MEASUREMENT

The use of work measurement as a basis for incentives is only a small part of its total applicant.

The objectives of work measurement are to provide a sound basis for:

1. Comparing alternative methods.
2. Assessing the correct initial manning (manpower requirement planning)
3. Planning and control
4. Realistic costing

5. Financial incentive schemes
6. Delivery date of goods.
7. Cost reduction and cost control
8. Identifying substandard workers
9. Training new employees.
10. Repetitive Work:The type of work in which the main operation or group of operationsrepeat continuously during the time spent at the job. These apply to work cycles of extreme short duration.
11. 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:

12. Time study (stop watch technique)
13. Synthesis
14. Work sampling
15. Analytical estimating
16. Predetermined motion and Time study

4.5. TIME STUDY

Time Study is concerned with the establishment of time standards for a qualified worker to perform a specified job at a defined level of performance.

Time study and work sampling involve direct observation and the remaining are data based and analytical in nature analytical in nature.

A work measurement techniques for recording the times and rates of working for the elements of a specified job carried out under specified conditions and for analysing the

datas as to determine the time necessary for carrying out the job at the defined level of performance

Synthetic Data: A work measurement technique for building up the time for a job or parts of the job at a defined level of performance by totalling element times obtained previously from time studies on other jobs containing the elements concerned or from synthetic data

Work Sampling : 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.

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).

Analytical Estimating

A work measurement technique, being a development of estimating, whereby the time required. To carry out elements of a job at a defined level of performance is estimated partly from knowledge and practical experience of the elements concerned and partly from synthetic data.

STEPS IN MAKING TIME STUDY

Stop watch time is the basic technique for determining accurate time standards. They are economical for repetitive type of work.

Steps in taking the time study are:

1. Select the work to be studied.
2. Obtain and record all the information available about the job, the operator and the working conditions likely to affect the time study work.
3. Break down the operation into elements. An element is a distinct part of a specified activity composed of one or more fundamental motions selected for convenience of observation and timing
4. Measure the time by means of a stop watch, taken by the operator to perform each element of the operation. Either continuous method or snap back method of timing could be used.
5. At the same time, asses the operators effective speed of work relative to the observer's concept of "Normal" speed. This is called performance rating
6. Adjust the observed time by rating factor to obtain Normal time for each element

Normal Time = Observed X Rating /100

7. Add the suitable allowances to compensate for fatigue, personal needs, contingencies etc. to give standard time for each element.
8. Compute allowed time for the entire job by adding elemental standard times considering frequency of occurrence of each element
9. Make a detailed job description describing the method for which the standard time is established
10. Test and review standards where necessary.

4.6. PERFORMANCE RATING

Performance ratings or rankings are a common practice in employee performance appraisals. It involves assigning a rating or ranking to employees based on their performance evaluation. This rating or ranking helps to measure employees' performance and allows managers to compare employees against each other. It can

also be used to identify areas for improvement and reward higher performing employees.

Key points to understand about performance rating or ranking:

- Evaluation criteria
- Rating scales
- Comparative ranking
- Calibration meetings
- Impact on rewards and decisions
- Fairness and objectivity
- Continuous improvement

4.7. ALLOWANCES

The normal time for an operation does not contain any allowances for the worker it is impossible to work throughout the day even though the most practicable, effective method has been developed. Even under the best working method situation, the job will still demand the expenditure of human effort and some allowance must therefore be made for recovery from fatigue and for relaxation. Allowances must also be made to enable the worker to attend to his personal needs.

The allowances are categorised as:

- ❖ Relaxation allowance
- ❖ Interference allowance
- ❖ Contingency Allowance

RELAXATION ALLOWANCE:

Relaxation allowances are calculated so as to allow the worker to recover from fatigue.

Relaxation allowance is a addition to the basic time intended to provide the worker with the opportunity to recover from the physiological and psychological effects of carrying out specified work under specified conditions and to allow attention to personal needs. The amount of allowance will depend on nature of the job.

Relaxation allowances are of two types – fixed allowances and variable allowances

FIXED ALLOWANCES CONSTITUTE:

a. Personal needs allowance. It is intended to compensate the operator for the time necessary to leave. The work place to attend to personal needs like drinking water, washing hands. Women require longer personal allowance than men. A fair personal allowance is 5 % for men and 7% for women

b. Allowances for basic fatigue. This allowance is given to compensate for energy expended during working. A common figure considered as allowance is 4% of the basic time.

VARIABLE ALLOWANCE

Variable allowance is allowed to an operator who is working under poor environmental conditions that cannot be improved, added stress and strain in performing the job.

The variable fatigue allowance is added to the fixed allowance to an operator who is engaged on medium and heavy work and working under abnormal conditions. The amount of variable fatigue allowance varies from organisation to organisation.

INTERFERENCE ALLOWANCE

It is an allowance of time included into the work content of the job to compensate the operator for the unavoidable loss of production due to simultaneous stoppage of two or more machines being operated by him. This allowance is applicable for machine or process controlled jobs.

Interference allowance various in proportion to number of machines assigned to the operator. The interference of the machine increases the work content.

CONTIGENCY ALLOWANCE

A contingency allowance is a small allowance of time which may be included in a standard time to meet legitimate and expected items of work or delays, the precise measurement of which is uneconomical because of their infrequent or irregular occurrence

This allowance provides for small unavoidable delays as well as for occasional minor, extra work

Some of the examples calling for contingency allowance are

• Tool breakage involving removal of tool from the holder and all other activities to insert new tool in to the tool holder.

• Power failures of small duration

• Obtaining the necessary tools and gauges from central tool store. Contingency allowance should not exceed 5%.

POLICY ALLOWANCE

Policy allowances are not the genuine part of the time study and should be used with utmost care and only in clearly defined circumstances.

The usual reason for making the policy allowance is to line up standard times with requirements of wage agreement between employers and trade unions.

The policy allowance as defined by ILO.

A policy allowance is an increment, other than bonus increment, applied to a standard time (or to some constituent part of it, e.g. work content) to provide a satisfactory level of earnings for a specified level of performance under exceptional

circumstances. Policy allowances are sometimes made as imperfect functioning of a division or part of a plant.

4.8. STANDARD TIME

The length of time it should take a qualified worker using appropriate process andtools to complete a specific job. Actual time is the time a particular employee actually takes to perform a particular job operation.Normal time is the time needed to complete an operation by an employee working at efficiency having no delays.

4.9. WORK SAMPLING

Work sampling was originally developed by L.H.C. Tippett in Britain in 1934 for the British Cotton Industry Research Board. Work sampling is a fact finding tool.

Work sampling is defined as.

"A technique in which a statistically competent number of instantaneous observations aretaken, over a period of time, of a group of machines, processes or workers. Each observation recorded for a particular activity or delay is a measure of the percentage of time observed by the occurrence."

Work sampling has three main applications

1. Activity and delay sampling – to measure the activities and delays of workers or machine. E.g. the percentage of time in a day, a person is working and the percentage that a person is not working.

2. Performance sampling – to measure working time and non working time of a person manual work, and to establish a performance index or performance level for a person duringhis working time

3.Work measurement- under certain circumstances, to measure a manual task, that is, to establish a time standard for an operation.

Procedure for conducting a work sampling study.

The following steps are involved in making sampling study;

1.Decide on the objective of the study- It is very important to first set the objectives of study as the duration of the study, number of observations, the design study sheet and elemental breakdown depends upon the objective.

2.Obtain the approval of the supervisor of the department in which work study is to be conducted. Make sure that the operators to be studied and the other people in the department understand the purpose of the study. Obtain their co-operation.

3.Decide upon work and delay elements – Work and delay elements represent the headings under which the observations are to be recorded. The nature of the work and delay elements differ from company to company depending upon the objective of the study and the work.

4.Decide upon the duration of the study – The duration of study depends upon the objective, number of observers, the accuracy desired and the frequency of occurrence of the activity

5. Determine the desired accuracy of results – This may be stated as the standard error of a percentage or desired accuracy. The confidence level is also to be stated.

6.Make a preliminary estimate of the percentage occurrence of the activity or delay to be measured.

7.Design the study.

(a)Determine number of observations to be made

(b) Determine number of observers needed.

(c) Determine the number of days or shifts needed for the study.

(d) Make the detailed plans for taking observations.

(e) Design the observation form

8.Make the observations according to the plan, analyse and summarise the data.

9. Check the accuracy or precision of the data at the end of the study

10. Prepare the report and state conclusions.

Advantages of work sampling compared to time study

1.Many operations or activities which are impractical or costly to measure by time study can be measured by work sampling
2.A simultaneous work sampling study of several operators or machines may be made by a single observer.
3.It usually requires lesser man-hours and costs less to make a work sampling study instead of making a continuous time study.
4.Observations may be taken over a period of days or weeks thus reducing the chances of day to day variations affecting results.
5.Any interruption during study will not affect the results.
6.Work sampling measurements may be made with a pre assigned degree of reliability.
7.Work sampling studies are preferred to continuous time studies by the operators being studied
8.A stop watch is not needed for work sampling studies
9.Work sampling studies are cause less fatigue and are less tedious.

Disadvantages of work sampling.

1. Work sampling is uneconomical for short cycle jobs.
2. It is also uneconomical for studying a single workman or even small group of workmen or machines.
3. Time study permits a finer break down of activities and delays than is possible with work sampling study
4. Workman may change their normal pattern of working on seeing the observer, making the sampling study of very little value.
5. Insufficient observations are likely to produce inaccurate results.
6. It does not normally account for speed of the operator.

4.10.SEQUENCING

Sequencing is the ability to put things in order to decide how you go about doing something. It may involve thinking about how different options will work out: likely outcomes and consequences.

Our existing experiences and knowledge and problem solving skills are used to help work out the best thing to do. The decisions that are made allow the person to plan and to work out the order they want to do things in: to sequence their actions.

Monitoring

As a plan is put into action, the person needs to check that things are working out the way they wanted. If something unexpected happens, they might need to change the plan half way through, e.g., meeting a friend while shopping and stopping to chat, might mean that plans need to change.

Plans need to be monitored to check that everything will get done and that goals will be achieved. This is done in 'real time' i.e., as we go along. If a need to change is noticed, the cycle of problem solving and planning may start again.

4.11.SCHEDULING

It is the process of arranging, controlling and optimizing work and workloads in a production process or manufacturing process. Scheduling is used to allocate plant and machinery resources, plan human resources, plan production processes and purchase materials.

It is an important tool for manufacturing and engineering, where it can have a major impact on the productivity of a process. In manufacturing, the purpose of scheduling is to minimize the production time and costs, by telling a production facility when to make, with which staff, and on which equipment. Production scheduling aims to maximize the efficiency of the operation and reduce costs.

Key concepts in scheduling

Inputs : Inputs are plant, labor, materials, tooling, energy and a clean environment.

Outputs: Outputs are the products produced in factories either for other factories or for the end buyer. The extent to which any one product is produced within any one factory is governed by transaction cost.

Output within the Factory : The output of any one work area within the factory is an input to the next work area in that factory according to the manufacturing process. For example, the output of cutting is an input to the bending room.

