Production and Operations Management

Production and Operations Management is a peer-reviewed academic journal covering research on all topics in product and process design, operations, and supply chain management. Production and Operations Management is published by Wiley-Blackwell on behalf of the Production and Operations Management Society.

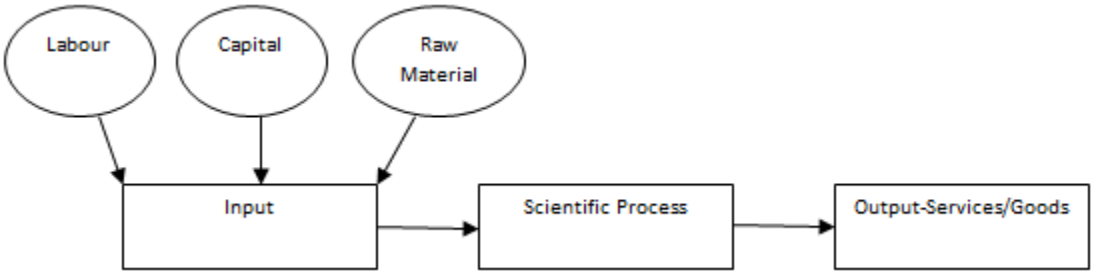
Production

Production is a scientific process which involves transformation of raw material (input) into desired product or service (output) by adding economic value. Production can broadly categorize into following based on technique:

Production through separation: It involves desired output is achieved through separation or extraction from raw materials. A classic example of separation or extraction is Oil into various fuel products.

Production by modification or improvement: It involves change in chemical and mechanical parameters of the raw material without altering physical attributes of the raw material. Annealing process (heating at high temperatures and then cooling), is example of production by modification or improvement.

Production by assembly: Car production and computer are example of production by assembly.



Importance of Production Function and Production Management

Successful organizations have well defined and efficient line function and support function. Production comes under the category of line function which directly affects customer experience and there by future of organization itself.

Aim of production function is to add value to product or service which will create a strong and long lasting customer relationship or association. And this can be achieved by healthy and productive association between Marketing and Production people. Marketing function people are frontline representative of the company and provide insights to real product needs of customers.

An effective planning and control on production parameters to achieve or create value for customers is called production management.

Operations Management

As to deliver value for customers in products and services, it is essential for the company to do the following:

1. Identify the customer needs and convert that into a specific product or service (numbers of products required for specific period of time)
2. Based on product requirement do back-ward working to identify raw material requirements

3. Engage internal and external vendors to create supply chain for raw material and finished goods between vendor → production facility → customers.

Operations management captures above identified 3 points.

Production Management v/s Operations Management

A high level comparison which distinct production and operations management can be done on following characteristics:

- Output: Production management deals with manufacturing of products like (computer, car, etc) while operations management cover both products and services.
- Usage of Output: Products like computer/car are utilized over a period of time whereas services need to be consumed immediately
- Classification of work: To produce products like computer/car more of capital equipment and less labour are required while services require more labour and lesser capital equipment.
- Customer Contact: There is no participation of customer during production whereas for services a constant contact with customer is required.

Production management and operations management both are very essential in meeting objective of an organization.

Meaning of Production Management

Every organization has management principles. And the application of that principle to production function is the term "production management." This management concept involves planning, scheduling, supervising and control of the activities that concern the production of goods to meet the needs of consumers and also generate profit for the business.

Production Management involves using resources judiciously, to create acceptable products. In this case, raw materials are being transformed into value-added products efficiently. The production manager is also in charge of this area of the business. In other words, decisions such as quantity, quality, price, design, packaging style and material for the product, among others, are made by the production manager. He also ensures that the output matches the specifications.

Importance of Production Function and Production Management

Every successful organization has a line function as well as a support function that must be efficient. But production comes under the line function category which has a direct impact on the customers. Hence it dictates customer experience. Customer experience is critical for the survival of any organization.

The Function of Production Management

The role of Production Management is quite elaborate. But the sole aim is to ensure the business produces quality products that can satisfy the needs of customers on a regular basis. Below are functions of production management.

Production Control – Here the manager supervises and directs the production process. He or she also must find out and ensure the right production plan is followed during the production process. If there are deviations, the production manager has to take the right steps to correct them.

Scheduling – This function is critical in every organization. It has to do with planning when the actual production would begin and ends.

Cost and Quality Control – Every company knows how essential quality control and price are. Customers are not just looking for the best products. But they also want to have them at the lowest possible price. Quality control is an essential duty the production manager has to perform. It entails multiple checks performed on the product to ensure quality is intact.

Maintenance of Machines – Production management also entails making sure that instruments used are in good working condition. And that means replacing the ones that are underperforming or changing damaged parts to enable the machine to function optimally.

Helps the Firm to Accomplish its Objectives

Production management helps the firm to achieve its sales and business objectives by producing goods and services that meet the need of consumers. Sales and profit will increase if the product produced satisfies the customers' needs.

Boost Business Reputation and Goodwill

A satisfied customer will undoubtedly want to repeat patronage. That's why businesses should ensure that quality products are delivered continuously. Making sure that your customers are always happy can also boost business reputation.

Meaning of Operation Management

Operation Management is in charge of managing the conversion process. This unit handles the day-to-day running of the business to ensure operations within the organization are carried out smoothly. It is also in charge of production administration, manufacturing and other processes like the rendering of services.

The Function of Operations Management

As earlier mentioned the duty of the operations manager entails making sure that resource are used for the right thing and plays a significant role in the production process to ensure the team delivers quality output. Below are the functions of operations management.

Finance

Operation management's responsibility is to make sure that the company's resources are used in the right manner to generate goods that satisfy its customers.

Strategy

Operations managers also help in the development of plans or tactics that could lead to the maximization of resources and production of products that gives the company a competitive edge over its competitors.

Product Design

It is the operations manager's responsibility to come up with product design that not only caters to the needs of customers but follows the market trend.

Forecasting

Operation management also predicts the performance of products or services in the future. In other words, he critically analyses what customers' demand for certain products would be in the future.

Conclusion

Both are relevant to an establishment. They both help the firm to accomplish its objectives. In the past, the mindset people had was that operation management isn't pertinent. But if you read this post carefully, you will discover how important the role of the operations manager is. It is best for companies to implement both management concepts to and ensure they are run efficiently to achieve business growth and customer satisfaction.

History of Operations Management

Business did not always recognize the importance of operations management. In fact, following World War II the marketing and finance functions were predominant in American corporations. The United States had just emerged from the war as the undisputed global manufacturing leader due in large part to efficient operations. At the same time, Japan and Europe were in ruins, their businesses and factories destroyed. U.S. companies had these markets to themselves, and so the post-World War II period of the 1950s and 1960s represented the golden era for U.S. business. The primary opportunities were in the areas of marketing, to develop the large potential markets for new products, and in finance, to support the growth. Since there were no significant competitors, the operations function became of secondary importance, because companies could sell what they produced. Even the distinguished economist John Kenneth Galbraith observed, "The production problem has been solved."

Then in the 1970s and 1980s, things changed. American companies experienced large declines in productivity growth, and international competition began to be a challenge in many markets. In some markets such as the auto industry, American corporations were being pushed out.

Pre-Industrial Revolution

One of the first people to address the issues of operations management was the Scottish philosopher -- and father of modern economics -- Adam Smith. In 1776 Smith wrote "The Wealth of Nations," in which he described the division of labor. According to Smith, if workers divided their tasks, then they could produce their products more efficiently than if the same number of workers each built products from start to finish. This concept would later be used by Henry Ford with the introduction of the assembly line.

Post-Industrial Revolution

During the industrial revolution, machinery allowed factories to grow in capacity and greatly increased their output. Despite this growth, there was considerable inefficiency in production. Two individuals helped to

overcome these inefficiencies in the early 20th century: Frederick Winslow Taylor and Ford. Taylor developed a scientific approach for operations management, collecting data about production, analyzing this data and using it to make improvements to operations. Ford increased efficiency in production by introducing assembly line production and improved the supply chain through just-in-time delivery.

Post-World War II

Technological developments during the second world war created new possibilities for managers looking to improve their operations. Specifically, the development of computational technology allowed for a greater degree of data to be analyzed by firms. The abilities of computers have continued to increase exponentially, allowing for a high degree of data analysis and communication. Modern producers are now able to track their inventory from raw materials, through production and delivery.

Modern Day

Quality management systems are popular in today's operations management. Quality management is a system for mapping, improving and monitoring operations processes. A variety of quality management systems are in use among top firms, the most notable systems being the ISO systems and Six Sigma. These systems aim to increase the efficiency of business processes. Although operations management has typically dealt with the manufacturing process, the growth of the service industry has created a field of service operations management.

Product design and Process Design:

Product design as a verb is to create a new product to be sold by a business to its customers. A very broad coefficient and effective generation and development of ideas through a process that leads to new products.Thus, it is a major aspect of new product development.

Due to the absence of a consensually accepted definition that reflects the breadth of the topic sufficiently, two discrete, yet interdependent, definitions are needed: one that explicitly defines product design in reference to the artifact, the other that defines the product design process in relation to this artifact.

Product design as a noun: the set of properties of an artifact, consisting of the discrete properties of the form (i.e., the aesthetics of the tangible good or service) and the function (i.e. its capabilities) together with the holistic properties of the integrated form and function.

Product design process: the set of strategic and tactical activities, from idea generation to commercialization, used to create a product design. In a systematic approach, product designers conceptualize and evaluate ideas, turning them into tangible inventions and products. The product designer's role is to combine art, science, and technology to create new products that people can use. Their evolving role has been facilitated by digital tools that now allow designers to do things that include communicate, visualize, analyze, 3D modeling and actually produce tangible ideas in a way that would have taken greater manpower in the past.

Product design process

There are various product design processes, and many focus on different aspects. One example formulation/model of the process is described by Don Koberg and Jim Bagnellin, in "The Seven Universal Stages of Creative Problem-Solving." The process is usually completed by a group of people with different skills and training—e.g. industrial designers, field experts (prospective users), engineers (for engineering design aspects), depending upon the nature and type of product involved. The process often involves figuring out what is required, brainstorming possible ideas, creating mock prototypes, and then generating the product. However,

that is not the end. Product designers would still need to execute the idea, making it into an actual product and evaluating its success (seeing if any improvements are necessary).

Analysis

Accept Situation: Here, the designers decide on committing to the project and finding a solution to the problem. They pool their resources into figuring out how to solve the task most efficiently.

Analyze: In this stage, everyone in the team begins research. They gather general and specific materials which will help to figure out how their problem might be solved. This can range from statistics, questionnaires, and articles, among many other sources.

Concept

Define: This is where the key issue of the matter is defined. The conditions of the problem become objectives, and restraints on the situation become the parameters within which the new design must be constructed

Synthesis

Ideate: The designers here brainstorm different ideas, solutions for their design problem. The ideal brainstorming session does not involve any bias or judgment, but instead builds on original ideas.

Select: By now, the designers have narrowed down their ideas to a select few, which can be guaranteed successes and from there they can outline their plan to make the product

Implement: This is where the prototypes are built, the plan outlined in the previous step is realized and the product starts to become an actual object.

Evaluate: In the last stage, the product is tested, and from there, improvements are made. Although this is the last stage, it does not mean that the process is over. The finished prototype may not work as well as hoped so new ideas need to be brainstormed.

Process Design:

The design of a process can constrain the freedom of product and service designers to operate as they would wish. The overlap between the two design activities is generally greater in operations which produce services.

Process Design and Analysis

Introduction

The objective of organization is to provide service and product, which satisfy customer and create value for them. A product and service designed is based on the customer feedback and requirement of the market. Process design is where the product is broken down into parts, which further can be helpful in the actual manufacturing process.

A product, for example, has attractive packaging to provide the right aesthetics plus has function and features, which provide value to customers. Process design ensures that there is smooth and continuous relationship between required output and all the intermediate process.

For example, manufacturing of Air-Conditioners, process design has to be such that maximum supply is achieved during the hot months of summer when demand of the product is at the highest. So people, process and machines need to align to give continuous production throughout the year as to satisfy seasonal demand.

Process Planning

Process development for process design can be summarized through following steps:

1. Process Requirement: The very 1st step is to collect and gather information to give structure with the end objective. That is to make process requirement document highlighting various stages, risk and stakeholders for production. This will include assessment of available technology, raw material requirement, factory/plant layout and demand forecast.
2. Team Building: Once the process requirements are finalized, for each objective, a team is finalized based on skill level and experience. Function of the team is to get familiarize with the whole process.
3. Planning and Implementation: Process planning team will develop module; policies and procedure require for production, which are after required approval internal as well as external is implemented.
4. Audit: A regular audit is carried out to ensure that process thus implemented is in line and delivering value to customers.
5. End of Life: Over a course of time there may be enhancement of the product or product may get discontinued in these circumstances, process thus develop is discontinued.

Production Process

Based on the nature of product and service production or conversion process can be divided into two broad categories, continuous production (assembly line, oil refinery) and intermittent production (job work, service).

Production process for both manufacturing industry and service industry can be classified into broad categories based on standardization of product or service. It can range from single project assignment like a building or bridge (manufacturing) to interior design (service) and mass production project like a car (manufacturing) to a fast-food joint (Services).

Process Design

A successful process design has to take into account the appropriateness of the process to overall organization objective. Process design requires a broad view of the whole organization and should not have a myopic outlook. And the process should deliver customer value with constant involvement of the management at various stages.

In order to achieve a good process design, effective process strategy is required, which deals with a singular line items required to manufacture the end product. Effective process strategy deals with raw material procurement, customer participation, technology investment, etc.

Over a period of time process design has undergone change and new concepts like Flexible Manufacturing Systems have been developed, which delivers efficient and effective production design and analysis.

MANUFACTURING PROCESS TECHNOLOGY

Manufacturing process management (MPM) is a collection of technologies and methods used to define how products are to be manufactured. MPM differs from ERP/MRP which is used to plan the ordering of materials and other resources, set manufacturing schedules, and compile cost data.

A cornerstone of MPM is the central repository for the integration of all these tools and activities aids in the exploration of alternative production line scenarios; making assembly lines more efficient with the aim of reduced lead time to product launch, shorter product times and reduced work in progress (WIP) inventories as well as allowing rapid response to product or product changes.

- Production process planning
- Manufacturing concept planning
- Factory layout planning and analysis
- work flow simulation.
- walk-path assembly planning
- plant design optimization
- Mixed model line balancing.
- Workloads on multiple stations.
- Process simulation tools e.g. die press lines, manufacturing lines
- Ergonomic simulation and assessment of production assembly tasks
- Resource planning
- Computer-aided manufacturing (CAM)
- Numerical control CNC
- Direct numerical control (DNC)
- Tooling/equipment/fixtures development
- Tooling and Robot work-cell setup and offline programming (OLP)
- Generation of shop floor work instructions
- Time and cost estimates
- ABC – Manufacturing activity-based costing
- Outline of industrial organization
- Quality computer-aided quality assurance (CAQ)
- Failure mode and effects analysis (FMEA)
- Statistical process control (SPC)
- Computer aided inspection with coordinate-measuring machine (CMM)

What's CAD/CAM used for?

CAD/CAM applications are used to both design a product and programme manufacturing processes, specifically, CNC machining. CAM software (US site) uses the models and assemblies created in CAD software to generate toolpaths that drive machine tools to turn designs into physical parts. CAD/CAM software is used to design and manufacture prototypes, finished parts and production runs.

CAD/CAM stands for computer-aided design & computer-aided manufacturing. CAD/CAM software is used to design and manufacture prototypes, finished products, and production runs. An integratedCAD/CAM system offers one complete solution for design through manufacturing.

Computer-aided design (CAD) is a computer technology that designs a product and documents the design's process. CAD may facilitate the manufacturing process by transferring detailed diagrams of a product's materials, processes, tolerances and dimensions with specific conventions for the product in question.

Computer-aided design (CAD) is the use of computers (or workstations) to aid in the creation, modification, analysis, or optimization of a design. CAD software is used to increase the productivity of the designer, improve the quality of design, improve communications through documentation, and to create a database for manufacturing. CAD output is often in the form of electronic files for print, machining, or other manufacturing operations. The term CADD (for Computer Aided Design and Drafting) is also used.

Its use in designing electronic systems is known as electronic design automation (EDA). In mechanical design it is known as mechanical design automation (MDA) or computer-aided drafting (CAD), which includes the process of creating a technical drawing with the use of computer software

CAD software for mechanical design uses either vector-based graphics to depict the objects of traditional drafting, or may also produce raster graphics showing the overall appearance of designed objects. However, it involves more than just shapes. As in the manual drafting of technical and engineering drawings, the output of CAD must convey information, such as materials, processes, dimensions, and tolerances, according to application-specific conventions.

CAD may be used to design curves and figures in two-dimensional (2D) space; or curves, surfaces, and solids in three-dimensional (3D) space

CAD is an important industrial art extensively used in many applications, including automotive, shipbuilding, and aerospace industries, industrial and architectural design, prosthetics, and many more. CAD is also widely used to produce computer animation for special effects in movies, advertising and technical manuals, often called DCC digital content creation. The modern ubiquity and power of computers means that even perfume bottles and shampoo dispensers are designed using techniques unheard of by engineers of the 1960s. Because of its enormous economic importance, CAD has been a major driving force for research in computational geometry, computer graphics (both hardware and software), and discrete differential geometry.

Computer-aided manufacturing (CAM) is the use of software to control machine tools and related ones in the manufacturing of work pieces. This is not the only definition for CAM, but it is the most common. CAM may also refer to the use of a computer to assist in all operations of a manufacturing plant, including planning, management, transportation and storage. Its primary purpose is to create a faster production process and components and tooling with more precise dimensions and material consistency, which in some cases, uses only the required amount of raw material (thus minimizing waste), while simultaneously reducing energy consumption.[citation needed] CAM is now a system used in schools and lower educational purposes. CAM is a

subsequent computer-aided process after computer-aided design (CAD) and sometimes computer-aided engineering (CAE), as the model generated in CAD and verified in CAE can be input into CAM software, which then controls the machine tool. CAM is used in many schools alongside Computer-Aided Design (CAD) to create objects.

MATERIALS REQUIREMENT PLANNING (MRP

MRP refers to the basic calculations used to determine components required from end item requirements. It also refers to a broader information system that uses the dependence relationship to plan and control manufacturing operations.

"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."

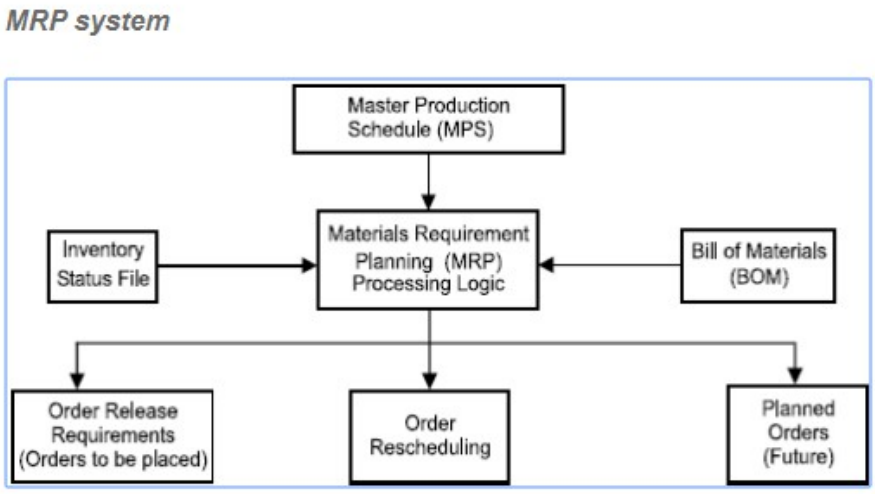
Objectives of MRP

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 build up of inventory.
2. ***Reduction in the manufacturing and delivery lead times:*** MRP identifies materials and component 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 order.
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 coordination among various work centers and hence help to achieve uninterrupted flow of materials through the production line. This increases the efficiency of production system.

MRP System

The inputs to the MRP system are: (1) A master production schedule, (2) An inventory status file and (3) Bill of materials (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.

MRP system



1. ***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 forecasts of demand before MRP system begins to operate. The MRP system whatever the master schedule demands and translates MPS end items into specific component requirements. Many systems make a simulated trial run to determine whether the proposed master can be satisfied.

2. ***INVENTORY STATUS FILE:*** Every inventory item being planned must have an inventory status file which gives complete and up to date information on the on-hand quantities, gross requirements, scheduled receipts and planned order releases for an item. It also includes planning information such as lot sizes, lead times, safety stock levels and scrap allowances.
3. ***BILL OF MATERIALS (BOM):*** BOM identifies how each end product is manufactured, specifying all subcomponents items, their sequence of build up, their quantity in each finished unit and the work centers performing the build up sequence. This information is obtained from product design documents, workflow analysis and other standard manufacturing information.

Design of the production system involves planning for the inputs, conversion process and outputs of production operation. The effective management of capacity is the most important responsibility of production management. The objective of capacity management (*i.e.,* planning and control of capacity) is to match the level of operations to the level of demand.

Capacity planning is to be carried out keeping in mind future growth and expansion plans, market trends, sales forecasting, etc. It is a simple task to plan the capacity in case of stable demand. But in practice the demand will be seldom stable. The fluctuation of demand creates problems regarding the procurement of resources to meet the customer demand. Capacity decisions are strategic in nature. Capacity is the rate of productive capability of a facility. Capacity is usually expressed as volume of output per period of time.

Production managers are more concerned about the capacity for the following reasons: Sufficient capacity is required to meet the customers demand in time.

- Sufficient capacity is required to meet the customers demand in time.
- Capacity affects the cost efficiency of operations.
- Capacity affects the scheduling system.
- Capacity creation requires an investment.

Capacity planning is the first step when an organization decides to produce more or new products.

Measurement of Capacity Planning

The capacity of the manufacturing unit can be expressed in number of units of output per period. In some situations measuring capacity is more complicated when they manufacture multiple products. In such situations, the capacity is expressed as man-hours or machine hours. The relationship between capacity and output.

i. ***Design capacity:*** Designed capacity of a facility is the planned or engineered rate of output of goods or services under normal or full scale operating conditions. For example, the designed capacity of the cement plant is 100 TPD (Tonnes per day). Capacity of the sugar factory is 150 tonnes of sugarcane crushing per day.
ii. ***System capacity:*** System capacity is the maximum output of the specific product or product mix the system of workers and machines is capable of producing as an integrated whole. System capacity is less than design capacity or at the most equal, because of the limitation of product mix, quality specification, breakdowns. The actual is even less because of many factors affecting the output such as actual demand, downtime due to machine/equipment failure, unauthorized absenteeism.
iii. ***Licensed capacity:*** Capacity licensed by the various regulatory agencies or government authorities. This is the limitation on the output exercised by the government.
iv. ***Installed capacity:*** The capacity provided at the time of installation of the plant is called installed capacity.
v. ***Rated capacity:*** Capacity based on the highest production rate established by actual trials is referred to as rated capacity.

Process of Capacity Planning

Capacity planning is concerned with defining the long-term and the short-term capacity needs of an organization and determining how those needs will be satisfied. Capacity planning decisions are taken based upon the consumer demand and this is merged with the human, material and financial resources of the organization.

Capacity requirements can be evaluated from two perspectives long-term capacity strategies and short-term capacity strategies.