Output for the Next Factory : By way of example, the output of a paper mill is an input to a print factory. The output of a petrochemical plant is an input to an asphalt plant, a cosmetics factory and a plastics factory.

Output for the end Buyer : Factory output goes to the consumer via a service business such as a retailer or an asphalt paving company.

Resource Allocation : Resource allocation is assigning inputs to produce output. The aim is to maximize output with given inputs or to minimize quantity of inputs to produce required output.

First come, first served

- First in, first out (FIFO), also known as first come, first served (FCFS), is the simplest scheduling algorithm.
- FIFO simply queues processes in the order that they arrive in the ready queue. This is commonly used for a task queue.
- Since context switches only occur upon process termination, and no reorganization of the process queue is required, scheduling overhead is minimal.
- Throughput can be low, because long processes can be holding the causing the short processes to wait for a long time (known as the convoy effect).

- No starvation, because each process gets chance to be executed after a definite time.
- Turnaround time, waiting time and response time depends on the order of their arrival and can be high for the same reasons above.
- No prioritization occurs, thus this system has trouble meeting process deadlines.
- The lack of prioritization means that as long as every process eventually completes, there is no starvation. In an environment where some processes might not complete, there can be starvation.
- It is based on queuing.
- It is non preemptive.

Priority scheduling

Earliest deadline first (EDF) or least time to go is a dynamic scheduling algorithm used in real-time operating systems to place processes in a priority queue. Whenever a scheduling event occurs (a task finishes, new task is released, etc.), the queue will be searched for the process closest to its deadline, which will be the next to be scheduled for execution.

Shortest remaining time first

Similar to shortest job first (SJF). With this strategy the scheduler arranges processes with the least estimated processing time remaining to be next in the queue. This requires advanced knowledge or estimations about the time required for a process to complete.

If a shorter process arrives during another process' execution, the currently running process is interrupted (known as pre-emption), dividing that process into two separate computing blocks. This creates excess overhead through additional context switching. The scheduler must also place each incoming process into a specific place in the queue, creating additional overhead.This algorithm is designed for maximum throughput in most scenarios.

Waiting time and response time increase as the process's computational requirements increase. Since turnaround time is based on waiting time plus processing time, longer processes are significantly affected by this. Overall waiting time is smaller than FIFO, however since no process has to wait for the termination of the longest process.

No particular attention is given to deadlines, the programmer can only attempt to make processes with deadlines as short as possible.Starvation is possible, especially in a busy system with many small processes being run.To use this policy we should have at least two processes of different priorityHowever, a different variation of SJF called as SRTF(shortest remaining time first) is also there which is pre-emptive in nature.

Fixed priority pre-emptive scheduling

The operating system assigns a fixed priority rank to every process, and the scheduler arranges the processes in the ready queue in order of their priority. Lower-priority processes get interrupted by incoming higher-priority processes.Overhead is not minimal, nor is it significant.FPPS has no particular advantage in terms of throughput over FIFO scheduling.If the number of rankings is limited, it can be characterized as a collection of FIFO queues, one for each priority ranking. Processes in lower- priority queues are selected only when all of the higher-priority queues are empty.

Waiting time and response time depend on the priority of the process. Higher-priority processes have smaller waiting and response times.Deadlines can be met by giving processes with deadlines a higher priority.Starvation of lower-priority processes is possible with a large number of high-priority processes queuing for CPU time.

Round-robin scheduling

The scheduler assigns a fixed time unit per process, and cycles through them. If process completes within that time-slice it gets terminated otherwise it is rescheduled after giving a chance to all other processes. Each cycle of time is known as quantum. RR scheduling involves extensive overhead, especially with a small time unit.Balanced

throughput between FCFS/ FIFO and SJF/SRTF, shorter jobs are completed faster than in FIFO and longer processes are completed faster than in SJF.

Good average response time, waiting time is dependent on a number of processes, and not average process length.Because of high waiting times, deadlines are rarely met in a pure RR system.Starvation can never occur, since no priority is given. Order of time unit allocation is based upon process arrival time, similar to FIFO.If Time-Slice is large it becomes FCFS /FIFO or if it is short then it becomes SJF/SRTF.

Multilevel queue scheduling

This is used for situations in which processes are easily divided into different groups. For example, a common division is made between foreground (interactive) processes and background (batch) processes. These two types of processes have different response-time requirements and so may have different scheduling needs. It is very useful for shared memory problems.

Loading

A load means the quantity of work, and allocating the quantity of work to the processes necessary to manufacture each item is called loading.

It is performed in the CRP (Capacity Requirements Planning) of the manufacturing planning. Each item planned in MRP is first explored to the processes necessary to manufacture it, which is usually called process explosion. Next loading is performed for the explored process. In loading, each load is usually piled up by time (hour), by which a setup time and a real operating time are determined. The real operating time may be set by manufacturing lot or by real operating time per item unit. In the former case, the time of hour is piled up as load, while in the latter case, loading is performed after calculating the real operating time per manufacturing unit by multiplying the number of manufacturing items by real operating time.

In addition, the calculated load is piled up for a certain period, which is determined by selecting either the earliest start date or the last start date as a base date. This method

enables loading for each process or each period.Load planning encapsulates the various ways of loading a consignment, whether to have pallets, whether single units. There can be a mix of various units-pallets + single units + barrels etc. Also there might be different kind of requirements of certain consignment like refrigeration, liquid holding; all these can be planned to be transported even in a single vehicle. Load planning has a great impact on the cost of transportation for the client, for the transporter it has an impact on the transit time.

4.12. QUALITY CONTROL

INTRODUCTION

In any business organization, profit is the ultimate goal. To achieve this, there are several approaches. Profit may be maximized by cutting costs for the same selling price per unit. If it is a monopolistic business, without giving much of importance to the cost reduction programmes, the price may be fixed suitably to earn sufficient profit. But, to survive in a competitive business environment, goods and services produced by a firm should have the minimum required quality. Extra quality means extra cost. So, the level of quality should be decided in relation to other factors such that the product is well absorbed in the market. In all these cases, to have repeated sales and thereby increased sales revenue, no one will deny the fact that the basic quality is considered to be one of the supportive factors.

Quality is a measure of how closely a good or service conforms to specified standard.

Quality standards may be any one or a combination of attributes/variables of the product being manufactured. The attributes will include performance, reliability, appearance, commitment to delivery time, etc. Variables may be some measurement variables like, length, width, height, diameter, surface finish, etc.

Most of the above characteristics are related to products. Similarly, some of the quality characteristics of services are: meeting promised due dates, safety, comfort, security, less waiting time and so forth. So, the various dimensions of quality are

performance, features, reliability, conformance, durability, serviceability, aesthetics, perceived quality, safety, comfort, security, commitment to due dates, less waiting time, etc. Quality assurance is the system of policies, procedures and guidelines which help in building specified standards of product/service quality.

NEED FOR CONTROLLING QUALITY

In the absence of quality, the following will result:

(a) No yardstick for comparing the quality of goods/services.

(b) Difficulty in maintaining consistency in quality.

(c) Dissatisfied customers due to increased maintenance and operating costs of products/ services.

(d) Increased rework cost while manufacturing products/providing services.

(e) Reduced life time of the products/services.

(f) Reduced flexibility with respect to usage of standard spare parts.

Hence, controlling quality is an essential activity.

DEFINITION OF A QUALITY SYSTEM

There is no simple way to define a quality system. In general, a quality system is a part of overhead. The system does not add any value to the products. It only ensures that the product works and meets customer expectations. Suppliers do not always ship quality parts that are used to manufacture the product, and the process is never constant. Then there is a possibility of the associated workers/ people making mistakes inadvertently. All these problems need to be looked into so that the quality specifications are strictly adhered to.

A quality system is a process that combines with manufacturing process to ensure that a manufacturing process produces quality-perfect products. The scope of a quality system is more than a manufacturing process. A quality system covers areas

related to the suppliers who produce parts for the product. It also covers other departments in the company to ensure that customers are properly informed, trained and serviced whenever problems are presented. Finally, it covers the design department to ensure that products are designed to specifications and they perform as intended.

Strategic areas of quality control programme in manufacturing are as follows:

- ★ Supplier quality
- ★ Incoming raw materials quality
- ★ Process quality
- ★ Final inspection
- ★ Customer quality

Statistical quality control deals with decisions related to the functions of specification, production or inspection.

The basic components of product quality are listed below:

- Careful consideration of product design specifications.
- Adequate inspection procedures for manufactured or assembled products.
- Acceptance procedures for purchased raw materials and parts, and control practices to maintain quality levels in in-process stage.
- Commitment from top management, lower levels of management and supervisors towards quality.
- Formulation for quality assurance procedures which are necessary to integrate and coordinate all these functions.

TYPE OF DATA

The measurement data in statistical quality control can be classified into variable data and attribute data.Variable data are continuous in nature and are measurable on a sliding scale. These data can have a range of values and provide more information than the attribute data. Examples of variable data are: dimension, voltage, weight,

etc.Attribute data are discrete in nature and can be binary. An example of attribute data is an accept/reject test of a shaft using Go/NoGo gauges.

4.13.INSPECTION

Inspection means checking, checking the materials, products or Manufacture Inspection components at various stages in includes the interpretation of a specification, measurement and comparison to check whether the product conforms to the set standards or not. In short, inspection means sorting out good products from bad products.

Inspection Activities

1.**Incoming (Receiving) Inspection –** Inspection of incoming materials and component pants ensure that they are as per the specifications required.

2.**In Process Inspection –** Inspection of raw materials as it goes from one operation to another

3. **Finished Goods Inspection –** Final inspection of products to detect the defects and its sources and it carries out tests to ensure that the product performs its intended functions.

4. **Planning of inspection involves the decision where to inspect-** To decide the location one has to take into account the cost of inspection and benefits of inspecting.

4.14.SELECTION OF INSPECTION POINTS (STATIONS)

1. Inspect before costly operation in order to avoid high processing costs of defective items.

2.Inspect before any series of operations during which inspection will be difficult or costly.

3.Inspect after operations, which generally result in high rate of defective.

4. Inspect before points at which potential damage may be caused.

5. Inspect before 'points of no return' after which no rectification is possible.

6.Inspect before a change in quality responsibility e.g. between departments.

Distinction between Inspection and Quality Control

Quality control is a broad term which encompasses many including inspection. Inspection is Concerned with quality of past production e.g. if the foundry is required to produce 1000 castings which are good. Then the inspector will check whether these castings are o.k. as per specification or not. If not, they will be rejected. In quality control, the concern is for future production, as the castings are being produced, periodic inspections are carried out from the lot and castings in each sample are inspected for quality. If the items in the sample are satisfactory, production will continue otherwise corrective action is taken immediately.

Thus, quality control is a broader activity including inspection and many other activities to build and regulate the quality in to the product.

4.15. ACCEPTANCE SAMPLING

The objective of acceptance sampling is to take decision whether to accept or reject a lot based on sample's characteristics. The lot may be incoming raw materials or finished parts.

An accurate method to check the quality of lots is to do 100% inspection. But, 100% inspection will have the following limitations:

- The cost of inspection is high.
- Destructive methods of testing will result in 100% spoilage of the parts.
- Time taken for inspection will be too long.
- When the population is large or infinite, it would be impossible or impracticable to inspect each unit.

Hence, acceptance sampling procedure has lot of scope in practical application. Acceptance sampling can be used for attributes as well as variables.

Acceptance sampling deals with accept or reject situation of the incoming raw materials and finished goods. Let the size of the incoming lot be N and the size of the sample drawn be n. The probability of getting a given number of defective/good parts out of a sample consisting of n pieces will follow Binomial Distribution. If the lot size is infinite or very large, such that when a sample is drawn from it and not replaced, then the usage of binomial distribution is justified. Otherwise, we will have to use hyper-geometric distribution.

Specifications of a single sampling plan will contain a sample size (n) and an acceptance number C. As an example, if we assume the sample size as 50 and the acceptance number as 3, the interpretation of the plan is explained as follows: Select a sample of size 50 from a lot and obtain the number of defective pieces in the sample. If the number of defective pieces is less than or equal to 3, then accept the whole lot from which the sample is drawn. Otherwise, reject the whole lot. This is called single sampling plan. There are several variations of this plan.

In this process, one will commit two types of error, viz. type I error and type II error. If the lot is really good, but based on the sample information, it is rejected, then the supplier/producer will be penalized. This is called producer's risk or type I error. The notation for this error is a On the other hand, if the lot is really bad, but it is accepted based on the sample information, then the customer will be at loss. This is called consumer's risk or type II error. The notation for this error is B. So, both parties should jointly decide about the levels of producer's risk (a) and consumer's risk (β) based on mutual agreement.

4.16. OPERATING CHARACTERISTIC CURVE (O.C. Curve)

The concepts of the two types of risk are well explained using an operating characteristic curve. This curve will provide a basis for selecting alternate sample plans. For a given value of sample size (n), acceptance number (C) . In the above figure, percent defective is shown on x-axis. The probability of accepting the lot for a given per cent defective is shown on y-axis. The value for percent defective indicates the quality

level of the lot inspected. AQL means acceptable quality level. LTPD means lot tolerance percent defectives. These represent quality levels of the lot submitted for inspection. If the quality level of the lot inspected is at AQL or less than AQL, then the customers are satisfied with the quality of the lot. The corresponding probability of acceptance is called 1-alpha

4.17.CONTROL CHARTS

Control charts show the performance of a process from two points of view. First, they show a snap-shot of the process at the moment the data are collected. Second, they show the process trend as time progresses. Process trends are important because they help in identifying the out-of-control status if it actually exists. Also, they help to detect variations outside the normal operational limits, and to identify the causes of variations.

Control Charts for Variable

As the name indicates, these charts will use variable data of a process. X-chart gives an idea of the central tendency of the observations. These charts will reveal the variations between sample observations. R-chart gives an idea about the spread (dispersion) of the observations. This chart shows the variations within the samples.

4.18.CONTROL CHARTS FOR ATTRIBUTES

In many situations, quality measurements are expressed as attributes (good or bad etc.). In such situations, the percent defective chart (P-chart) or the number of defectives per sample area (C-chart) are considered to be more suitable control charts to control the quality. Both charts convey a similar type of information, but P-chart is based on a normal distribution, and the C-chart is based on the Poisson distribution.

4.19. QUALITY CIRCLES

A quality circle or quality control circle is a group of workers who do the same or similar work, who meet regularly to identify, analyze and solve work related problems. Normally small in size, the group is usually led by a supervisor or manager and presents its solutions to management; where possible, workers implement the solutions themselves in order to improve the performance of the organization and motivate employees.

Quality circles were at their most popular during the 1980s, but continue to exist in the form of Kaizen groups and similar worker participation schemes.Typical topics for the attention of quality circles are improving occupational safety and health, improving product design, and improvement in the workplace and manufacturing processes.

Quality circles are typically more formal groups. They meet regularly on company time and are trained by competent persons who may be personnel and industrial relations specialists trained in human factors and the basic skills of problem identification, information gathering and analysis, basic statistics, and solution generation.Quality circles are generally free to select any topic they wish other than those related to salary and terms and conditions of work, as there are other channels through which these issues are usually considered.

Development of Quality Circles

Publicising the Idea: Introduction of QC is just like an organisational change programme Hence, like an organisational change programme, the workers need to be convinced about the need for and significance of QC from the points of view of the workers and the organisation. Moreover, participation in QC being voluntary, its publicity among the workers is necessary. To begin with, management can also arrange for initial training to those workers who want to form a quality circle.

Constitution of QC: Workers doing the same or similar type of work are drawn voluntarily to form quality circle. The membership of a QC is generally restricted to eight

to ten. Once a QC is formed, they remain as permanent members of the circle unless they leave that work area.

Initial Problem Solving: The members of QC should discuss the problem at threadbare and, then, prepare a list of alternative solutions. Thereafter, each alternative solution should be evaluated and the final solution should be arrived at on the basis of consensus.

Presentation and Approval of Suggestions: The final solution arrived at should be presented to the management either in oral or in written form. The management may evaluate the solution by constituting a committee for this purpose. The committee may also meet the members of the quality circle for clarifications, if required. Presentation of solutions to the management helps improve the communication between management and workers and reflects management's interest to the members of QC.

Implementation: Once the suggestion or solution is approved by the management, the same is being put into practice in a particular workplace. Quality circles may be organized gradually for other workplaces or departments also. In this way, following above outlined process, the entire organisation can have quality circles.

4.20. TQM

TQM has been defined in various ways. Some of the important definitions of TQM are given below:

"TQM is the management approach of an organisation, 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 organisation and to society."

. "TOM is an integrated organisational approach in delighting customers (both internal and external) by meeting their expectations on a continuous basis through everyone involved with the organisation working on continuous improvement in all products, services, and processes along with proper problem-solving methodology."

"TQM is the control of all transformation processes of an organisation to best satisfy customers' needs in the most economical manner." -Prof. Leopald S. Vasin

"TQM is a people-focussed management system that aims at continual increase in customer satisfaction at conti- nually lower cost. TQM is a total system approach (not a separate area or programme), and an integral part of high-level strategy. It works horizontally across functions and departments, involving all employees, top to bottom. And exceeds backwards and forwards to include the supply chain and the customer chain."-Total Quality Forum of USA

"TQM is an approach to improving the effectiveness and flexibility of business as a whole. It is essentially a way of organising and involving the whole organisation, every department, every activity, every single at every level."

CHARACTERISTICS OF TQM

The above definitions revealed the following characteristics ofTQM:

✓TQM is a customer oriented.

✓TQM required a long term commitment for continuous improvement of all processes.

✓TQM is a teamwork.

✓TQM requires the leadership of top management and continuous involvement.

✓TQM is a strategy for continuous improving performance at all levels and in all areas of responsibility.

BASIC CONCEPTS OF TQM

A successful TQM programme requires the following six basicConcepts:

1. Top management commitment: Top management should participate and completely involve in the total quality programme. They should ensure their complete commitment to the approach through management meetings, company magazines or newsletters. Also, top management should make sure that everybody within the organisation from top to bottom is communicated about the TQM programme.

2. Focus on the customer: Achieving customer satisfaction is the heart of TQM. Customers include both internal and external customers. So focus on the customer is the key for any TQM programme.
3. Effective involvement and utilisation of the entire work force: This concept is sometimes referred as principle of employees involvement' or 'respect for people'. TQM is a team work. Total quality recognises that each person is responsible for the quality of his work and for the work of the group. All persons must be trained in TQM, Statistical Process Control (SPC), and other appropriate quality improvement skills so that they can effectively participate on quality teams.

4. Continuous improvement: TQM is based on the quest for progress and improvement. TQM believes that there is always a better way of doing things, way to make better use of the company's total quality resources, a way to be more productive. For this purpose various quality tools and techniques may be used.
5. Treating suppliers as partners: Since the suppliers influence the company's quality, therefore a partnering relationship should between the management and the suppliers.

6. Establishing performance measures for the processes: As we know, quantitative data are necessary to measure the continuous quality improvement activity. Therefore performance measures such as uptime, productivity, sales turnover, absenteeism, percent non-conforming, customer satisfaction, etc., should be determined for each functional area. These results can be used for further improvement activities.

PRINCIPLES OF TQM

The important underlying principles of TQM are as follows:

1. Customers' requirements must be met the first time, everytime.
2. There must be agreed requirements, for both internal and external customers.

3. Everybody must be involved, from all levels and across all functions.
4. Regular communication (both formally and informally) with staff at all levels is must. Two way communication at all levels must be promoted.
5. Identifying training needs and relating them with individual capabilities and requirements is must.
6. Top management's participation and commitment is must.
7. A culture of continuous improvement must be established.
8. Emphasis should be placed on purchasing and supplier management.
9. Every job must add value.
10. Quality improvement must eliminate wastes and reduce Total cost.

There must be a focus on the prevention of problems

4.21. SIX SIGMA

Six Sigma as a management standard in product variation be traced back to the work during 1920's mean is the point where a process(presently even for service variation) can when Walter Shewhart showed that three Sigma from the requires correction. Many measurement standards such as zero into force butDefects, later came engineer named Bill Smith. " Six Sigma In the early and mid 1980's, Motorola engineer felt that the traditional quality levels of not provide enough depth of information. TheyCredit for coining the term "Six Sigma" goes to a Motorola " is a federally registered trade mark of Motorola. Measuring defects in thousands of opportunities didDecided to measure the defects per million opportunities. This helped Motorola to achieve bottom line results in their organization which resulted in a savings more than $16 million. Companies around the world, most notably General Electric Company.

Since then, hundreds of have adopted Six Sigma as a way of doing business.

Definition

SixSigma is a disciplined data-driven approach and methodology for eliminatingDefects which amounts to driving towards six standard deviations between the mean and the

nearerSpecification limit in any process (manufacturing/transactional) of products/services. A Six Sigma

Defect is defined as any flaw that inhibits the attainment of customer expectations and specifications. As defined by General Electric company, Six Sigma is a vision of quality which equates with only 3.4 defects per million opportunities for each product or service transaction and it strives for perfection. Six Sigma level indicates that we are 99.99966% confident that the product/service delivered by us is defect free. This means that only 0.00034% of the times the product/service delivered is defect prone. When 0.0000034 is multiplied by one million, it comes to 3.4 defects per millionOpportunities (DPMO).

An “opportunity” is defined as a chance for nonconformance or not meeting the required specifications. This means that we need to be nearly flawless in executing our key processes.

Actual Sigma level =Actual number of defects

Total number of opportunities for the organization to make mistakes from the customer angle

A process is said to be at Six Sigma level provided that the process is not producing more than 3.4 defects per million opportunities. The fundamental objective of Six Sigma methodology is the process improvement and reduction of variation through its application.

At its core, Six Sigma revolves around the following few concepts:

• It is critical to attributes which are most important to the customers. It focuses on the process more specifically what it can deliver.

• It aims for stability of the process which means that it ensures consistent and predictable and processes to improve product quality which is the utmost expectation of the customer

• It focuses on the design for Six Sigma to meet customer needs and process capability. Design for Six Sigma is a systematic methodology, utilizing tools, training and

measurements, to enable us to design products and processes that meet customer expectations and can be produced at Six Sigma quality levels.