1. ***LONG-TERM CAPACITY STRATEGIES:*** Long-term capacity requirements are more difficult to determine because the future demand and technology are uncertain. Forecasting for five or ten years into the future is more risky and difficult. Even sometimes company's today's products may not be existing in the future. Long range capacity requirements are dependent on marketing plans, product development and life- cycle of the product. Long-term capacity planning is concerned with accommodating major changes that affect overall level of the output in long-term. Marketing environmental assessment and implementing the long-term capacity plans in a systematic manner are the major responsibilities of management. Following parameters will affect long range capacity decisions.

    a. ***Multiple products***: Company's produce more than one product using the same facilities in order to increase the profit. The manufacturing of multiple products will reduce the risk of failure. Having more than one product helps the capacity planners to do a better job. Because products are in different stages of their life-cycles, it is easy to schedule them to get maximum capacity utilization.
    b. ***Phasing in capacity*****:** In high technology industries, and in industries where technology developments are very fast, the rate of obsolescence is high. The products should be brought into the market quickly. The time to construct the facilities will be long and there is no much time as the products should be introduced into the market quickly. Here the solution is phase in capacity on modular basis. Some commitment is made for building funds and men towards facilities over a period of 3–5 years. This is an effective way of capitalizing on technological breakthrough.
    c. ***Phasing out capacity:***The outdated manufacturing facilities cause excessive plant closures and down time. The impact of closures is not limited to only fixed costs of plant and machinery. Thus, the phasing out here is done with humanistic way without affecting the community. The phasing out options makes alternative arrangements for men like shifting them to other jobs or to other locations, compensating the employees, etc.
2. ***SHORT-TERM CAPACITY STRATEGIES:*** Managers often use forecasts of product demand to estimate the short-term workload the facility must handle. Managers looking ahead up to 12 months, anticipate output requirements for different products, and services. Managers then compare requirements with existing capacity and then take decisions as to when the capacity adjustments are needed.

For short-term periods of up to one year, fundamental capacity is fixed. Major facilities will not be changed. Many short-term adjustments for increasing or decreasing capacity are possible. The adjustments to be required depend upon the conversion process like whether it is capital intensive or labor intensive or whether product can be stored as inventory.

Capital intensive processes depend on physical facilities, plant and equipment. Short-term capacity can be modified by operating these facilities more or less intensively than normal. In labor intensive processes short-term capacity can be changed by laying off or hiring people or by giving overtime to workers. The strategies for changing capacity also depend upon how long the product can be stored as inventory.

The short-term capacity strategies are:

- ***Inventories*****:** Stock of finished goods during slack periods to meet the demand during peak period.
- ***Backlog:***During peak periods, the willing customers are requested to wait and their orders are fulfilled after a peak demand period.
- ***Employment level (hiring or firing)*****:** Hire additional employees during peak demand period and layoff employees as demand decreases.
- ***Employee training:*** Develop multi-skilled employees through training so that they can be rotated among different jobs. The multi-skilling helps as an alternative to hiring employees.
- ***Subcontracting*****:** During peak periods, hire the capacity of other firms temporarily to make the component parts or products.
- ***Process design:***Change job contents by redesigning the job.

Routing may be defined as the selection of path which each part of the product will follow while being transformed from raw materials to finished products. Path of the product will also give sequence of operation to be adopted while being manufactured. In other way, routing means determination of most advantageous path to be followed from department to department and machine to machine till raw material gets its final shape, which involves the following steps:

- Type of work to be done on product or its parts.
- Operation required to do the work.
- Sequence of operation required.
- Where the work will be done.
- A proper classification about the personnel required and the machine for doing the work.

For effective production control of a well-managed industry with standard conditions, the routing plays an important role, *i.e*., to have the best results obtained from available plant capacity. Thus routing provides the basis for scheduling, dispatching and follow-up.

Techniques of Routing While converting raw material into required goods different operations are to be performed and the selection of a particular path of operations for each piece is termed as 'Routing'. This selection of a particular path, *i.e*. sequence of operations must be the best and cheapest to have the lowest cost of the final product. The various routing techniques are:

1. ***Route card*:** This card always accompanies with the job throughout all operations. This indicates the material used during manufacturing and their progress from one operation to another. In addition to this the details of scrap and good work produced are also recorded
2. ***Work sheet:*** It contains

    a. Specifications to be followed while manufacturing.
    b. Instructions regarding routing of every part with identification number of machines and This sheet is made for manufacturing as well as for maintenance.
3. ***Route sheet*:** It deals with specific production order. Generally made from operation sheets. One sheet is required for each part or component of the order. This includes the following:
    a. Number and other identification of order.
    b. Symbol and identification of part.
    c. Number of pieces to be made.
    d. Number of pieces in each lot if put through in lots.
    e. Operation data which includes:
        i. List of operation on the part.
        ii. Department in which operations are to be performed.
        iii. Machine to be used for each operation.
        iv. Fixed sequence of operation, if any.
4. ***Move order*:** Though this is document needed for production control, it is never used for routing system. Move order is prepared for each operation as per operation sheet. On this the quantity passed forward, scrapped and to be rectified are recorded. It is returned to planning office when the operation is completed.
5. Scheduling can be defined as "prescribing of when and where each operation necessary to manufacture the product is to be performed." It is also defined as "establishing of times at which to begin and complete each event or operation comprising a procedure". The principle aim of scheduling is to plan the sequence of work so that production can be systematically arranged towards the end of completion of all products by due date.

Principles of Scheduling

1. ***The principle of optimum task size:*** Scheduling tends to achieve maximum efficiency when the task sizes are small, and all tasks of same order of magnitude.
2. ***Principle of optimum production plan:*** The planning should be such that it imposes an equal load on all plants.

3. ***Principle of optimum sequence:*** Scheduling tends to achieve the maximum efficiency when the work is planned so that work hours are normally used in the same sequence.

Inputs to Scheduling

1. *Performance standards:* The information regarding the performance standards (standard times for operations) helps to know the capacity in order to assign required machine hours to the facility.
2. Units in which loading and scheduling is to be expressed.
3. Effective capacity of the work centre.
4. Demand pattern and extent of flexibility to be provided for rush orders.
5. Overlapping of operations.
6. Individual job schedules.

Scheduling Strategies

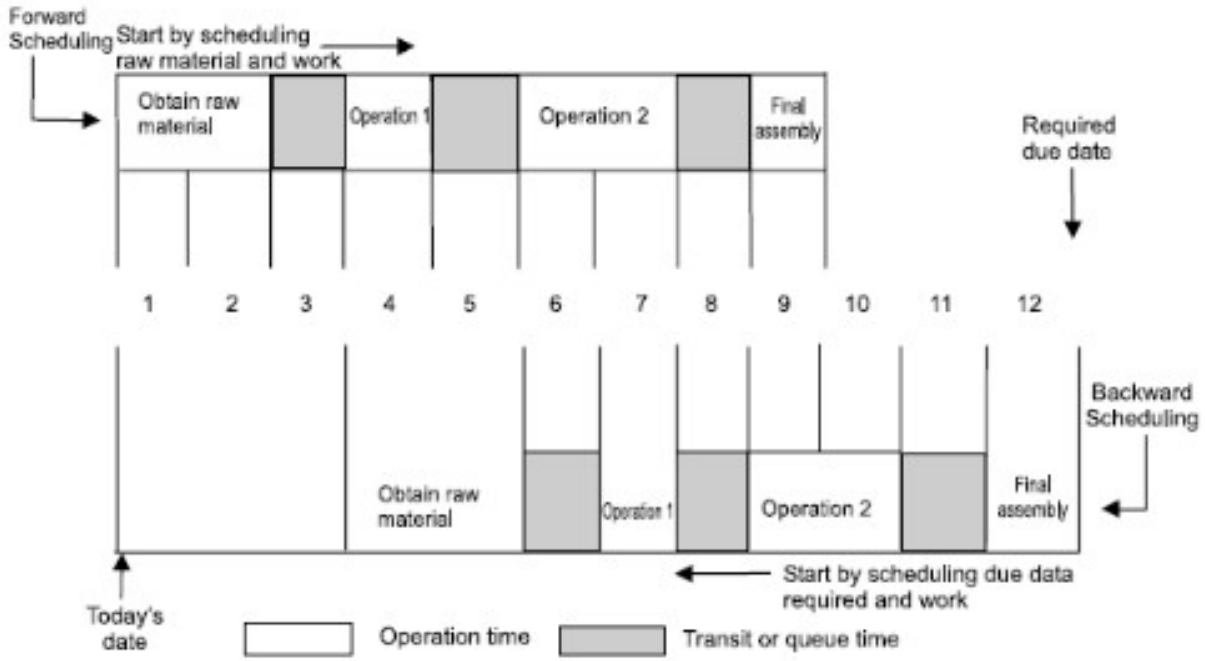
Scheduling strategies vary widely among firms and range from 'no scheduling' to very sophisticated approaches. These strategies are grouped into four classes:

- ***Detailed scheduling:*** Detailed scheduling for specific jobs that are arrived from customers is impracticable in actual manufacturing situation. Changes in orders, equipment breakdown, and unforeseen events deviate the plans.
- ***Cumulative scheduling:*** Cumulative scheduling of total work load is useful especially for long range planning of capacity needs. This may load the current period excessively and under load future periods. It has some means to control the jobs.
- ***Cumulative detailed:*** Cumulative detailed combination is both feasible and practical approach. If master schedule has fixed and flexible portions.
- ***Priority decision rules:*** Priority decision rules are scheduling guides that are used independently and in conjunction with one of the above strategies, *i.e*., first come first serve. These are useful in reducing Work-In-Process (WIP) inventory.

Types of Scheduling Types of scheduling can be categorized as forward scheduling and backward scheduling.

1. ***Forward scheduling:*** is commonly used in job shops where customers place their orders on "needed as soon as possible" basis. Forward scheduling determines start and finish times of next priority job by assigning it the earliest available time slot and from that time, determines when the job will be finished in that work centre. Since the job and its components start as early as possible, they will typically be completed before they are due at the subsequent work centers in the routing. The forward method generates in the process inventory that are needed at subsequent work centers and higher inventory cost. Forward scheduling is simple to use and it gets jobs done in shorter lead times, compared to backward scheduling.
2. ***Backward scheduling:*** is often used in assembly type industries and commit in advance to specific delivery dates. Backward scheduling determines the start and finish times for waiting jobs by assigning them to the latest available time slot that will enable each job to be completed just when it is due, but done before. By assigning jobs as late as possible, backward scheduling minimizes inventories since a job is not completed until it must go directly to the next work centre on its routing. Forward and backward scheduling methods are shown in the following figure.

Forward and backward scheduling



The scheduling methodology depends upon the type of industry, organization, product, and level of sophistication required. They are:

1. Charts and boards,
2. Priority decision rules, and
3. Mathematical programming methods.

1. *Gantt Charts and Boards*

Gantt charts and associated scheduling boards have been extensively used scheduling devices in the past, although many of the charts are now drawn by computer. Gantt charts are extremely easy to understand and can quickly reveal the current or planned situation to all concerned. They are used in several forms, namely,

1. Scheduling or progress charts, which depicts the sequential schedule;
2. Load charts, which show the work assigned to a group of workers or machines; and
3. Record a chart, which are used to record the actual operating times and delays of workers and machines.

2. *Priority Decision Rules*

Priority decision rules are simplified guidelines for determining the sequence in which jobs will be done. In some firms these rules take the place of priority planning systems such as MRP systems. Following are some of the priority rules followed.

Symbol	*Priority rule*
FCFS	First come, first served
EDO	Earliest due date
LS	Least slack (that is, time due less processing time)
SPT	Shortest processing time
LPT	Longest processing time
PCO	Preferred customer order
RS	Random selection

3. ***Mathematical Programming Methods*** Scheduling is a complex resource allocation problem. Firms process capacity, labor skills, materials and they seek to allocate their use so as to maximize a profit or service objective, or perhaps meet a demand while minimizing costs. The following are some of the models used in scheduling and production control.

Linear programming model:

Here all the constraints and objective functions are formulated as a linear equation and then problem is solved for optimality. *Simplex method, transportation methods* and *assignment method* are major methods used here.

PERT/CPM network model: PERT/CPM network is the network showing the sequence of operations for a project and the precedence relation between the activities to be completed.

QUALITY

Different meaning could be attached to the word quality under different circumstances. The word quality does not mean the quality of manufactured product only. It may refer to the quality of the process (*i.e*., men, material, and machines) and even that of management. Where the quality manufactured product referred as or defined as "Quality of product as the degree in which it fulfills the requirement of the customer. It is not absolute but it judged or realized by comparing it with some standards".

Quality begins with the design of a product in accordance with the customer specification further it involved the established measurement standards, the use of proper material, selection of suitable manufacturing process etc., quality is a relative term and it is generally used with reference to the end use of the product.

Crosby defined as "Quality is conformance to requirement or specifications". Juran defined as "Quality is fitness for use". "The Quality of a product or service is the fitness of that product or service for meeting or exceeding its intended use as required by the customer."

Fundamental Factors Affecting Quality

The nine fundamental factors **(9 M's)**, which are affecting the quality of products and services, are: markets, money, management, men, motivation, materials, machines and mechanization. Modern information methods and mounting product requirements.

1. ***Market:*** Because of technology advancement, we could see many new products to satisfy customer wants. At the same time, the customer wants are also changing dynamically. So, it is the role of companies to identify needs and then meet it with existing technologies or by developing new technologies.
2. ***Money:*** The increased global competition necessitates huge outlays for new equipments and process. This should be rewarded by improved productivity. This is possible by minimizing quality costs associated with the maintenance and improvements of quality level.

3. ***Management:*** Because of the increased complex structure of business organization, the quality related responsibilities lie with persons at different levels in the organization.
4. ***Men:*** The rapid growth in technical knowledge leads to development of human resource with different specialization. This necessitates some groups like, system engineering group to integrate the idea of full specialization.
5. ***Motivation:*** If we fix the responsibility of achieving quality with each individual in the organization with proper motivation techniques, there will not be any problem in producing the designed quality products.
6. ***Materials:*** Selection of proper materials to meet the desired tolerance limit is also an important consideration. Quality attributes like, surface finish, strength, diameter etc., can be obtained by proper selection of material.
7. ***Machines and mechanization:*** In order to have quality products which will lead to higher productivity of any organization, we need to use advanced machines and mechanize various operations.
8. ***Modern information methods:*** The modern information methods help in storing and retrieving needed data for manufacturing, marketing and servicing.
9. ***Mounting product requirements:*** Product diversification to meet customers taste leads to intricacy in design, manufacturing and quality standards. Hence, companies should plan adequate system to tackle all these requirements.

CONTROL

The process through which the standards are established and met with standards is called control. This process consists of observing our activity performance, comparing the performance with some standard and then taking action if the observed performance is significantly too different from the standards.

The control process involves a universal sequence of steps as follows:

i. Choose the control object
ii. Choose a unit of measure
iii. Set the standard value
iv. Choose a sensing device which can measure
v. Measure actual performance
vi. Interpret the difference between actual and standard
vii. Taking action.

Need for Controlling Quality

In the absence of quality, the following will result:

i. No yardstick for comparing the quality of goods/services.
ii. Difficulty in maintaining consistency in quality.
iii. Dissatisfied customers due to increased maintenance and operating costs of products/services.
iv. Increased rework cost while manufacturing products/providing services.
v. Reduced life time of the products/services.
vi. Reduced flexibility with respect to usage of standard spare parts.
vii. Hence, controlling quality is an essential activity.

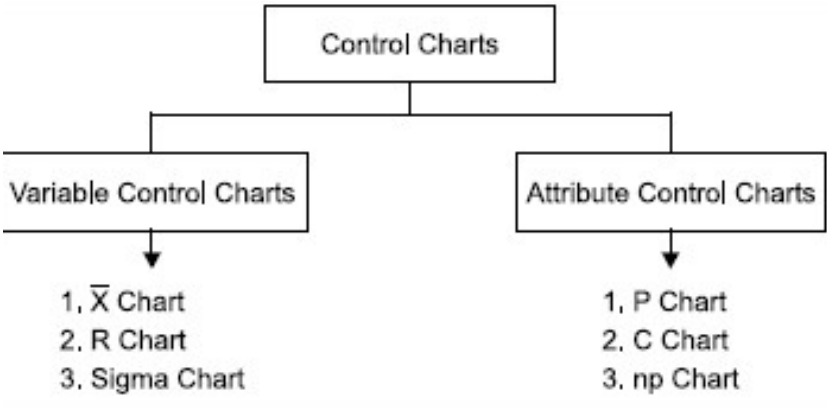
Statistical process control (SPC) is the application of statistical techniques to determine whether the output of a process conforms to the product or service design. It aims at achieving good quality during manufacture or service through prevention rather than detection. It is concerned with controlling the process that makes the product because if the process is good then the product will automatically be good.

Control Charts

SPC is implemented through control charts that are used to monitor the output of the process and indicate the presence of problems requiring further action. Control charts can be used to monitor processes where output is measured as either *variables* or *attributes*. There are two types of control charts: Variable control chart and attribute control chart.

1. ***Variable control charts:*** It is one by which it is possible to measures the quality characteristics of a product. The variable control charts are **X-BAR** chart, **R-BAR** chart, **SIGMA** chart.
2. ***Attribute control chart:*** It is one in which it is not possible to measures the quality characteristics of a product, *i.e.*, it is based on visual inspection only like good or bad, success or failure, accepted or rejected. The attribute control charts are **p-charts, np-charts, c-charts, u-charts.** It requires only a count of observations on characteristics *e.g*., the number of nonconforming items in a sample.

Control charts



CHARACTERISTICS OF CONTROL CHARTS

A control chart is a time-ordered diagram to monitor a quality characteristic, consisting of:

- A nominal value, or centre line, the average of several past samples.
- Two control limits used to judge whether action is required, an upper control limit (UCL) and a lower control limit (LCL).
- Data points, each consisting of the average measurement calculated from a sample taken from the process, ordered overtime. By the Central Limit Theorem, regardless of the distribution of the underlying individual measurements, the distribution of the sample means will follow a normal distribution. The control limits are set based on the sampling distribution of the quality measurement.

BENEFITS OF USING CONTROL CHARTSFollowing are the benefits of control charts:

- A control chart indicates when something may be wrong, so that corrective action can be taken.
- The patterns of the plot on a control chart diagnosis possible cause and hence indicate possible remedial actions.
- It can estimate the process capability of process.
- It provides useful information regarding actions to take for quality improvement.

OBJECTIVES OF CONTROL CHARTS Following are the objectives of control charts:

- To secure information to be used in establishing or changing specifications or in determining whether the process can meet specifications or not.
- To secure information to be used on establishing or changing production procedures.
- To secure information to be used on establishing or changing inspection procedures or acceptance procedures or both.
- To provide a basis for current decision during production.
- To provide a basis for current decisions on acceptance for rejection of manufacturing or purchased product.
- To familiarize personnel with the use of control chart.

CONTROL CHARTS FOR VARIABLES As the name indicates, these charts will use variable data of a process. X chart given 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.

X-Chart and R-Chart: The formulas used to establish various control limits are as follows:

1. Standard Deviation of the Process, σ, Unknown R-Chart: To calculate the range of the data, subtract the smallest from the largest measurement in the sample the control limits:

The control limits are: $UCL_R = D_4 \bar{R}$ and $LCL_R = D_3 \bar{R}$

where $\bar{R}$ = average of several past R values and is the central line of the control chart, and

D_3, D_4 = constants that provide three standard deviation (three-sigma) limits for a given sample size

$\bar{X}$-Chart: The control limits are:

$$UCL_{\bar{X}} = \bar{\bar{X}} + A_2 \bar{R} \text{ and } LCL_{\bar{X}} = \bar{\bar{X}} - A_2 \bar{R}$$

where $\bar{\bar{X}}$ = central line of the chart and the average of past sample mean's, and

A_2 = constant to provide three-sigma limits for the process mean.

2. Standard Deviation of the Process, σ, Known Control charts for variables (with the standard deviation of the process, σ, known) monitor the mean, X , of the process distribution. The control limits are:

$$UCL = \bar{\bar{X}} + 2\sigma_{\bar{X}}$$

and

$$LCL = \bar{\bar{X}} - 2\sigma_{\bar{X}}$$

where $\bar{\bar{X}}$ = centre line of the chart and the average of several past sample means, Z is the standard normal deviate (number of standard deviations from the average),

$\sigma_{\bar{X}} = \sigma / \sqrt{n}$ and is the standard deviation of the distribution of sample means, and n is the sample size

Procedures to construct X-chart and R-chart

1. Identify the process to be controlled.
2. Select the variable of interest.
3. Decide a suitable sample size (n) and number of samples to be collected (k).
4. Collect the specified number of samples over a given time interval.
5. Find the measurement of interest for each piece within the sample.
6. Obtain mean (X) of each sample.
7. Establish control limits for X and R-charts.

CONTROL CHARTS FOR ATTRIBUTES P-charts and C-charts are charts will used for attributes. This chart shows the quality characteristics rather than measurements.

P-CHART

A p-chart is a commonly used control chart for attributes, whereby the quality characteristic is counted, rather than measured, and the entire item or service can be declared good or defective. The standard deviation of the proportion defective, p, is:

PROBLEMS ON XEROX PAGES

TYPES OF SAMPLING ERRORS There are two types of errors. They are type-I and type-II that can occur when making inferences from control chart.

Type-I: Error or a-error or Level of Significance: Reject the hypothesis when it is true. This results from inferring that a process is out of control when it is actually in control. The probability of type-I error is denoted by a, suppose a process is in control. If a point on the control chart falls outside the control limits, we assume that, the process is out of control. However, since the control limits are a finite distance (3s) from the mean.

There is a small chance about 0.0026 of a sample falling outside the control limits. In such instances, inferring the process is out of control is wrong conclusion. The control limits could be placed sufficiently far apart say 4 or 5 a stand deviations on each side of the central lines to reduce the probability of type-I error.

Type-II: Error or ß-error: Accept the hypothesis when it is false. This results from inferring that a process is in control when it is really out of control. If no observations for outside the control limits we conclude that the process is in control while in reality it is out control. For example, the process mean has changed.

The process could out of control because process variability has changed (due to presence of new operator). As the control limits are placed further apart the probability of type-II error increases. To reduce the probability of type-II error it tends to have the control limits placed closer to each other. This increases the probability of type-I error. Thus, the two types of errors are inversely related to each other as the control limits change. Increasing the sample size can reduce both a and ß.

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 goods parts out 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 errors, *viz*., type-I error and type-II error. If the lot is really good, but based on the sample information, it is rejected, and 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 ß. So, both parties should jointly decide about the levels of producer's risk (a) and consumer's risk (ß) based on mutual agreement.

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), the O.C. curve.

In the next figure per cent defective is shown on *x*-axis. The probability of accepting the lot for given per cent defective is shown on *y*-axis. The value for per cent defective indicates the quality level of the lot inspected. AQL means acceptable quality level and LTPD indicates lot tolerance per cent 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 –a. On the other hand, if the quality level is more than or equal to LTPD, the quality of the lot is considered to be inferior from consumer's viewpoint. The corresponding probability of acceptance of the lot is called ß. The quality leveling between AQL and LTPD is called indifferent zone.

SINGLE SAMPLING PLAN The design of single sampling plan with a specified producer's risk and consumer's risk is demonstrated in this section. The required data for designing such plan are as follows:

1. Producer's Risk (α)

2. Consumer's Risk (ß)
3. Acceptable Quality Level (AQL)
4. Lot Tolerance Per cent Defectives (LPTD)

The objective of this design is to find out the values for the sample size (n) and acceptance number (C). The values for n and C are to be selected such that the O.C. curve passes through the following two coordinates:

- Coordinate with respect to the given a and AQL.
- Coordinate with respect to the given b and LTPD.

But, the values of n and C should be integers. So, it will be very difficult to find n and C exactly for the given parameters of the design. Hence, we will have to look for approximate integer values for n and C such that the O.C. curve more or less passes through the above two coordinates.

INSPECTION

Inspection is an important tool to achieve quality concept. It is necessary to assure confidence to manufacturer and aims satisfaction to customer. Inspection is an indispensable tool of modern manufacturing process. It helps to control quality, reduces manufacturing costs, eliminate scrap losses and assignable causes of defective work.

The inspection and test unit is responsible for appraising the quality of incoming raw materials and components as well as the quality of the manufactured product or service. It checks the components at various stages with reference to certain predetermined factors and detecting and sorting out the faulty or defective items. It also specified the types of inspection devices to use and the procedures to follow to measure the quality characteristics.

Inspection only measures the degree of conformance to a standard in the case of variables. In the case of attributes inspection merely separates the nonconforming from the conforming. Inspection does not show why the nonconforming units are being produced.