Approaches for Six Sigma

There are two approaches for achieving Six Sigma which are as listed below:

- DMADV
- DMAIC

DMAIC means Define, Measure, Analyze, Improve and Control. The Six Sigma DMAIC process is an improvement system for existing processes falling below specification and looking for incremental improvement. It is systematic, scientific and fact based. This closed-loop process eliminates unproductive steps, often focuses on new measurements and applies technology for improvement.

DMADV means Define, Measure, Analyze, Design, and Verify. The Six Sigma DMADV process is an improvement system used to develop new processes or products at Six Sigma quality levels. This can be used even for existing processes if they require more than just incrementalImprovement.

Both DMAIC and DMADV are executed by Six Sigma Green Belts and Six Sigma Black Belts and these are overseen by Six Sigma Master Black Belts. Steps of Six Sigma DMAIC. As already mentioned,DMAIC means Define, Measure, Analyze, Improve and Control.

These are explained in this section.

Step 1: Define

This step establishes a leadership team which will decide on the project on which it will work. It also identifies key considerations like, cost benefits, customer expectations, product quality enhancement and ability of the team to have a positive impact on the process. The specific actionsof this step are listed below:

• Define all your products by making a list of them along with corresponding end results.

• Identify your customers of each end product, make assumptions about what they expect, survey customers to validate assumptions and select a product/project for continuous improvement process.

Step 2: Measure

In this step, the team examines all aspects of the project, develops a thorough understanding of it and identifies the critical requirements and processes. Once this is done, the team defines performance measures for key characteristics and establishes an effective means of measuring them. Then, the measurements of the process to determine current performances are done. The sub-steps are as listed below:

• Define your needs in terms of essential inputs for products/projects selected.

• Set-up quality measures.

Define the method of computing errors/unit, errors/million and actual Sigma level.

• Measure the current performance of the process.

Step 3: Analyze

In this step, the team analyzes the results of this collected data and lays the groundwork for improving the process. This analysis includes identification and quantification of the sources and locations of defect causing variables within the process. These are achieved through defining the work process by flow charting existing process.

Identifying error/defect-producing steps and determining present error rate.

Step 4: Improve

In this step, the team performs the following.

• Designing a plan of action.

• Implementing the plan.

• Monitoring the results for the recommended changes.

• Performing risk assessments on the potential changes.

• Identification of process improvements based on the collected data and analysis

•The improvement of the work process can be achieved by doing the following:

• Lowering the probability of occurrence of mistakes by using suitable statistical quality

Control tools.

Simplification of the process wherever possible.

• Elimination of non-value adding tasks.

• Flowcharting the revised process

Highlighting the importance of Six Sigma and developing necessary skills.

Step 5: Control In

This step, the team reviews the entire process to ensure that the appropriate changes have been made and to identify the actions that will permanently maintain those changes. Further, steps are taken to control future process performance.

Steps of Six Sigma DMADV

The first three steps of DMAIC and DMADV are one and the same except the last two steps. The steps of DMADV are listed below. Though the first three steps of DMADV are same as that of DMAIC, they are fine-tuned with respect to application of Six Sigma to new products or services.

Step 1: Define the project goals and customer (internal and external) deliverables.

Step 2: Measure and determine customer needs and specifications.

Step 3: Analyze the process options to meet the customer needs.

Step 4: Design detailed process to meet the customer needs.

Step 5: Verify the design performance and ability to meet customer needs.

Types of Six Sigma Belts

The Six Sigma Belts are classified into the following categories:

- ✓ Green Belts
- ✓ Black Belts

• Master Black Belts

In addition to these belts, there is one more category known as Six Sigma Champions. Six Sigma Green Belts are Six Sigma team leaders capable of forming and facilitating

Six Sigma teams and managing Six Sigma projects from concept to completion. Typically, Green belt training consists of five days of classroom training and it is conducted in conjunction with Six Sigma team projects. Training covers facilitation techniques and management of meetings, project management, quality management tools, quality control tools, problem solving and exploratory data analysis. Their activities are centred around increasing customer satisfaction levels and business productivity. Green Belts are not full time positions. A Green Belt should be focusing on 1 to 2 projects. Usually, Black Belts help Green Belts in choosing their projects prior to the training, attendTraining with their Green Belts and assist them with their projects after the training.The desirable skills of Green Belts are good problem solving ability, experience in leading aTeam, expertise in project management, competence to apply basic improvement tools, etc.Improving and controlling key processes that influence customer satisfaction and/or productivity growth.

Black Belts are full time positions. They should focus on 1 to 3 projects. Direction and leadership for them should come from a Master Black Belt.

They are technical leaders who are technically oriented individuals held in high regard by their peers. They should be actively involved in the organizational change and development process These candidates may come from a wide range of disciplines and need not be formally trained statisticians or engineers. However, because they are expected to master a wide variety of technical tools in a relatively short period of time, technical leader candidates will probably possess a background in college-level mathematics-the basic tool of quantitative analysis.

Statistical methods should be a prerequisite. Black Belts coach Green Belts and receive coaching and support from Master Black Belts. The desirable skills of Black Belts are customer advocacy, self motivation, positive personality, good communication, project management expertise, technical aptitude, leadership, deep process knowledge, good problem solving ability, result orientation, etc.

Master Black Belts. Master Black Belts are the persons with highest level of technical and organizational proficiency. Because Master Black Belts train Black Belts, they should be sound on mathematical theory on which the statistical methods are based. They must be able to assist Black Belts in applying the methods correctly in unusual situations. Whenever possible, statistical training should be conducted only by Master Black Belts. If it is necessary for Black Belts and Green Belts to provide training, they should only do so under the guidance of Master Black Belts.

Because of the nature of the master's duties, communications and teaching skills should be considered as important as technical competence in selecting candidates. Master Black Belts are full time positions. The desirable skills of Master Black Belts are experience in different areas, analytical and technical competence, advanced statistical knowledge, ability to coach six sigma leaders.

Six Sigma Champions. In addition to different sigma belts, there is one more quality agent who also contributes to Six Sigma efforts, who is known as Six Sigma Champion.

Business leaders who lead Six Sigma by sponsoring projects are called “Champions”. Champions are trained in the essentials of the Six Sigma methodology focusing on selecting the projects that are aligned with business goals. Champions must select and mentor Six Sigma project leaders called ‘Belts”. Champions must support, align and integrate the Six Sigma launch into their organizations.

Benefits of Six Sigma

The benefits of Six Sigma are as listed below:

• It ensures enhanced product quality.

• It enables predictable delivery of the products.

• It helps to achieve productivity improvement.

• It helps to have rapid response to changing needs of customers

• It also facilitates the development and introduction of new products into the marketplace .

4.22. KAIZEN

''Kaizen' refers to a Japanese word which means 'improvement' or 'change for the better'. 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 means 'continuous improvement of processes and functions of an organization through change'. In a layman's language, Kaizen brings continuous small improvements in the overall processes and eventually aims towards organization's success.

Japanese feel that many small continuous changes in the systems and policies bring effective results than few major changes.Kaizen process aims at continuous improvement of processes not only in manufacturing sector but all other departments as well. Implementing Kaizen tools is not the responsibility of a single individual but involves every member who is directly associated with the organization.Every individual, irrespective of his/her designation or level in the hierarchy needs to contribute by incorporating small improvements and changes in the system.

Five S of Kaizen

I. SEIRI-SEIRI stands for Sort Out. According to Seiri, employees should sort out and organize things well. Label the items as 'Necessary', 'Critical', 'Most Important', 'Not needed now', 'Useless' and so on. Throw what all is useless. Keep aside what all is not needed at the moment. Items which are critical and most important should be kept at a safe place.

II. SEITION-Seition means to Organize. Research says that employees waste half of their precious time searching for items and important documents. Every item should have its own space and must be kept at its place only.

III. SEISO-The word "SEISO" means shine the workplace. The workplace ought to be kept clean. De- clutter your workstation. Necessary documents should be kept in proper folders and files. Use cabinets and drawers to store your items.

IV. SEIKETSU-SEIKETSU refers to Standardization. Every organization needs to have certain standard rules and set policies to ensure superior quality.

V. SHITSUKE or Self Discipline-Employees need to respect organization's policies and adhere to rules and regulations. Self discipline is essential. Do not attend office in casuals. Follow work procedures and do not forget to carry your identity cards to work. It gives you a sense of pride and respect for the organization.

Ten principles of Kaizen

1) Let go of assumptions.
2) Be proactive about solving problems.
3) Don't accept the status quo.
4) Let go of perfectionism and take an attitude of iterative, adaptive change.
5) Look for solutions as you find mistakes.
6) Create an environment in which everyone feels empowered to contribute.

7) Don't accept the obvious issue; instead, ask "why" five times to get to the root cause.
8) Cull information and opinions from multiple people.
9) Use creativity to find low-cost, small improvements.
10) Never stop improving.

Kaizen Cycle for Continuous Improvement

Get employees involved: Seek the involvement of employees, including gathering their help in identifying issues and problems. Doing so creates buy-in for change. Often, this is organized as specific groups of individuals charged with gathering and relaying information from a wider group of employees.

Find problems: Using widespread feedback from all employees, gather a list of problems and potential opportunities. Create a shortlist if there are many issues.

Create a solution: Encourage employees to offer creative solutions, with all manner of ideas encouraged. Pick a winning solution or solutions from the ideas presented.

Test the solution: Implement the winning solution chosen above, with everyone participating in the rollout. Create pilot programs or take other small steps to test out the solution.

Analyze the results: At various intervals, check progress, with specific plans for who will be the point of contact and how best to keep ground-level workers engaged. Determine how successful the change has been.

Standardize: If results are positive, adopt the solution throughout the organization.

Repeat: These seven steps should be repeated on an ongoing basis, with new solutions tested where appropriate or new lists of problems are tackled.

ASSIGNMENT QUESTIONS

PART-A

1. The alternative of each of the flow process charts which has the

_____ ratio between number of operations and inspection' divided by

'the total number symbols used in the chart as the best alternative.

(a) Minimum

(b) Maximum

(c) Average

(d) None of the above

2. _____ is concerned with finding the facts about a situation and

Affects a critical examination of these facts, developing a new and better method

of doing that work.

(a) Time study

(b) Method study

(c) Six-sigma

(d) None of the above

3. _____ step aims to eliminate the activity altogether if it is necessary.

(a) Record

(b) Examine

(c) Install

(d) None of the above

4. _____ precedes examine step of the method study.

(a) Develop

(b) Install

(c) Record

(d) Maintain

5. _____ is a path of men, materials and equipments on a scale model.

(a) Outline process chart

(b) Multiple activity chart

(c) Flow diagram

(d) None of the above

6. p chart is a control chart used to control _____ quality.

(a) A variable

(b) An attribute

(c) Both (a) and (b)

(d) None of the above

7. In the formula for p chart, sp means _____.

(a) Variance of per cent defectives

(b) Standard deviation of per cent defectives

(c) Standard deviation of fraction faults

(d) None of the above

8. A process may have tight spread but not meeting specification may happen if

the part'sspecificationcentre of variances got shifted towards the

_____ of the centreofvariances samples.

(a) Left side

(b) Right side

(c) Bottom

(d) None of the above

9. In double sampling plan, the design will give _____ different

values to implementthe plan.