Inspection is the most common method of attaining standardization, uniformity and quality of workmanship. It is the cost art of controlling the production quality after comparison with the established standards and specifications. It is the function of quality control. If the said item does not fall within the zone of acceptability it will be rejected and corrective measure will be applied to see that the items in future conform to specified standards.

Objectives of Inspection

1. To detect and remove the faulty raw materials before it undergoes production.
2. To detect the faulty products in production whenever it is detected.
3. To bring facts to the notice of managers before they become serous to enable them discover weaknesses and over the problem.
4. To prevent the substandard reaching the customer and reducing complaints.
5. To promote reputation for quality and reliability of product.

Purpose of Inspection

- ❖ To distinguish good lots from bad lots.
- ❖ To distinguish good pieces from bad pieces.
- ❖ To determine if the process is changing.
- ❖ To determine if the process is approaching the specification limits.
- ❖ To rate quality of product.
- ❖ To rate accuracy of inspectors.
- ❖ To measure the precision of the measuring instrument.
- ❖ To secure products-design information.
- ❖ To measure process capability.

Types of Inspection

- ➢ Floor inspection
- ➢ Centralized inspection
- ➢ Combined inspection
- ➢ Functional inspection
- ➢ First piece inspection
- ➢ Pilot piece inspection
- ➢ Final inspection

1. ***FLOOR INSPECTION*** In this system, the inspection is performed at the place of production. It suggests the checking of materials in process at the machine or in the production time by patrolling inspectors. These inspectors move from machine to machine and from one to the other work centers. Inspectors have to be highly skilled. This method of inspection minimize the material handling, does not disrupt the line layout of machinery and quickly locate the defect and readily offers field and correction.

   Advantages

   a. Detection of errors of the source reduces scrap and rework.
   b. Correction is done before it affects further production, resulting in saving cost of unnecessary work on defective parts.
   c. Material handling time is reduced.
   d. Job satisfaction to worker as he can't be held responsible for bad work at a later date.
   e. Greater number of pieces can be checked than a sample size.
   f. Does not delay in production.

   Disadvantages

   g. Delicate instruments can be employed.
   h. Measuring or inspection equipment have to be recalibrated often as they are subjected to wear or dust.
   i. High cost of inspection because of numerous sets of inspections and skilled inspectors.
   j. Supervision of inspectors is difficult due to vibration.
   k. Pressure on inspector.
   l. Possibility of biased inspection because of worker.

   Suitability

   m. Heavy products are produced.
   n. Different work centers are integrated in continuous line layout.
2. ***CENTRALISED INSPECTION*** Inspection is carried in a central place with all testing equipment; sensitive equipment is housed in air-conditioned area. Samples are brought to the inspection floor for checking. Centralized inspection may locate in one or more places in the manufacturing industry.

   Advantages

   a. Greater degree of inspection due to sensitive equipment.
   b. Less number of inspectors and tools.
   c. Equipment needs less frequency of recalibration.
   d. Cost of inspection is reduced.
   e. Unbiased inspection.
   f. Supervision of inspectors made possible.
   g. No distraction to the inspector.

   Disadvantages

   h. Defects of job are not revealed quickly for prevention.
   i. Greater material handling.
   j. High cost as products are subjected to production before they are prevented.
   k. Greater delay in production.
   l. Inspection of heavy work not possible.
   m. Production control work is more complicated.
   n. Greater scrap.
3. ***COMBINED INSPECTION*** Combination of two methods whatever may be the method of inspection, whether floor or central. The main objective is to locate and prevent defect which may not repeat itself in subsequent operation to see whether any corrective measure is required and finally to maintain quality economically.
4. ***FUNCTIONAL INSPECTION:*** This system only checks for the main function, the product is expected to perform. Thus an electrical motor can be checked for the specified speed and load characteristics. It does not reveal the variation of individual parts but can assure combined satisfactory performance of all parts put together. Both manufacturers and purchasers can do this, if large number of articles is needed at regular intervals. This is also called assembly inspection.

5. ***FIRST PIECE OR FIRST-OFF INSPECTIONS*** First piece of the shift or lot is inspected. This is particularly used where automatic machines are employed. Any discrepancy from the operator as machine tool can be checked to see that the product is within in control limits. Excepting for need for precautions for tool we are check and disturbance in machine set up, this yields good result if the operator is careful.
6. ***PILOT PIECE INSPECTION*** This is done immediately after new design or product is developed. Manufacturer of product is done either on regular shop floor if production is not disturbed. If production is affected to a large extent, the product is manufactured in a pilot plant. This is suitable for mass production and products involving large number of components such as automobiles aero planes etc., and modification are design or manufacturing process is done until satisfactory performance is assured or established.
7. ***FINAL INSPECTION*** This is also similar to functional or assembly inspection. This inspection is done only after completion of work. This is widely employed in process industries where there are not possible such as, electroplating or anodizing products. This is done in conjunction with incoming material inspection.

Methods of Inspection: There are two methods of inspection. They are: 100% inspection and sampling inspection.

a. ***100% INSPECTION:*** This type will involve careful inspection in detail of quality at each strategic point or stage of manufacture where the test is involved is non-destructive and every piece is separately inspected. It requires more number of inspectors and hence it is a costly method. There is no sampling error. This is subjected to inspection error arising out of fatigue, negligence, difficulty of supervision etc.

   Hence, completer accuracy of influence is seldom attained. It is suitable only when a small number of pieces are there or a very high degree of quality is required. Example: Jet engines, aircraft, medical and scientific equipment.

b. ***SAMPLING INSPECTION:*** In this method randomly selected samples are inspected. Samples taken from different patches of products are representatives. If the sample proves defective, the entire concerned is to be rejected or recovered. Sampling inspection is cheaper and quicker. It requires less number of Inspectors. It is subjected to sampling errors but the magnitude of sampling error can be estimated.

   In the case of destructive test, random or sampling inspection is desirable. This type of inspection governs wide currency due to the introduction of automatic machines or equipments which are less susceptible to chance variable and hence require less inspection, suitable for inspection of products which have less precision importance and are less costly. Example: Electrical bulbs, radio bulbs, washing machine etc.

Drawbacks of Inspection Following are the disadvantages of inspection:

- Inspection adds to the cost of the product but not for its value.
- It is partially subjective, often the inspector has to judge whether a products passes or not.
- Fatigue and Monotony may affect any inspection judgment.
- Inspection merely separates good and bad items. It is no way to prevent the production of bad items.

TQM SEE OUR CLASS NOTES

Now-a-days, customers demand products/services with greater durability and reliability at the most economic price. This forces producers to strictly follow quality procedures right from design till shipment and installation of the products. So that goal of any competitive industry is to provide a product or service at the most economical costs, ensuring full customer satisfaction. This can be achieved through Total Quality Management (TQM), because, quality is not a technical function, but a systemic process extending throughout all phases of the business, *e.g*., marketing, design, development, engineering, purchasing, production/operations.

As per Feigebaum, "*Total Quality Management* is an effective system of integrating the quality development, quality maintenance and quality improvement efforts of various groups in an organization so as to enable marketing, engineering, production and service at the most economical levels which allow for full customer satisfaction".

Benefits of TQM

The benefits of TQM can be classified into the following two categories:

1. Customer satisfaction oriented benefits.
2. Economic improvements oriented benefits.
    1. ***Customer satisfaction oriented benefits:*** The benefits under this category are listed below:
        a. Improvement in product quality.
        b. Improvement in product design.
        c. Improvement in production flow.
        d. Improvement in employee morale and quality consciousness.
        e. Improvement of product service.
        f. Improvement in market place acceptance.
    2. ***Economic improvements oriented benefits:*** The benefits under this category are as follows:
        - Reductions in operating costs.
        - Reductions in operating losses.
        - Reductions in field service costs.
        - Reductions in liability exposure.

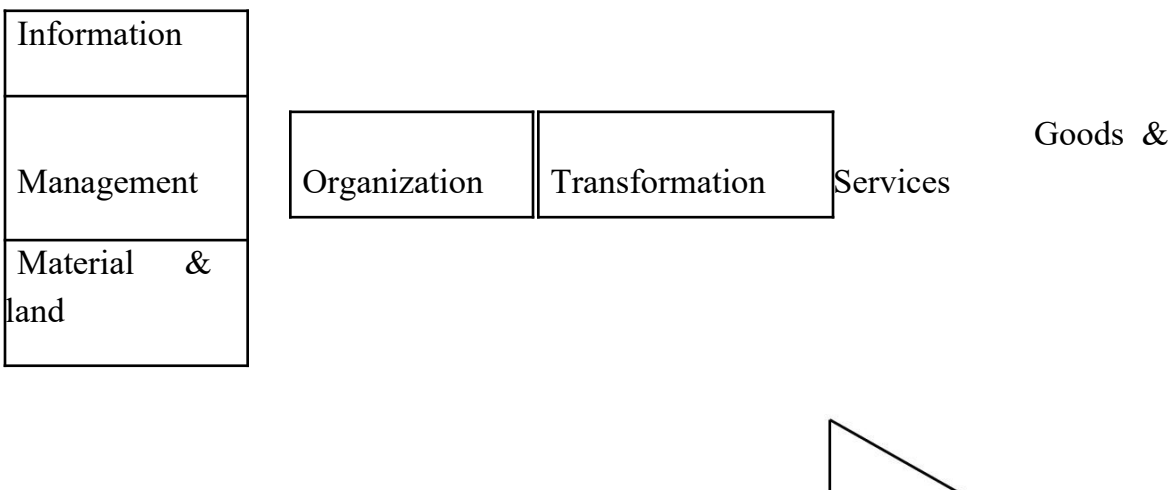
ROLE AND SCOPE OF PRODUCTION MANAGEMENT, CONCEPT OF PRODUCTION MANAGEMENT

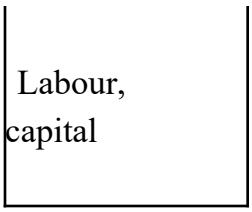
MEANING OF PRODUCTION

Production is an intentional act of producing something in an organized manner. It is the fabrication of a physical object through he use of men, material and some function which has some utility e.g. repair of an automobile, legal advice to a client, banks, hotels, transport companies etc.

Thus irrespective of the nature of organization, production is some act of transformation, i.e. inputs are processed and transformed into some output. The main inputs are information, management, material, land, labour and capital. Fig. shown below explains the production process of an organization.

PRODUCTION PROCESS SYSTEM





Labour, capital

Thus the basis of Production is the transformation of inputs into goods and services. The main objectives of a production process are :

(i) optimum use of resources at optimum cost.

(ii) manufacture of the desired quality and quantity of goods and services.

Meaning of Production Management

Production management is a branch of management which is related to the production function. Production may be referred to as the process concerned with the conversion inputs (raw materials, machinery, information, manpower, and other factors of production) into output (semi finished and finished goods and services) with the help of certain processes (planning, scheduling and controlling etc.) while management is the process of exploitation of these factors of production in order to achieve the desired results. Thus production management is the management which by scientific planning and regulation sets into motion the part of an enterprise to which it has been entrusted the task of actual transformation of inputs into output. A few definitions of production management are being reproduced hereunder to understand the meaning of the term clearly :

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

The definition seems to be quite incomplete as it ignores the human factors involved in a production process and lays stress only on the materialistic features.

Elwood S. Buffa has defined the term in a broader sense as :

(ii) "Production management deals with decision making related to production process so that the resulting goods or services are produced according to specifications in amounts and by the schedules demanded, and at a minimum cost".

Thus production management is concerned with the decision making regarding the production of goods and services at a minimum cost according to the demands of the customers through the management process of planning, organizing and controlling. In order to attain these objectives, effective planning and control of production activities is very essential. Otherwise, the customers shall remain unsatisfied and ultimately certain-activities may have to be closed.

Production management, thus, is assigned with the following tasks –

(i) Specifying and accumulating the input resources, i.e., management, men, information, materials, machine and capital.

(ii) Designing and installing the assembly or conversion process to transform the inputs into output, and

(iii) Coordinating and operating the production process so that the desired goods and services may be produced efficiently and at a minimum cost.

SCOPE OF PRODUCTION MANAGEMENT

Production management is mainly associated with the factory management crept with the development of factory system. Before the evolution of factory system, manufacturing activities were carried on by single person that posed no or very insignificant problem of production and therefore question of production management did not arise. But with the inception of factory system, the situation changed and so many problems of production were begun to creep up and necessity arose to tackle with the problems of quality control, layout facilities, meeting the schedules and organization of production activities. Thus the scope of production management began to develop.

The various activities that form scope of production function can be studied in the following broad areas –

1. *Product Selection and Design :* The product mix makes the production system either efficient or inefficient. Choosing the right products, keeping the mission and overall objectives of the organization in mind is the key to success. Design of the product, which gives it enough functional and aesthetic value, is of paramount importance. It is the design of the product which makes the organization competitive or noncompetitive. Value engineering does help to retain enough features, while eliminating the unnecessary ones.

2. *Activities Relating to Production System Designing :* Decision related to the production system design is one of the most important activity of the production management. This activity is related to production engineering and includes problems regarding design of tools and jigs, the design, development and installation of equipment and the selection of the optimum size of the firm. All these areas require the technical expertise on the part of the production manager and his staff.

3. *Facilities Location:* The selection of an optimum plant location very much depends upon the decision taken regarding production engineering. A wrong decision may prove disastrous. Location should as far as possible cut down the production and distribution cost. There are diverse factors to be considered for selecting the location of a plant.

4. *Method Study :* The next decision regarding production system design concerns the use of those techniques which are concerned with work environment and work measurement. Standard methods should be devised for performing the repetitive functions efficiently. Unnecessary movements should be eliminated and suitable positioning of the workers for different processes should be developed. Such methods should be

devised with the help of time study and motion study. The workers should be trained accordingly.

5. *Facilities Layout and Materials Handling :* Plant layout deals with the arrangements of machines and plant facilities. The machines should be so arranged that the flow of production remains smooth. There should not be overlapping, duplication or interruption in production flow. Product layout, where machines are arranged in a sequence required for the processing of a particular product, and process layout, where machines performing the similar processes are grouped together are two popular methods of layout. The departments are laid out in such a way that the cost of material handling is reduced. There should be proper choice of materials handling equipment. These days, computer software is available for planning the process layout (e.g. CRAFT, CORELAP etc.). Group Technology (G.T.), Cellular Manufacturing Systems (CMS) and Flexible Manufacturing Systems (FMS) have made our concepts of layout planning undergo a tremendous change.

6. *Capacity Planning :* This deals with the procurement of productive resources. Capacity refers to a level of output of the conversion process over a period of time. Full capacity indicates maximum level of output. Capacity is planned for short-term as well as for long term. Process industries pose challenging problems in capacity planning, requiring in the long run, expansion and contraction of major facilities in the conversion process. Some tools that help us in capacity planning are marginal costing (Break Even Analysis), learning curves, linear programming, and decision trees.

7. *Production Planning :* The decisions in production planning include preparation of short-term production schedules, plan for maintaining the records of raw materials, finished and semi-finished stock, specifying how the production resources of the concern are to be employed over some future time in response to the predicted demand for products and services. Production planning takes a given product or line of products and organizes in advance the manpower, materials, machines and money required for a predetermined output in a given period of time.

Thus, production planning is a management technique which attempts to gain the best utilization of a firm's manufacturing facilities. It is gained by the integration and coordination of the manpower, machines, materials and plant services employed in the manufacturing cycle.

8. *Production control :* After planning, the next managerial production function is to control the production according to the production plans because production plans cannot be activated unless they are properly guided and controlled. For this purpose, production manager has to regulate work assignment, review work process, check and remove discrepancies, if any, in the actual and planned performances.

According to Soriegel and Lansburgh "Production control is the process of planning production in advance of operations; establishing the exact route of each individual item, part or assembly; setting, starting and finishing dates for each important item, assembly and the finished products; and releasing the necessary orders as well as initiating the required follow-up to effect the smooth functioning of the enterprise".

Thus production control involves the following stages :

(i) Planning — setting targets of production.

(ii) Routing — to decide the route or flow-of production activity.

(iii) Dispatching — to issue materials and authorizations for the use of machines and plant services.

(iv) Follow-up — it compares the actual production with the targeted production. Deviations are found out and corrected and reasons are investigated.

9. Inventory Control : Inventory control deals with the control over raw-materials, work-in-progress, finished products, stores, supplies, tools, and so is included in production management.

The raw materials, supplies etc. should be purchased at right time, of right quality, in right quantity, from right source and at right price. This five 'R's consideration enables the scientific purchases.

Store-keeping is also an important aspect of inventory control. The raw materials, work-in-progress, finished goods, supplies, tools etc. should be stored efficiently. The different levels of inventory should be managed properly and the issue of materials to departments should be made promptly and effectively. Proper records should also be kept for various items of inventory control.

The production manager has to look after the inventory control activities at three levels –

(i) Control of inventories such as raw materials, purchased parts, finished goods and supplies through the inventory control technique;

(ii) Control of flow of materials into the plants through the technique of judicious purchasing;

(iii) Control of work-in-progress through production control.

10. Quality control : The other important decision taken by the production manager concerns quality control. Product quality refers to the composite product characteristics of engineering and manufacturing that determines the degree to which the product in use will meet the expectations of the customers. Quality control can be ensured through the techniques of inspection and statistical quality control.

11. Maintenance and Replacement : In this we cover preventive methods to avoid machine break-downs, maintenance, policies regarding repair and replacement

decisions. Maintenance manpower is to be scheduled and repair jobs are to be sequenced. There are some preventive replacements also. Machine condition is to be constantly monitored. Effective maintenance is a crucial problem for India which can help better capacity utilization and make operations systems productive enough.

12. *Cost Reduction and Control :* Cost reduction ultimately improves productivity. The industry becomes competitive. Essentially cost reduction and cost elimination are productivity techniques. Value engineering, budgetary control, standard costing, cost control of labour and materials etc. help to keep costs optimal.

All Production decisions are subject to control measures, after receiving proper feed-back. Control function is exercised over the quantity to be produced, quality expected, time needed, inventory consumed & carried and costs incurred. Control system is designed after due cost benefit analysis. Controls should be selective. A self-controlling cybernetic system though preferable is not possible in all complex industries.

Environmental changes ultimately affect all the systems of the organization. A dynamic environment makes it compulsory to adapt the production system to the changes in technology and other factors of the environment. Product mix, composition of products, introduction of new products, changing the layout system is some of the representative decisions which respond to environmental feedback.

Apart from these factors, the production system designer should pay full attention to two other important problems, viz. (i) human factor, i.e., the impact of production systems on the workers operating it and (ii) research and development activities. These two problems have a vital impact on production system designing.

Brief History of Production Management

If we assess the past, covering a period of 200 years after Adam Smith, it can be observed that total production capacity as well as productivity have expanded considerably. Production Management has become an empirical applied science. Undoubtedly, during this period, we have responded to the expansion of markets and large scale business units by using the concepts of division of labour and progressive mechanisation in order to achieve economies of large scale production. The history of production management can be studied as under :

TYPES OF PRODUCTION SYSTEMS AND PLANT LOCATION

A system is a logical arrangement of components designed to achieve particular objectives according to a plan. According to Webster, "System is a regularly interacting inter-dependent group of items forming a unified whole". A system may have many components and variation in one component is likely to affect the other components of the system e.g. change in rate of production will affect inventory, overtime hours etc. Production system is the framework within which the production activities of an organization are carried out. At one end of system are inputs and at the other end output. Input and output are linked by certain processes or operations or activities imparting value to the inputs. These processes, operations or activities may be called production systems. The nature of production system may differ from company to company or from plant to plant in the same firm.

Elements of Production System

(i) Inputs : Inputs are the physical and human resources utilised in the production process. They consist of raw materials, parts, capital equipments, human efforts etc.

(ii) Conversion Process : It refers to a series of operations which are performed on materials and parts.

(iii) Outputs : Outputs are the prodl1;cts or completed parts resulting from the conversion process. Output generates revenue.

(iv) Storage : Storage take place after the receipt of inputs, between one operation and the other and after the output.

(v) Transportation : Inputs are transported from one operation to another in the production process.

(vi) Information : It provides system control through measurement, comparison, feedback, and corrective action.

Types of Production Systems

There are two main types of production systems : (i) Continuous System (ii) Intermittent System

i) Flow or Continuous System : According to Buffa, "Continuous flow production situations are those where the facilities are standardised as to routings and flow since inputs are standardised. Therefore a standard set of processes and sequences of process can be adopted". Thus continuous or flow production refers to the manufacturing of large quantities of a single or at most a very few varieties of products with a standard set of processes and sequences. The mass production is carried on continuously for stock in anticipation of demand.

Characteristics :

(i) The volume of output is generally large (mass production) and goods are produced in anticipation of demand.

(ii) The product design and the operations sequence are standardised i.e.identical products are produced.

(iii) Special purpose automatic machines are used to perform standardised operations.

(iv) Machine capacities are balanced so that materials are fed at one end of the process and finished product is received at the other end.

(v) Fixed path materials handling equipment is used due to the predetermined sequence of operations.

(vi) Product layout designed according to a separate line for each product is considered.

Merits

(i) The main advantage of continuous system is that work-in-progress inventory is minimum.

(ii) The quality of output is kept uniform because each stage develops skill through repetition of work.

(iii) Any delay at any stage is automatically detected.

(iv) Handling of materials is reduced due to the set pattern of production line. Mostly the materials are handled through conveyer belts, roller conveyers, pipe lines, overhead cranes etc.

(v) Control over materials, cost and output is simplified.

(vi) The work can be done by semi-skilled workers because of their specialization.

Demerits : Continuous system, however, is very rigid and if there is a fault in one operation the entire process is disturbed. Due to continuous flow, it becomes necessary to avoid piling up of work or any blockage on the line. Unless the fault is cleared immediately, it will force the preceding as well as the subsequent stages to be stopped. Moreover, it is essential to maintain stand-by equipments to meet any breakdowns resulting in production stoppages. Thus investments in machines are fairly high.

Continuous production is of the following types :

(a) Mass Production : Mass production refers to the manufacturing of standardised parts or components on a large scale. Mass production system offers economies of scale as the volume of output is large. Quality of products tends to be uniform and high due to standardisation and mechanisation. In a properly designed and equipped process, individual expertise plays a less prominent role.

(b) Process Production : Production is carried on continuously through a uniform and standardised sequence of operations. Highly sophisticated and automatic machines are used. Process production is employed in bulk processing of certain materials. The typical processing Industries are fertilizers plants, petrochemical plants and milk dairies which have highly automated systems and sophisticated controls. They are not abour-intensive and the worker is just an operator to monitor the system and take corrective steps if called for.

On the basis of the nature of production process, flow production may be classified into *Analytical and Synthetic Production.*

In *Analytical Process* of production, a raw material is broken into different products e.g. crude oil is analysed into gas, naptha, petrol etc. Similarly, coal is processed to obtain coke, coal gas, coal tar etc

Synthetic Process of production involves the mixing of two or more materials to manufacture a product for instance, lauric acid, myristic acid, stearic acid are synthesised to manufacture soap.

(c) Assembly Lines : Assembly line a type of flow production which is developed in the automobile industry in the USA. A manufacturing unit prefers to develop and employ assembly line because it helps to improve the efficiency of production. In an assembly line, each machine must directly receive material from the previous machine and pass it directly to the next machine. Machine and equipment should be arranged in such a manner that every operator has a free and safe access to each machine. Space should be provided

for free movement of fork lifts, trucks etc. which deliver materials and collect finished products.

(ii) Intermittent Production System

According to Buffa, "Intermittent situations are those where the facilities must be flexible enough to handle a variety of products and sizes or where the basic nature of the activity imposes change of important characteristics of the input (e.g. change. in the product design). In instances such as these, no single sequence pattern of operations is appropriate, so the relative location of the operation must be a compromise that is best for all inputs considered together". In the industries following the intermittent production system, some components may be made for inventory but they are combined differently for different customers. The finished product is heterogenous but within a range of standardized options assembled by the producers. Since production is partly for stock and partly for consumer demand, there are problems to be met in scheduling, forecasting, control and coordination.