(a) 4

(b) 5

(c) 6

(d) None of the above

10. The lines extending from top right corner towards bottom left corner of the monogram to design a single sampling plan correspond to _____.

(a) Rejection numbers

(b) Acceptance numbers

(c) Neutral numbers

(d) None of the above

PART – B

1. What is work study?

2.What is work sampling?

3 .Explain quality circle.

4. Define TQM.

PART-C

1. Define work study and explain its types and objectives.

2. What is Quality control and explain its types?

3. Define inspection and it's techniques.

4 .Briefly Explain about Total Quality Management.

5 .What is six Sigma and explain its benefits?

UNIT- 5

SERVICE OPERATIONS MANAGEMENT

INTRODUCTION TO SERVICES MANAGEMENT- NATURE OF SERVICES ,TYPES OF SERVICES- SERVICE ENCOUNTER- DESIGNING SERVICE ORGANIZATIONS- SERVICE FACILITY LOCATION AND LAYOUT, SERVICE BLUEPRINTING-WAITING LINE ANALYSIS FOR SERVICE IMPROVEMENT- SERVICE PROCESSES AND SERVICE DELIVERY.

Unit Module Structuring

1. **Introduction to services management**
2. **Types of services**
3. **Designing service organizations**
4. **Service facility location and layout**
5. **Waiting line analysis for service improvement**

Self- Learning Material Development – STAGE- I

Table of Contents for the Unit

5.1. INTRODUCTION TO SERVICES MANAGEMENT:

We all use service operations every day. They are important in our lives, ill, transporting us, serving our meals, selling us goods, connecting us to social media and so on. Many of us are also responsible for serving others, either as part of our jobs, or as part of daily life for our friends and families. Yet, if service is so important, why does service often disappoint? It is often because of a failure to deploy the principles of service operations management. And, although the development of operations management as a discipline has its roots in production management, service operations management concentrates on those operations issues that are particularly relevant to service organisations.

5.2. WHAT IS SERVICE?

Most early definitions of 'service' focus on its difference compared with manufacturing. Often, the main distinctions between services and products were seen as:

- Intangibility, in that they are not physical items.
- Heterogeneity, in that they are difficult to standardise.
- Inseparability, in that their production and consumption are simultaneous.
- Perishability, in that they cannot be stored.

These features of services are known as the 'IHIP" characteristics, and have been the subject of considerable academic debate because.

None of the IHIP characteristics is unique to services as opposed to physical products.

Technology has had a significant effect on the extent to which the IHIP characteristics apply and how the limits that they place on service operations can be overcome.

SERVICE OPERATIONS MANAGEMENT:

The principles of operations management in any kind of organization are broadly the same. It is concerned with transforming a set of inputs into outputs. This is usually illustrated as an input-transformation-output model. Resources and processes are the two vital ingredients of all operations, and much of operations management is concerned with how they are managed. It is the importance of the customer's (or customer surrogate's) presence in the operation that makes service operations management distinctive. So, service operations management needs to reflect both operations and customer perspectives, and the overlap between them.

Not all services exhibit the IHIP characteristics to the same extent, and different services delivered by the same operation can vary considerably in how they conform to the characteristics. From the customer perspective, 'service outcomes' describe the results of being processed and of having their 'state changed by their experience. The main categories of outcome are 'products', benefits, emotions, judgements and intentions.

Both the operations and customer perspectives are important, but it is where the two perspectives meet that is the core of most services. This has led to the concepts of 'co-production' and 'co-creation", both of which are used to indicate those circumstances when customers collaborate with the service operation to produce/create value.

SERVICE OPERATIONS MANAGERS' RESPONSIBILITIES

Overall, service operations management is concerned with the control of resources and processes that deliver value. Here, we classify them under four headings.

- ✓ Framing service operations.
- ✓ Understanding service people.
- ✓ Delivering service.
- ✓ Improving service operations.

5.3.THE IMPORTANCE OF SERVICE OPERATIONS MANAGEMENT:

Service operations managers have an important and responsible role because they are responsible for managing the design and delivery of services, are responsible for managing most of an organisation's resources, and therefore costs and investments, and have a significant impact on the ability of the organisation to innovate and improve its performance. Good service operations management is better for the customer, better for staff, better for the organisation and also better for society and the environment.

5.4.THE CHALLENGES FOR SERVICE OPERATIONS MANAGEMENT

Of the many challenges facing service operations managers there are a number of key challenges faced by most, if not all, service operations.

These are:

- ✓ Balancing the operations and customer perspectives.
- ✓ Managing multiple customer groups.
- ✓ Managing tactically and strategically.

SERVICE MANAGEMENT:

Service management in the manufacturing context, is integrated into supply chain management as the intersection between the actual sales and the customer point of view. The aim of high-performance service management is to optimize the service-intensive supply chains, which are usually more complex than the typical finished-goods supply chain. Most service-intensive supply chains require larger inventories and tighter integration with field service and third parties. They also must accommodate inconsistent and uncertain demand by establishing more advanced information and

product flows. Moreover, all processes must be coordinated across numerous service locations with large numbers of parts and multiple levels in the supply chain.

Among typical manufacturers, post-sale services (maintenance, repair, and parts) account for less than 20% of revenue. But among the most innovative companies in service, those same activities often generate more than 50% of the profits

BENEFITS:

The main drivers for a company to establish or optimize its service management practices are varied:

- High service costs can be reduced, i.e. by integrating the service and products supply chain.
- Inventory levels of service parts can be reduced and therefore reduce total inventory costs.
- Customer service or parts/service quality can be optimized.
- Increasing service revenue.
- Reduce obsolescence costs of service parts through improved forecasting.
- Improve customer satisfaction levels.
- Reduce expediting costs - with optimized service parts inventory, there is no need to rush orders to customers.
- Minimize technician visits - if they have the right part in hand, they can fix the problem on the first visit.

COMPONENTS:

Generally, service management comprises six different capabilities that companies should consider for optimization:

- Service strategy and service offerings
  - Service strategy definition
  - Service offerings definition and positioning

- Go-to-market strategy
- Service portfolio management

- Spare parts management
  - Parts supply management
  - Inventory management
  - Parts demand management
  - Fulfillment operations and logistics
  - Service parts management
- Returns, repairs, and warranties
  - Warranty and claims management
  - Reverse logistics
  - Returns processing
  - Remanufacturing
- Field service management or field force effectiveness
  - Technician enablement
  - Mobility
  - E-learning
  - Activity scheduling
  - Service billing
- Customer management
  - Order management and availability
  - Channel and partner management
  - Customer insight
  - Technical documentation
- Assets, maintenance, task scheduling, event management
  - Remote monitoring
  - Diagnostics and testing
  - Asset management/optimization

- Configuration management

Services are those essential and separately identifiable intangible activities satisfying the wants of consumers. It is not necessary that services are linked to the sale of a commodity or another service. For example, banking services, warehousing services, etc. Services require personal interaction between the service provider and the consumer, which helps the service provider to make necessary changes in the service according to the nature and requirements of the consumer. Services do not include any manufacturing or production of goods, it only aims at fulfilling the needs and wants of a consumer.

According to Kotler, Armstrong, Saunders, and Wong, "A service is an activity or benefit that one party can offer to another, which is essentially intangible and does not result in the ownership of anything. It production may or may not be tied to a physical product."

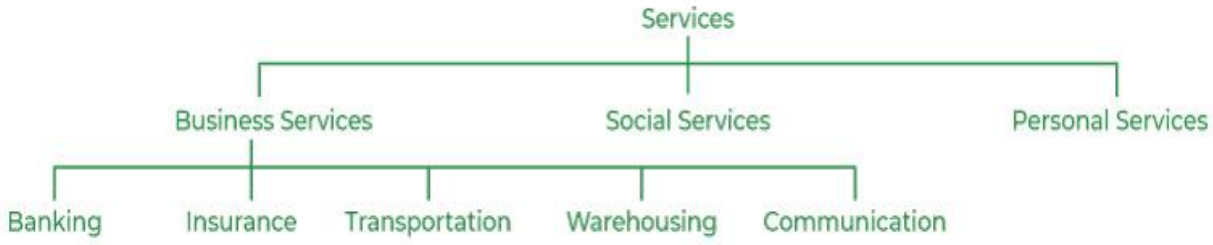
Nature of Services:

- **Intangibility:** Services are intangible in nature. It means that the services provided to a consumer cannot be touched, seen, or felt, instead, they can be experienced only. As individuals cannot taste, feel, or touch a service, they cannot determine its quality before consumption; hence, it gives rise to the purchase. Therefore, it is essential for the service providers to continuously work on their services to provide desired results to the customers. For example, a doctor should provide a favourable experience to a patient.
- **Inconsistency:** As there is no tangible product in the services, they are inconsistent in nature and have to be exclusively performed by the service provider every time. Besides, different customers have different expectations, wants and demands. Therefore, the service providers should alter their offer to meet the customers' requirements as closely as possible. For example, beauty parlor services, etc.
- **Inseparability:** The production and consumption of services are inseparable as they co-occur. For example, if we manufacture a television today, we can sell it at a

later date. However, we cannot do the same with services, as they have to be consumed as and when they are produced. Even though the service providers can design a substitute for their services as per the requirements, customer interaction is an essential part of services.

- **Inventory:** As discussed earlier, services do not mean any tangible component; therefore, we cannot store them for future use. In simple terms, services are perishable in nature, and one cannot store the service itself but can store some associated goods to the service for future use. For example, one can purchase an airplane ticket and store it, but can experience the journey only when the airlines provide it to the customer.
- **Involvement:** A customer is involved in the production of the service. In simple terms, as the customer is the recipient of the service, their participation at the time of service delivery is a must. However, the service providers can make necessary changes in the services as per the need of the customer. For example, Urban Clap cannot provide massage service if the customer is not present or does not participate.

5.5. TYPES OF SERVICES



Business Services

The services used by business organizations to conduct activities are known as business services. The business services assist the business but do not deliver a tangible commodity. For example, transportation services do not give a tangible result,

but transport goods, inventory, raw materials, etc., from one place to another. The major business services are insurance, banking, warehousing, transportation and communication services.

Social Services

The services provided by an individual or a group of individuals voluntarily for the accomplishment of some social goals are known as social services. The social goals include improving the standard of living for the weaker section of society, providing educational and health facilities to poor children and people, or providing hygienic conditions in slum areas. The social service providers usually voluntarily provide the services along with some considerations to cover their costs. Therefore, these service providers do not have a profit earning motive. For example, educational facilities or services provided by NGOs to poor children.

Personal Services

The services that give different customers' a different experience are known as personal services. These types of services are inconsistent in nature and differ based on the service provider, customers' demands, preferences, etc. For example, restaurants, hotels, tourism, etc.