Characteristics :

(i) The flow of production is intermittent, not continuous.

(ii) The volume of production is generally small.

(iii) A wide variety of products are produced.

(iv) General purpose, machines and equipments are used so as to be adaptable to a wide variety of operations.

(v) No single sequence of operations is used and periodical adjustments are made to suit different jobs or batches.

(vi) Process layout is most suited.

Intermittent system is much more complex than continuous production because every product has to be treated differently under the constraint of limited resources. Intermittent system can be -effective in situations which satisfy the following conditions :

(i) The production centres should be located in such a manner so that they can handle a wide range of inputs.

(ii) Transportation facilities between production centres should be flexible enough to accommodate variety of routes for different inputs.

(iii) It should be provided with necessary storage facility.

Intermittent Production May be of two types :

(a) ***Job Production :*** Job or unit production involves the manufacturing of single complete unit with the use of a group of operators and process as per the customer's order. This is a 'special order' type of production. Each job or product is different from the other and no repetition is involved. The product is usually costly and non-

standardised. Customers do not make demand for exactly the same product on a continuing basis and therefore production becomes intermittent. Each product is a class by itself and constitutes a separate job for production process. Ship building, electric power plant, dam construction etc. are common examples of job production.

Characteristics :

(i) The product manufactured is custom-made or non-standardised.

(ii) Volume of output is generally small.

(iii) Variable path materials handling equipment are used.

(iv) A wide range of general purpose machines like grinders, drilling, press, shaper etc. is used.

Merits :

It is flexible and can be adopted easily to changes in product design. A fault in one operation does not result into complete stoppage of the process. Besides it is cost effective and time-effective since the nature of the operations in a group are similar. There is reduced material handling since machines are close in a cell. The waiting period between operations is also reduced. This also results in a reduced work-in-progress inventory.

Demerits :

Job shop manufacturing is the most complex system of production e.g. in building a ship thousands of individual parts must be fabricated and assembled. A complex schedule of activities is required to ensure smooth flow of work without any bottlenecks. Raw materials and work-in-progress inventories are high due to uneven and irregular flow of work. Work loads are unbalanced, speed of work is slow and unit costs are high.

(b) Batch Production : It is defined as "The manufacture of a product in small or large batches or lots at intervals by a series of operations, each operation being carried out on the whole batch before any subsequent operation is performed". The batch production is a mixture of mass production and job production. Under it machines turn out different products at intervals, each product being produced for comparatively short time using mass production methods.

Both job production and batch production are similar in nature, except that in batch production the quantity of product manufactured is comparatively large.

Demerits :

Work-in-progress inventory is high and large storage space is required. Due to frequent changes in product design no standard sequence of operation can be used. Machine set-ups and tooling arrangements have to be changed frequently. The main problem in batch production is the idle time between one operation and the other. The work has to wait until a particular operation is carried out on the whole batch.

Comparison of Different Production Systems

As we have discussed various systems and sub-systems in detail in the above lines, we can now make a comparative study of them as follows :

(i) Manufacturing Cost : Cost of production per unit is lowest in process production while it is highest in job production because large scale continuous production is carried out under process production. Unit cost in mass production is higher than the process production while it is lower than the batch production or job production.

(ii) Size and Capital Investment : As stated earlier, the scale of operation is small in job production, medium in batch production, large in mass production and very large in process production. Hence the size of capital investment differs from system to system. Process production calls for the higher investment while mass production requires lesser amount of capital investment. It is lower in case of job production and comparatively higher in batch production.

(iii) Flexibility in Production : In case of change in demand of the product, the production facilities may be adjusted very shortly without increasing much expenses under the system of job or batch production. But both the sub-systems of continuous production system i.e., mass production or process production employ single purpose machine in their manufacturing processes. They cannot adjust their production facilities so quickly and easily as is possible in job or batch production where general purpose machines are used.

(iv) Required Technical Ability : Both job and batch production require high skilled technical foreman and other executives. But under mass production for process production systems, managerial ability plays an important role because it require higher ability for planning and coordinating several functions in mass and process production than in the case of job and batch production.

(v) Organisational Structure : Mostly functional organisation is adopted in case of job and batch production systems. On the other hand, divisional organisation is preferred in mass and product process production systems due to the greater emphasis for centralisation.

(vi) *Job Security :* Job and batch systems of production do not provide and type of job security to workers due to their intermittent character. During odd times, workers

particularly unskilled workers are thrown out of job. On the contrary, mass and process production systems provide greater job security to workers because production operations are carried out continuously in anticipation of stable and continuous demand of the product.

(vii) Industrial Application : The application of different systems is suitable in different industries depending upon the nature of work. The mechanism of job production applies in products of construction and manufacturing industries like buildings, bridges, special purpose machines etc. Batch production is mostly used in mechanical engineering and consumer-goods industries like cotton, jute, machine tools, shoe-making etc. Mass production is found in automobiles, sugar refining, refrigerators, electrical goods etc. Process production is most appropriate in chemical, petroleum, milk processing industries etc.

Thus, a comparative view of the different systems of production reveals that no one system is suitable for all types of industries and therefore each system is different in itself and must be studied with reference to the nature of industry.

PLANT LOCATION

Plant : A plant is a place, where men, materials, money, machinery etc. are brought together for manufacturing products. The objective of minimisation of cost of production can be achieved only when the plant is of the right size and at a right place where economies of all kinds in production are available. The planning for 'where' to locate the operations facilities should start from 'what' are organization's objectives, priorities, goals and the strategies required to achieve the same in the general socio-economic-techno-business-legal environment currently available and expected to be available in the long-term future. Unless the objectives and priorities of an organization are clear i.e. the general direction is clear, effective functional or composite strategies cannot be designed. And, it is these strategies of which the location design is a product.

Different Situations for Plant Location Decision

(i) To select a proper geographic region : The organizational objectives alongwith the various long-term considerations about marketing, technology, internal organizational strengths and weaknesses, region specific resources and business environment, legal-governmental environment, social environment and geographical environment suggest a suitable region for locating the operations facility.

(ii) Selecting a specific site within the region : Once the suitable region is identified, the next problem is that of choosing the best site from an available set. Choice of a site is much less dependent on the organization's long-term strategies. It is

more a question of evaluating alternative sites for their tangible and intangible costs if the operations were located there. Cost economies now figure prominently at this final stage of facilities-location problem.

(iii) Location choice for the first time : In this case, there is no prevailing strategy to which one needs to confirm. However, the organizational strategies have to be first decided upon before embarking upon the choice of the location of the operating facility/facilities. The importance of the long-term strategies can not be over emphasized. Cost economics are always important but not at the cost of long-term business/ organizational objectives.

(iv) Location choice for an ongoing organization : A new plant has to fit into multi-plant operations strategy as discussed below :

(a) Plant Manufacturing Distinct Products or Product Lines

This strategy is necessary where the needs of technological and resource inputs are specialized fir distinctively different for the different products/product-lines. For example, a high quality precision product-line should preferably not be located along with other product-line requiring little emphasis on precision. It may not be proper to have too many contradictions such as sophisticated and old equipment, highly skilled and not so skilled personnel, delicate processes and those that could permit rough handling, all under one roof and one set of managers. Such a setting leads to much confusion regarding the required emphasis and the management policies. Product specialization may be necessary in a highly competitive market; it may also be necessary in order to fully exploit the special resource potential of a particular geographical area. Instances of product specialization could be many : A watch manufacturing unit and a machine tools unit; a textile unit and a sophisticated organic chemical unit; an injectible pharmaceuticals unit and a consumer products unit; etc. All these pairs have to be distinctively different-in technological sophistication, in process, and in the relative stress on certain aspects of management. The more decentralised these pairs are in terms of the management and in terms of their physical location, the better would be the planning and control and the utilization of the resources.

(b) Manufacturing Plants Each supplying to a Specific Market Area

Here, each plant manufactures almost all of the company's product. This type of strategy is useful where market proximity consideration dominates the resources and technology considerations. This strategy requires a great deal of coordination from the corporate office. An extreme example of this strategy is that of soft-drinks bottling plants.

(c) Manufacturing Plants Divided According to the Product/Product Line being Manufactured; and these Special-Product Plants Located in Various Market Areas.

(d) Plants Divided on the Basic of the Processes or Stages in Manufacturing

Each production process or stage of manufacturing may require distinctively different equipment capabilities, labour skills, technologies, and managerial policies and emphasis. Since the products of one plant feed into the other plant, this strategy requires much centralized coordination of the manufacturing activities from the corporate office who are expected to understand the various technological and resources nuances of all the plants. Sometimes such a strategy is used because of the defence/national security considerations. For instance, the Ordnance Factories in India.

(e) Plants Emphasizing Flexibility in Adapting to Constantly Changing Product Needs

This needs much coordination between plants to meet the changing needs and at the same time ensure efficient use of the facilities and resources. The new plant or branch-facility has to fit into the organization's existing strategy, mainly because the latter has been the product of deep thinking about the long-term prospects and problems, and strengths and weaknesses for the organization as a whole.

Factors Affecting Plant Location Decisions

Hardly there is any location which can be ideal or perfect. One has to strike a balance between various factors affecting plant location. Some factors are crucial in deciding the location of the plant while some other factors are less important. In taking the decision of location of plant, due regard should be given to minimisation of cost of production & distribution and maximisation of profit. The decision of plant location should be based on nine M's, namely money, material, manpower, market, motive power, management, machinery, means of communication and momentum to an early start. The following some of the important factors which the management must carefully bear in mind in selecting an optimum site for the plant :

(i) Nearness to Raw Material : It will reduce the cost of transporting raw material from the vendor's end to the plant. Especially those plants which consume raw material in bulk, or raw material is heavy weight, must be located close to the source of raw material. If the raw materials are perishable, the plant is to be located near the source of material. This is true of fruit canning industry. Sugar and paper and other industries using weight losing materials are also located near point of supply. Industries which depend for their

raw materials on other industries tend to be located near such industries e.g. the petrochemicals industries are located near refineries. Similarly, Thermal Power Stations are situated near coal mines. In case the raw material are imported, the unit must be established near the port.

When a company uses a number of raw materials and their sources are at different location, the ideal site for the plant shall be a place where the transportation costs of various raw materials are the minimum.

Apart from these considerations, a promoter must view the supply of raw materials from the following angles also :

(a) If supply of raw materials is linked with finance, it must be set up where the raw material is available at reduced or concessional rates.

(b) Reliability and continuity of the source of supply, and

(c) The security of means of transport.

ii) Nearness to Markets : It reduces the cost of transportation as well as the chances of the finished products getting damaged and spoiled in the way. Moreover a plant being near to the market can catch a big share of the market and can render quick service to the customers. Industries producing perishable or fragile commodities are also attracted towards the market because of savings in time and transportation costs. Industrial units have a tendency to disperse if they find a new market for their products.

(iii) Availability of Labour : Stable labour force, of right kind, of adequate size (number) and at reasonable rates with its proper attitude towards work are a few factors which govern plant location to a major extent. The purpose of the management is to face less bycotts, strikes or lockouts and to achieve lower labour cost per unit of production.

(iv) Availability of Fuel and Power : Because of the wide spread of electric power, in most cases fuel (coal, oil etc.) has not remained a deciding factors for plant location. It is of course essential that electric power should remain available continuously, in proper quantity and at reasonable rates.

(v) Availability of Water : Water is used for processing, as in paper and chemical industries, and is also required for drinking and sanitary purposes. Depending upon the nature of the plant, water should be available in adequate quantity and should be of proper quality (clean and pure). A chemical, fertilizer, thermal power station etc. should not be set-up at a location which IS famous for water shortage.

vi) climatic Conditions : Climate conditions also influence the location decision. Some industries need special type of climate to run the unit effectively. For example, cotton

industry requires a humid climate and therefore it is mainly localised at Bombay, Ahmedabad, etc. But the scientific development and new inventions have lowered down the importance of the factor. So due to the development of artificial humidification, cotton textile industry can now be started in any region of the county. The question of climate is more important for agricultural product like tea, coffee, rubber, cotton etc. even today.