Types of Business Services

Banking

Commercial banks play an essential role in an economy by providing their customers with institutional credit. These commercial banks transact the banking business, i.e., they accept money with the motive of lending and investing the deposited money by the public, repay them on demand, or provide them withdrawing facilities through cheques, drafts, orders, etc. The banks also earn some profit by lending money to the companies. In simple terms, banking services provide finance to businesses in any

form, for different purposes, such as purchasing raw materials, building, machines, and their daily routine activities. Besides, the banks also provide the companies with locker, draft, debit card and credit card facilities.

Insurance

Insurance services involve facilitating the companies with insurance for their business. In simple terms, insurance companies sign an agreement with companies, charge a premium fee, and then transfer their risk to themselves. The signed insurance agreement contains a promise by the insurance company to pay the mentioned insured company a fixed amount either on the maturity of the fixed period or in case of an accident or mishap to the business. Different kinds of insurance are life insurance, marine insurance, fire insurance, health insurance, etc.

Transportation

Transportation refers to the transfer of people, goods, raw materials, etc., from one place to another. Companies mainly use transport services to transfer finished goods, raw materials, inventory, human resources, etc., from one place to another. Transportation plays a crucial role in the development of an organization as these are the only services that transport raw materials, essential products, and human resources from one place to another. Different modes of transportation supporting these services are rail, air, sea, road and waterways.

Warehousing

Warehousing means storing goods, materials, etc., in a scientific and systematic manner. Usually, there is a time gap between the production and utilization of the goods; therefore, an organization needs to preserve the goods until they are utilized. Warehousing solves this problem of the companies by providing storage facilities to the companies. Today’s warehousing services provide the right quantity at the right

time and place, in the right physical form, and at the right cost. Typically, warehousing services are used by importers, wholesalers, exporters, manufacturers, customs, transport businesses, etc.

Communication

Communication is the process of creating a common understanding amongst people by exchange of messages through different sources. For the success of a business, it needs to establish a good relationship or link with the outside world, including customers, creditors, suppliers, competitors, etc., as it cannot run in isolation. Therefore, it is essential for companies to use fast, accurate and efficient communication services. Communication services can be used for placing an order, filing a complaint, providing suggestions, expressing ideas, sharing information, etc. The main communication services used by companies are telecom and postal.

Service encounters are transactional interactions in which one person (e.g., a vendor, office clerk, travel agent) provides a service or good (e.g., a product, an appointment, airline tickets) to another person.

Many different communicative acts are included in service encounters including, for example, greetings, leave takings, requests, and offers. It is important to fully understand the service encounter context in order to appropriately perform communicative acts. Many of the pragmatic strategies addressed in the other modules still apply to the communicative acts produced in service encounters; however, this unique service context warrants detailed pragmatic exploration.

In this module, we will specifically address unique features of service encounters as well as the pragmatic strategies used in this specific context. We will look at three specific components of service encounters:

- Openings and Tone Setting
- Negotiating Service

Closing the Interaction & Leave Taking

Services are everywhere - We all use service operations every day, and they are important in most people's lives. Also, we all serve others, both as part of our jobs and as part of daily life for our friends and families. The question of 'what is service?' can be difficult to answer concisely. Most definitions of 'service' mean 'what is a service, as opposed to a manufactured product?". **A common framework for classifying services divides services as generated by, and intended for, businesses, governments (or their agencies) or customers**. This results in nine categories of service: **B2B, B2G, B2C, G2B, G2G, G2C, C2B, C2G and C2C.** In addition, service types include non-profit services and internal services.

Services are what we do and consume - The amount of the world's economic activity that comes from services has been growing consistently. In most developed countries, services account for around 80 per cent of gross domestic product (GDP). The Clark sector model shows how, as economies develop, they follow a progression that moves them from a heavy dependence on agriculture and mining, through the development of their manufacturing sector, towards a more service-based economy.

Services are the way of the future - Three concepts illustrate how the service sector is developing. They are the experience economy (which seeks to recast services as 'memorable experiences'), servitisation (which seeks to change the way in which product functionality is delivered by emphasizing how services can be packaged along with the products they support) and **service-dominant logic** (SDL, which sees service as the basis for all business activity). Service science is related to service-dominant logic, and promotes a multidisciplinary approach that includes mathematical modeling, operations management, computer science, engineering and social science.

5.6. DESIGNING SERVICE ORGANISATION:

What is service process design? - A 'process' is how you do things, it is simply a framework around which you can think about who should do what, and when. Processes are the building blocks of all operations.Service processes have to be designed to be both efficient and deliver the right experiencethe strategicintentions of

the organization is usually the result of careful design and delivery of a whole set of interrelated processes. Service process design is influenced by theIHIP of intangibility, heterogeneity, inseparability and perish ability, all of which can have implications for the design. The service process is the 'glue' that holds the rest - the customers, staff, equipment and materials - together and is the mechanism that delivers the service concept, creating the customer's experience and delivering the service outcomes.

What are the main types of service process? - It is a mistake to take the same approach to designing service processes irrespective of their purpose; some way to distinguish between different types of process is needed. Three methods of distinguishing between service process are:

• By the volume of services that have to be processed. Service processes with different volume positions are likely to need configuring in different ways, and will need different types of resources.

• The variety of different services that have to be processed. Sometimes processes with different levels of variety are termed (in increasing levels of variety) 'runners', 'repeaters' and 'strangers'.

• The degree to which the process requires customer involvement. The difference between customer contact and customer involvement is that customer contact means the extent that customers have some type of communication with a process, whereas customer involvement is the extent to which the customer is an intrinsic part of the service delivery process.

These ways of distinguishing between service processes can be combined. So, for example, volume and variety can be combined to give what are known as 'capability' processes (low volume and high variety) and 'commodity' processes (high volume and low variety). Similarly, one method of combining variety with the degree of customer involvement is the **key decision area matrix** (KDAM). The matrix helps to understand where the prime value is added in a process. A special case of service operations is those that deal directly with high volumes of 'customers,' who constitute a' crowd'. There

are many situations where crowds can gather, such as sports events political gatherings, concerts and festivals, 'spontaneous events' due to social media and peak constitute a time transport hubs.

How can managers engineer' service processes?–Process mapping is an important and powerful tool. It is the charting of a servicein order to assist in the evaluation design and development of new or existing processes. Often, process maps use an agreed set of mapping symbols. These symbols can be arranged in order, and in series or in parallel, to describe any process .Processwith varying degrees of customer contact are sometimes mapped in a way that makes the degree of visibility of each part of the process obvious. An important part of service process design is the calculation of process's operating characteristics.

One calculation is how many items or customers a process should be capable of handling. This is best indicated by the 'output interval or 'cycle time', that the process is designed to achieve. Cycle time is the time between completed items (or customers) emerging from the process. Another simple calculation is how much capacity is needed in order to meet the output interval, but this needs the 'work content' of the process task (how long the task takes). With these maps and calculations, one can find any bottlenecks-the activity or stage where congestion occurs, because the workload placed is greater than the capacity to cope with it. Another issue of process design is the 'services cape', defined this as the physical surroundings of the service. Not only is it an important influence from a customer perspective, it is also important from an operations perspective because it affects the work experience of service staff.

How can service processes be repositioned? - When a service operation changes its position on the volume-variety spectrum, its processes also need to change. Moving from capability toward commodity is a common objective for many organizations. To do this, customers may require greater levels of consistency across service transactions carried out by different providers across locations, and the 'capability' of the organization, previously reliant on the skills and knowledge of specific individuals, must

be replicated through more specialized resources. Moving from commodity towards capability could involve a number of actions-for example, shifting the focus of the operation from managing back-office operations for consistent and maximum efficiency, towardsbuilding front-office flexibility. This may require customer-facing staff to give informed advice as to the best service for individual customers, up skilling the front line through greater staff trainingand the provision of information systems

What is the role of technology in service process design? - One of the most notable things about the increased dominance of technological issues in business is the way in which services have been transformed by new technology, nor is the pace of technological development slowing down. There are technologies that have not yet been developed that could change many service operations. The issues, therefore, are how to understand the nature of the general capabilities of new technologies as they emerge, and how to evaluate their potential impact on process performance. The 'primary capability' of a technology is what it is better at doing than what it may replace. Usually this is some mix of the ability to think or reason, the ability to see or sense, the ability to communicate or connect and the ability to move or manage people or objects. The benefits of such technologies (and what they should be evaluated against) include such factors as cost, technical performance, speed, reliability, convenience, safety and sustainability.

5.7.SERVICE FACILITY LOCATION:

THE LOCATION OF EACH SITE:

Location is the geographic positioning of a facility (or facilities) that is providing capacity. Location decisions are often expensive and may have a significant impact not only as an investment cost but also on operations costs, since location may be affected by local wage rates and business rates, for example. Location may also have an impact on revenues, particularly when the operation involves physical contact with customers. For operations that do not require direct physical contact with customers, such as call centers and internet service providers of health or benefits advisory services, location

decisions can be made to minimize the physical costs of the buildings and the running costs of the operation. For operations that need direct access to customers, expensive town-centre or out-of-town shopping malls may be essential.

Location decisions are a balancing act between supply-side factors and demand-side factors. Supply-side factors are those that influence the costs and difficulties of a location decision. The demand-side factors are those that influence revenues. Not all the factors below will apply to every location decision, but they are an indication of those factors that may need to be taken into account.

Supply-side factors include:

1. land costs - the costs of acquiring the land;
2. labor costs - wage costs, employment taxes, welfare provisions, etc.;
3. energy costs - the cost of energy or the availability or even consistency of the supply of energy;
4. transportation costs - the costs of getting resources to the site and of transporting materials to customers;
5. government factors - local taxes, capital restrictions, financial assistance and political climate, and planning restrictions;
6. social factors-language and local amenities;
7. Working environment - the history of labor relations and labor supply.

Demand-side factors include:

1. Convenience to customers - the site's accessibility for customers, including transport network. parking, distance from markets;

2. labor skills - the availability of particular talents, skills, accents and cultures;

3. Characteristics of the site - the intrinsic and maybe aesthetic appeal of the site;

4. Image - the reputation of the surrounding area and the extent to which there are complementary services in the vicinity.

FACTORS AFFECTING LOCATION IN SERVICE OPERATIONS

The service facilities that are discussed earlier can be costly like resorts/hotels, hospitals, universities, Ector sometimes they may not be costly enough like presence of the departmental stores, grocery market, banks, clinics, etc. Following are the factors that may impact the location decision regarding retail and the service facility:

1) **Dominant Factors:** Just like the factors affect the manufacturers, there are also factors that affect the service industry with one more factor incorporated i.e. vocational influence on the sales and the consumer satisfaction. In the case of service, generally it should be available at a very close location to the customers.

i) **Proximity to Customers:** In service sector, it is the location that drives the company. The customers demand that the location should be within their reach. For example, the customers prefer to go to the nearby departmental stores and grocery shops than opting for the supermarkets at a distant place.

ii) **Integration with Other Parts of the Organization:** In case of a new set-up, the establishment should be closely integrated with the rest of the organization such that any requirement arising at an early stage can be duly dealt with.

iii) **Transportation Cost and its Proximity to the Market:** In case of storing and distribution, it should be located close to the market. Any fluctuation in the demand can be easily encountered and the customer requirement can be timely satisfied.

iv) **Location of the Competitors:** The most common problem that a company can face while estimating the sales target is the impact of the competitors on the market. Management should not get complacent that the competition is there in the present market only, rather it should also have a note of the strategies that it might adopt in case the company is expanding to a different location. One should try and avoid locating in the area that is already characterized by fierce competition. However, the same may even work in favor in case of a food stall/hotels or a car showroom. Depending on the product or the service that the company deals in the strategy should be adopted.

1) **Secondary Factors:** Apart from the basic factors there are some other factors which may also have a significant impact. While setting up a retail outlet, the residential dwellings and the density, site visibility and traffic flow is given due consideration. If the above are available, the business is likely to flourish. On the other hand, if the same is located in a remote area which is not well connected, the customers may hesitate to go there. Moreover, the population density ensures that the business runs even during the late hours and resumes its operations quite early in the day thereby contributing more to the total revenue.

SERVICE LAYOUT:

As is the case with manufacturing, service layouts can often be categorized as product, process, or fixed-position layouts. In a fixed-position service layout (e.g., appliance repair, roofing, landscaping, home remodeling, copier service), materials, labor, and equipment are brought to the customer's residence or office Process layouts are common in services due mainly to the high degree of variety in customer processing requirements. Examples include hospitals, supermarkets and department stores, vehicle repair centers, and banks. If the service is organized sequentially, with all customers or work following the same or similar sequence, as it is in a car wash or a cafeteria line, a product layout is used.

However, service layout requirements are somewhat different from manufacturing layout requirements. The degree of customer contact and the degree of customization are two key factors in service layout design. If contact and customization are both high, as in health care and personal care, the service environment is a job shop, usually with high labor content and flexible equipment, and a layout that supports this. If customization is high but contact low (e.g. picture framing, tailoring), the layout can be arranged to facilitate workers and equipment. If contact is high but customization is low (e.g., supermarkets, gas stations), self-service is a possibility, in which case layout must take into account ease of obtaining the service as well as customer safety. If the degree of contact and the need for customization are low, the core service and the customer can be separated, making it easier to achieve a high degree of efficiency in operations.

Highly standardized services may lend themselves to automation (e. g., Web services, online banking, ATM machines)

SERVICE BLUEPRINTING:

CUSTOMER EXPERIENCE- A customer experience is the customer's direct and personal interpretation of their interaction and participation in the service process, involving their journey through a series of touch points. It is how customers perceive the whole of a service as they have contact with its operation's resources and processes. Because the experience is the customer's personal interpretation of a service, we can't actually design an experience, only the mechanisms for creating it. A customer experience statement is a description of the customer's experience and the outcomes from the point of view of the customer, written in an outside-in way. A critical part of the experience statement is the identification of the emotions the organization wants their customers to feel or, more correctly, the emotions that their customers will want to feel as a result of the service.

EFFECT OF SERVICESCAPES ON CUSTOMER EXPERIENCE - The services cape describes the physical and informational surroundings in which a service is both created and provided. It provides service cues that are indicators, stimuli and signals that have been built (purposely or inadvertently) into the service does that and provide particular messages. Messages are what customers will infer about the organization, its services management or staff. The emotions resulting from messages are how the customer feels, consciously or subconsciously, about those clues and messages. Boot clues and messages not only signal the nature of the experience and create the experience for the customer, they can also influence their behavior and that of the staff. So, in designing services and experiences, managers need to be concerned to ensure that all messages emanating from all the clues designed into the service are consistent with the service concept and the desired emotions.

DESIGN OF CUSTOMER JOURNEY- The customer's journey is the series of steps they take and the touch points they have as they experience the service process. Front-

office processes interact directly with customers and will be visible to them, creating the customer's experience. Such processes may involve personal contact with service employees (face to face or by telephone), or interaction through technology such as the organization's website or mobile apps. Some experiences/front-office processes are more intense in nature for provider and customer alike. An aspect of variability in the service encounter is the extent to which the customer perceives some degree of risk or uncertainty.

HOW CAN THE TOTAL CHAIN OF PROCESSES BE MANAGED?- Service operations managers need to be able manage the total chain of processes (back office, front office and external), which link together to deliver the service to customers. Several tools and techniques have been developed to help engineer' the customer's journey and influence the experience they have, including customer journey mapping, walk-through audits, emotion mapping and customer experience analysis. However, in some operations, it is misleading to think about 'customer' behavior as being about individualseach acting independently Crowding happens when an excessively large number of people gather within a specified area.

THE ROLE OF TECHNOLOGY IN SHAPING THE CUSTOMER EXPERIENCE

Very few front-office activities and virtually no back-office activities involve no technological support. In particular, informationtechnology plays a key role in many service innovations, resulting in often significant changes to the customer experience. Technological innovation has rarely been so rapid, and while the impactof specific technologies is difficult to predict, some impacts of service technology are emerging:

•.Many of the most significant technological developments in service sectors are capable of being channeled through mobile devices.

• Customers increasingly expect to access integrated services at almost any time.

• Technology-enabled ease of access to services means that customers find it easier to switch between services.

• Customers have become more tolerant of automated 'direct' contact with services, such as those provided by chat bots.

• Almost all new technologies have a far greater ability to collect data on how customers behave, and to exploit the potential to understand customer behavior.

• The volume of available information from internet comparison sites, customer reviews and blog posts (even when they are not totally reliable) can lead to 'content overload'

• Many of the newer service technologies have had the net effect of shifting the balance of responsibility for carrying out activities from the operation's resources and processes to the customer.

• The digitization of service technology and the interconnection of systems has increased customers' concerns about cyber security.

5.8. WAITING LINE ANALYSIS:

A queue can be any ordered collection of items waiting to be worked on in some way. It can comprise items of information, materials, vehicles or people. Queues occur in most service activities.Indeed, for any operation using a level capacity strategy, queues are 'designed-in". Furthermore,no capacity strategy is always perfect in balancing demand with capacity, so queues are almost inevitable. When the queue is comprised of people, they may be visible to both the customer and employee, as in the queue for a ride in an entertainment park, or they may be invisible to one and/or the other, as in a queue of callers to a switchboard or a list of customers awaiting a repair engineer.

Few people like queuing. In fact, it can be the cause of intense dissatisfaction with a service. Which is why practitioners and academics have studied how people react to it and how best to reduce the frustration that queuing can cause. It has been shown that not only does dissatisfaction with the wait increase with waiting time, but

also dissatisfaction with the service as a whole. So, given that perceived waiting time is usually greater than actual waiting time, c. the answer is usually taken to be to try to reduce perceived waiting time. Ten principles of waiting have been suggested:

1. Unoccupied time feels longer than occupied time. It is a good idea to try to provide customers with something to do, or forms of distraction, so that the time passes more rapidly for them. Some services show promotional videos to people waiting in a physical queue. Waiting areas for lifts often have mirrors to enable the customer to check their appearance. Telephone callcenters or helpdesks frequently play music while 'on hold', although this is not universally welcomed.

2. **Pre-process waits feel longer than in-process waits**. Once customers feel that they have made a start inside the service process and that something, however trivial, is happening, they tend to feel happier. A simple acknowledgement by a server that they have been noticed can have a significant impact. Also, using pre-process time in some way, such as completing a form ormaking choices about the service, can reduce the perceived waiting time.

3. **Anxiety makes the wait seem longer.** Sometimes customers do not know whether they have been forgotten or not, which can be allayed by giving them numbered tickets to demonstrate that they are part of the system. Also, the nature of the service will have a significant impact. If the customer is worried about flying or going to the dentist, the wait may seem interminable, possibly giving rise to some tense behavior with service providers. Customer-facing employeesshould be trained to observe the effects of anxiety and to find ways of giving reassurance

4. Uncertain waits are longer than known, finite waits, Customers are generally happier to wait if the expected duration is known, and if there is a good reason for it. If the duration is unknown, research suggests that customers become restless far more quickly. Theme parks frequently position markers at known points in the queue, info firming customers how long they should expect to wait. Of course, the real wait time is

often a little shorter than this, with customers then pleased that they did better than expected.

5. Unexplained waits seem longer than explained waits. Being provided with a plausible explanation of delay reduces uncertainty for the customer. It also gives the impression that the organization knows it should not take the customer for granted.

6. Unfair waits are longer than equitable waits. Generally, customers expect that those who arrive first should be seen first. Many organizations have replaced the multiple queue/multiple server approach because of the perceived unfairness of being stuck in a slow-moving queue. This approach also eliminates the anxiety as to which queue to join. In some cases, such as a hospital casualty department, there may be a good reason why some customers are seen out of turn, but it still seems necessary for there to be anexplanation rather than for the provider to assume that other customers will understand.

7. The more valuable the service, the longer customers will wait. The more complex the service, and the more it is customized to the needs of the individual, the more likely it is that customers may be prepared to wait. It should be noted, however, that this should not be assumed.

8. Solo waiting feels longer than group waiting. The realization that others are also feeling the pain may reduce the customer's anxiety of thinking that they have made the wrong choice. If others think it is worth waiting, it confirms the customer's decision to wait. Also, people tend to talk to each other, providing a distraction from the length of the wait.

9. Uncomfortable waits feel longer than comfortable waits. By making queuing conditions as comfortable and indeed as distracting as possible, the wait time will be perceived to be much shorter. Uncomfortable conditions sensitize customers to the time and poor service.

10. New or infrequent users feel they wait longer than frequent users. Frequent users of a service may be attuned to a wait and they may be more relaxed because they know what to expect. New or infrequent users are likely to be more anxious and uncertain, so operations should consider trying to identify them and provide them with information and reassurance.

A booking system is a queue, with the advantage to customers that they do not have to physically queue for the service. The advantage for the service provider is that the operations manager is better able to manage resources to meet demand. For example, the fast-track express systems used at entertainment parks such as Port Ventura World Parks & Resort in effect create a 'virtual queue''. Visitors to the park are given a time slot to return to a pre-booked ride, which allows them to use their time more effectively. Supermarkets that operate a ticket system at their delicatessen counters are using the same principle. In both cases, the service provider has found a way to ensure equity of treatment for its customers and has enabled customers to make better use of time otherwise spent queuing

QUEUING THEORY AND SIMULATION

Management scientists and mathematicians have studied the behavior of queues, producing statistical models to predict queue length and so on. The mathematics of these models are beyond the scope of this text, but fortunately there are a number of computer simulations available to predict the implications of operational decisions.

Simply put, there are three key parameters to queuing theory: the arrival rate of customers, the server fare and the number of servers or serving positions available. The arrival rate and server rate must be further understood in terms of their variability. Even if the average server rate and arrival rate are the same, queues will still form if there is variability in these rates.

Computer simulations now provide invaluable information to the service operations manager In a more complex situation than that described above, it would be

impossible to model the likely outcomes, but a simulation can identify the impact of different queue designs, priority rules and so on. Whether the situation is complex or simple, the key question remains: 'How long is an acceptable waiting time?".

Pooling

One important principle of queuing is that 'pooling' queues can bring benefits, because a system where multiple servers pull from the same queue of customers results in a shorter waiting time, yet gives the same level of utilization as a system where customers join separate queues. In other words, the arrangement of queues has an impact on queuing effectiveness without having to change the nominal capacity of the servers. In (a) customers are required to choose one queue. The problem here is that any delays occurring at one server will affect everyone in that queue. In arrangement (b), however, where the queue is pooled and the customer at the front of the queue goes to the first available server, delays by one server will affect that server only. There can also be psychological benefits. Forming a single queueeliminates the choice of where to go without second-guessing about the best queue to choose, and is also seen as more equitable.

QUEUE BEHAVIOR:

Most mathematical models of queuing theory assume that customers waiting in a queue behave rationally. Clearly, anyone who has been in a particularly long queue knows this is not necessarily true. A more holistic approach would need to include other factors, such as the following:

• **Queue discipline**. This is the set of rules that determine the order in which customers waiting in the queue are served. In most regions, simple queues, such as those in a shop, use a first-come, first-served queue discipline. However, there are cultural differences. Some countries have a very strong sense of queue discipline, where 'queue jumping' and 'cutting in' are socially unacceptable. Other countries are far more relaxed about such things. The implication is that any service must take cultural norms into account when trying to predict queue behavior.

• **Rejecting**. If the number of customers in a queue is already at the maximum number allowed,then the customer could be rejected by the system. For example, during periods of heavy demand, some websites will not allow customers to access part of the site until the demand on its services has declined.

• **Balking.** When a customer is a human being with free will (and the ability to get annoyed), heor she may refuse to join the queue and wait for service if it is judged to be too long. In queuingterms, this is called balking.

• **Reneging.** This is similar to balking, but here the customer has already queued for a certain length of time and then (perhaps being dissatisfied with the rate of progress) leaves the queue and therefore the chance of being served.

5.9. SERVICE PROCESS

At its simplest, a 'process' is how you do things, how you perform activities. A process is simply A framework, around which you can think about who should do what, and when. Even if your 'process' is to relax in an armchair and wait for inspiration to strike, it is still a process. Processes are not necessarily formal, highly constrained or detailed - though they might be. Some processes need to be meticulously defined, with every activity tightly controlled and double-checked. For example, the 'sitting-in-an-armchair' approach doesn't work for airline pilots performing their pre-flight checks: that kind of process must be both detailed and defined. But not all processes need be. The point is that processes need to be designed to fit with what they are supposed to achieve.

Service processes

Once more, the interesting question is 'what is distinctive about service processes?'. And, yet again, we need to return to the IHIP characteristics to answer it. it is best to think of these characteristics as spectra rather than absolute characteristics of all services. Services vary in the extent that they exhibit these characteristics. Some services, and therefore also the design of their processes, will not exhibit these

characteristics. For example, an internal (back-office) process that checks and approves expense claims deals with online submissions, follows strict guidelines on what is allowed, needs relatively little discretion, will rarely (if ever) see its customers, and can keep submissions in the inbox until there is time to process them. None of the IHIP characteristics apply to any great extent. The process can be designed in the same way as any manufacturing process. By contrast, management consultants can define their service only in the most general terms, must deal with an almost infinite variety of situations, will be very careful to manage how clients perceive them, and usually work on an assignment-by-assignment basis (while trying their best to persuade clients to commission another assignment).

5.10. SERVICE DELIVERY

Service - the customer perspective

It is the customer experience that gives service operations management its essential nature. By customer experience we mean the customer's direct and personal interpretation of, and response to, their participation and interaction in the service process and its outputs. The experience involves the customer's journey through a series of contact points and process steps. An experience is perceived purely from the point of view of an individual customer and is inherently personal, existing only in the customer's mind. This means that no two people can have the same experience. And, while customers often experience service in social or work groups, the experience is essentially an individual one.

The customer experience is made up of many different aspects. Partly, it is a response to the degree and nature of personal interaction with service staff. Yet individual customers may also interpret a service based on the reaction of the social or work group within which they receive service. If your work group likes a service, it could influence your reaction to it. Customers will also react to their perception of the responsiveness and flexibility of customer-facing staff. Another influence on the customer experience is the perceived degree of intimacy with the service. Even those

service settings that are mediated by information technology and which seem impersonal, such as internet-based services, may try to promote a convincing illusion of intimacy and service. Finally, the extent to which the customer feels valued by the service organization can have a profound impact on the service experience. Value may be demonstrated by 'qualifying behaviors', such as the courtesy and competence of staff, but also in signals of friendliness and pleasure at serving the customer. A simple 'Hello Mrs. Phillips, nice to see you again!' can be powerful in building positive service experiences.

Service outcomes

Service outcomes describe, from the customer perspective, the results of being processed and of having their "state" (mental and/or physical) changed by their experience. The main categories of outcome are 'products', benefits, emotions, judgments and intentions:

• **Products.** The qualifying outcome of service is the 'functional' output of the process and experience. Products are outputs such as the food and drink provided by a restaurant, or the ability of a delegate on a training course to construct a spreadsheet, or the new heart for the transplant patient. Products are qualifying in the sense that unless they are delivered up to a baseline or threshold level of performance, then the other outcomes are largely irrelevant.

•**Benefits.** Provided the service product is delivered confidently under specification, then the next outcome on which the customer judges service are the benefits provided. Benefits are one of the main reasons why a customer will have chosen the service provider. Benefits inform thecustomer perception or judgment on whether and to what degree they have 'profited' or gained from the service provided, their experience of it and the 'products' provided. The customer makes a judgment as to how well their requirements and needs have been met. Ultimately, the perception of benefits is a judgment about quite a broad conception of value. The patient who has undergone the heart operation will benefit from a longer and more active life. The benefits for students

will be better job prospects or higher salaries and/or new capabilities and skills. The benefit of using a firm of consultants may be reduced costs and/or greater commercial success. The judgment about benefits includes consideration of the financial cost of invoking the service, the time committed by the customer and the relative and sometimes long-term advantage accrued.

• **Emotions.** Experiencing a service results in the customer feeling emotions, of which there are many hundreds, including joy, surprise, love, fear, anger, shame and sadness. In a hospital, the patient hopefully experiences a well-managed stay, where they feel at ease and assured throughout, with minimal pain and inconvenience. A student at a university may have an enjoyable and challenging experience, with some memorable lectures and seminars and exciting extra-curricular activities. A senior manager employing a firm of consultants will hopefully feel assured, with increased confidence to pursue a particular strategy. The latter example is quite important, as it is too easy to consider emotions only in the context of business-to-customer services. Recipients of internal service and business-to-business service can and will have feelings about their service provider, which in turn are derived from their experiences.

Judgments:

As was indicated in our earlier discussion of benefits, an outcome of the service from a customer's point of view will be their conscious or unconscious assessment of the service provided, their experience and the perceived benefits gained. The customer will make judgments about their perceived value of the service received, but also about issues such as fairness (or equity). The idea of value is complicated, but here we will define it as the customer's assessment of the service provided, their experience and the benefits derived, weighed against all the costs involved. These assessments and feelings, conscious or unconscious, will then be manifested as a feeling of satisfaction or dissatisfaction (an emotion) about the overall service as well as individual elements of it.

Intentions. The customer's judgments, good, bad or indifferent, will result in intentions such as the intention to repurchase or not, the intention to recommend the received service to others, or the intention to complain or not. These intentions may or may not result in action.

The outcomes described above are not mutually exclusive. The customer's evaluation of any onecomponent will have an influence on other outcomes. (This was implicit in viewing the product as a 'qualifying outcome.) There is a hierarchy building through the outcomes, and customers' judgment in one area can reinforce but also detract from (or balance) the judgment of other outcomes. For example, an inspirational learning experience may help a student better understand their subject material and thus benefit from greater knowledge and confidence. However, outcomes may conflict- for example, when a patient feels disappointed that the outcome of their operation was unsuccessful (of no benefit for the patient), yet the patient is nevertheless highly satisfied with the way they were treated during their hospital stay (the experience). Often customers are unable to make informed judgments about certain outcomes (as in the case of this patient). Customers may feel uncertainty about whether a garage service is doing 'appropriate things under the hood of their car. Most people have little idea what is going on in the innards of their vehicles. Therefore, those things that the customer can understand often inform the judgment of outcomes. In the case of garage, it might be the comfort of the sofa in the waiting room, or the quality of coffee from the coffee machine.

The outcomes discussed above are those that can be directly perceived and/or experienced by the customer. There is also another set of outcomes that may or may not be visible to and appreciated by the customer, but are important because if they are not achieved to a satisfactory level, the more direct customer outcomes would not be achieved either. For example, a hospital may have clinical targets such as waiting times, numbers of operations to be performed and recovery rates. They are also likely to have operational targets such as theatre utilization rates, and financial targets such asadherence to budgets. These overarching organizational outcomes are concerned

with meeting targets and objectives. To be successful, an operation has to meet both its desired customer outcomes and organizational outcomes. Service operations management plays a vital role in achieving both where the operations and customer perspectives meet these aims.

ASSIGNMENT QUESTIONS:

PART - A

1. Which of the following is not a distinct characteristic of services _____?

(A) Inconsistency

(B) Intangibility

(C) Variability

(D) Inseparability

2.Services are typically produced and consumed simultaneously. This is an example of the _____ characteristic of services.

(A) Intangibility

(B) Inseparability

(C) Simultaneously

(D) Variability

3.Services cannot be stored. This describes the _____ characteristic of services.

(A) Inseparability

(B) Perish ability

(C) Inconsistency

(D) Intangibility

4. SSTs refers to _____.

(A) Standard service technologies

(B) Self-service technologies

(C) Service standards testing

(D) Self-service treatments

5.Business can counter the threats of competitive forces by implementing the five basic competitivestrategies. Which of the following is not one of them?

(A) Quality compromise

(B) Differentiation & Innovation

(C) Growth & Alliance

(D) Cost Leadership

6 Your text outlines five competitive forces that shape the structure of competition in its industry. Which one of the following is NOT one of the five basic Competitive forces discussed in your text?

(A) The bargaining power of Customers.

(B) Threat of new entrants.

(C) Threat of substitutes.

(D) Strategic dominance.

7. The value chain concept was developed by Michael Porter, where a firm is viewed as a series, or chain, or network of basic activities that add value to its products and services, and thus add a margin of value to the firm. One of the primary activities in a firm's "value chain" typically include:

(A) Administrative services.

(B) Technology development.

(C) Marketing and sales

(D) Human resource management

8. A drawback to a business of using just in time stock control is:

(A) High insurance costs

(B) Stock could quickly become out of date or obsolete

(C) Storage costs will be high

(D) Delays in deliveries could result in idle resources

9 .The most important determinant of service quality is:

(A) Reliability

(B) Tangibles

(C) Assurance

(D) Responsiveness

10. _____ cost refers to the product's purchase cost plus the discounted cost of maintenance and repair less the discounted salvage value.

(A) Variable

(B) Life cycle

(C) Net

(D) Out-of-pocket

PART – B

1. What is service?
2. What is service management?
3. What is service Facility location?
4. What is service Delivery?

PART-C

1. Explain the importance of service operations management?
2. What are the challenges for service operations management?
3. What is service Facility location? Explain.
4. Explain service layout and it's methods

5. What are the roles of technology in shaping the customer experience?

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