(vii) *Government Policy :* Certain states give aid as loans, machinery, built up sheds etc. to attract industrialists. In planned economy, Government plays an important role on the location of industry. In India Government follows the policy of balanced regional growth of the country which is very important from the point of view of defence and social problems like slum, disparity of income & wealth and optimum use of resources. In order to implement this policy, Government offers several incentives to entrepreneurs to locate their industrial units in backward regions or no-industry regions. It offers tax concessions or loan facilities or factory sheds at cheaper rates. Sometimes Government announces certain disincentives to industries located at a certain place. Thus Government policy plays an important role in the location of industry.

(viii) *Land :* The shape of the site, cost, drainage, the probability of floods, earthquakes (from the past history) etc. influence the selection of plant location.

(ix) *Community Attitude :* Success of Industry depends very much on the attitude of local people and whether they want to work or not.

(x) *Security :* Considerations like law and order situation, political stability and safety also influence the location decision. No entrepreneur will like to start the industry at a place which is not safe and where there are law and order disturbances off and on.

(xi) *Transport Facilities :* A lot of money is spent both in transporting the raw material and the finished goods. Depending upon the size of raw material and finished goods, a suitable method of transportation like roads, rail, water or air is selected and accordingly the plant location is decided. Transportation costs depend mainly on the weight carried and the distance to be covered. In some industries, weight of the raw material is much higher than that of finished product. e.g. in a weight losing industry like sugar manufacturing four to five tons of sugarcanes have to be carried per ton of sugar. Similarly in Iron and Steel Industry two tons of iron is required to produce one ton of pig iron. Therefore the transport costs can be saved by locating near the source of materials. In case of weight gaining industry,

location near the market may result in savings in transportation costs. e.g. in soft drink the weight of finished product is higher than raw material.

(xii) *Momentum of an early start :* Another factor of some importance has been the momentum of an early start. Some places got localised only because one or two units of that industry started production there. With the passage of time, these places gained importance and attracted other units of the industry. As a place gains importance, certain facilities usually beg in to develop. For example, (i) transport facilities are developed because railways and other agencies find it economical to serve that centres, (ii) specialised firms start to take up repair and maintenance job for such units, (iii) banking facilities are made available and (iv) labour possessing various skills are attracted there. These facilities further attract more industries.

(xiii) *Personal Factors :* Personal preferences and prejudices of an entrepreneur also play an important role in the choice of location.

PLANT LAYOUT

MEANING OF PLANT LAYOUT

Plant layout means the disposition of the various facilities (equipments, materials, manpower etc.) within the area of the site selected. Plant layout begins with the design of the factory building and goes up to the location and movement of work. All the facilities like equipments, raw materials, machinery, tools, fixtures, workers etc. are given a proper place. In the words of James Lundy, "It identically involves the allocation of space and the arrangement of equipment in such a manner that overall costs are minimised". According to Mo Naughton Waynel, "A good layout results in comforts, convenience, appearance, safety and profits. A poor layout results in congestion, waste, frustration and inefficiency".

Plant layout is very complex in nature as it involves concepts relating to such fields as engineering, architecture, economics and business administration. Since a plant layout, when properly designed, encompasses all production' and service facilities and provides for the most effective utilization of men, with materials and machines constituting the process, is a master blue print for coordinating all operations.

Objective of a Good Plant Layout

The principal objective of a proper plant layout is to maximize the production at the minimum of the costs. This objective should be kept in mind while designing a layout for a new plant as well as while making the necessary changes in the existing layout in response to changes in management policies and processes and techniques of production. Besides, it must satisfy the needs of all people associated with the production system, i.e. workers, supervisors and managers. If a layout is to fulfil this goal, it should be planned with the following clear objectives in mind :

i) There is the proper utilization of cubic space (Le. length, width and height). Maximum use of volume available should be made. For example, conveyors can be run above head height and used as moving work in progress or tools and equipments can be suspended from the ceiling. The principle is particularly true in stores where goods can be stored at considerable heights without inconvenience.

ii) Waiting time of the semi-finished products is minimised.

iii) Working conditions are safer, better (well ventilated rooms etc.) and improved.

iv) Material handling and transportation is minimised and efficiently controlled. For this, one has to consider the movement distances between different work areas as well as the number of times such movements occur per unit period of time.

v) The movements made by the workers are minimised.

vi) Suitable spaces are allocated to production centre.

vii) Plant maintenance is simpler.

viii) There is increased flexibility for changes in product design and for future expansion. It must be capable of incorporating, without major changes, new equipment to meet technological requirements or to eliminate waste.

ix) A good layout permits materials to move through the plant at the desired speed with the lowest cost.

x) There is increased productivity and better product quality with reduced capital cost.

xi) Boosting up employee morale by providing employee comforts and satisfaction.

xii) Th

coordination and control. There should be no ‘hiding-places’ into which goods can be mislaid. Goods – raw materials and ready stocks – must be readily observable at all times. It will reduce the pilferage of material and labour.

It should be noted here that the above stated objectives of plant layout are laudable in themselves, it is often difficult to reconcile all of them in a practical situation. And as such, the highest level of skill and judgement are required to be exercised. For this, close association between the entrepreneurs and experienced engineers is a must.

Types of Plant Layout

There are three basic types of plant layout : (i) Functional or process layout, (ii) product or line layout, (iii) stationary layout. However the choice of one or the other type of layout depends upon the machines and techniques used in the production.

(a) *Process Layout :* It is also known as functional layout and is characterised by keeping similar machines or similar operations at one location (place). In other words, separate departments are established for each specialised operation of production and machines relating to that functions are assembled there. For example, all lathe machines will be at one place, all milling machines at another and so on. This type of layout is generally employed for industries engaged in job order production and non-standardised products. The process layout may be illustrated in the diagram given below :

i) Wide flexibility exists as regards allotment of work to equipments and workers. The production capacity is not arranged in rigid sequence and fixed rate capacity with line balancing. Alteration or change in sequence of operations can easily be made as and when required without upsetting the existing plant layout plan.

ii) Better quality product, because the supervisors and workers attend to one type of machines and operations.

iii) Variety of jobs, coming as different job orders make the work more interesting for workers.

iv) Workers in one section are not affected by the nature of operations carried out in another section. e.g. a lathe operator is not affected by the rays of welding as the two sections are quite separate.

v) Like product layout, the breakdown of one machine does not interrupt the entire production flow.

vi) This type of layout requires lesser financial investment in machines and equipment because general purpose machines, which are usually of low costs, are used and duplication of machine is avoided. Moreover, general purpose machines do not depreciate or become obsolete as rapidly as specialised machines. It results in lower investment in machines.

vii) Under process layout, better and efficient supervision is possible because of specialisation in operation.

Disadvantages :

i) Automatic material handling is extremely difficult because fixed material handling equipment like conveyor belt cannot be possible to use.

ii) Completion of same product takes more time.

iii) Raw material has to travel larger distances for getting processed to finished goods. This increases material handling and the associated costs.

iv) It is not possible to implement the group incentive schemes on the basis of quantity of the products manufacturing.

v) This type of layout requires more floor space than the product layout because a distinct department established for each operation.

(vi) Compared to line layout inventory investments are usually higher in case of process layout. It increases the need of working capital in the form of inventory.

(vii) Under process layout, cost of supervision is high because (i) the number of employees per supervisor is less that resu1t in reduced supervisory span of control, and (ii) the work is checked after each operation.

(b) **Product Layout :** It is also known as line (type) layout. It implies that various operations on a product are performed in a sequence and the machines are placed along the product flow line i.e. machines are arranged in the sequence in which a given product will be operated upon. This type of layout is preferred for continuous production i.e. involving a continuous flow of in-process material towards the finished product stage. The fig. given below shows a product type of layout :

Advantages :

i) Automatic material handling, lesser material handling movements, time and cost.

ii) Product completes in lesser time. Since materials are fed at one end of the layout and finished product is collected at the other end, there is no transportation of raw materials backward and forward. It shortens the manufacturing time because it does not require any time consuming interval transportation till the completion of the process of production. Line balancing may eliminate idle capacity.

iii) Smooth and continuous flow of work. This plan ensures steady flow of production with economy because bottlenecks or stoppage of work at different points of production is got eliminated or avoided due to proper arrangement of machines in sequence.

iv) Less in-process Inventory. The semi-finished product or work-in-progress is the minimum and negligible under this type of layout because the process of production is direct and uninterrupted.

v) Effective quality control with reduced inspection points. It does not require frequent changes in machine set-up. Since production process is integrated and continuous, defective practice can easily be discovered and segregated. This makes inspection easy and economical.

vi) Maximum use of space due to straight production flow and reduced need of interim storing.

Disadvantages :

i) Since the specific product determines the layout, a change in product involves major changes in layout and thus the layout flexibility is considerably reduced.

ii) The pace or rate of working depends upon the output rate of the slowest machine. This involves excessive idle time for other machines if the production line is not adequately balanced.

iii) Machines being scattered along the line, more machines of each type have to be purchased for helping a few as stand by, because if one machine in the line fails, it may lead to shut down of the complete production line.

iv) It is difficult to increase production beyond the capacities of the production lines.

v) As the entire production is the result of the joint efforts of all operations in the line, it is difficult to implement individual incentive schemes.

vi) Since there are no separate departments for various types of work, supervision is also difficult.

vii) Under this system, labour cost is high because (a) absenteeism may create certain problems because every worker is specialist in his own work or he specialises on a particular machine. In order to avoid the bottleneck, surplus workers who are generalists and can be fitted on a number of machines will have to be employed; (b) monotony is another problem with the workers. By doing the work of repetitive nature along assembly line, they feel bore (c) as machines play the dominant role
in production under this system, workers have no opportunity to demonstrate their talent; (d) noise, vibrations, temperature, moisture, gas etc. may cause health hazards. In this way, labour costs are high.

It is now quite clear from the above discussion that both the systems have their own merits and demerits. Advantages of one type of layout are generally the disadvantages

of other type. Thus with a view to securing the advantage of both the systems a combined layout may be designed.

(c) Static Product Layout or Project Layout or Stationary Layout

The manufacturing operations require the movements of men, machines, and materials, in the product layout and process layout generally the machines are fixed installations and the operators are static in terms of their specified work stations. It is only the materials which move from operation to operation for the purpose of processing. But where the product is large in size and heavy in weight, it tends to be static e.g. ship building. In such a production system, the product remains static and men and machines move performing the operations on the product.

Advantages of stationary Layout : The advantages of this type of layout are as under :

1. *Flexible :* This layout is fully flexible and is capable of absorbing any sort of change in product and process. The project can be completed according to the needs of the customers and as per their specification.

2. *Lo*

back to their respective departments as soon as the work is over. This is economical, if a number of orders are at hand and each one is in a different stage of progress. Besides, one or two workers can be assigned to a project from start to finish. Thus it reduces labour cost.

3. *Saving in time :* The sequence of operations can be changed if some materials do not arrive or if some people are absent. Since the job assignment is so long, different sets of people operate simultaneously on the same assignment doing different operations.

4. *Other benefits :* (i) It requires less floor space because machines and equipment are in moving position and there is no need of fixing them. (ii) This arrangement is most suitable way of assembling large and heavy products.

Disadvantages of stationary layout : The disadvantages of this type of layout are :

(i) *Higher capital investment :* Compared to product or process layout, capital investment is higher in this type of layout. Since a number of assignments are taken, investment in materials, men and machines is made at a higher cost.

(ii) *Unsuitability :* This type of layout is not suitable for manufacturing or assembling small products in large quantities. It is suitable only in case where the product is big or the assembling process is complex.

Factors influencing Plant Layout

The following are some important factors which influence the planning of effective layout to a significant degree.

1. *Nature of the product :* The nature of product to be manufactured will significantly affect the layout of the plant. Stationary layout will be most suitable for heavy products while line layout will be best for the manufacture of light products because small and light products can be moved from one machine to another very easily and, therefore, more attention can be paid to machine locations and handling of materials.
2. *Volume of Production :* Volume of production and the standardisation of the product also affect the type of layout. If standardised commodities are to be manufactured on large scale, line type of layout may be adopted. If production is made on the order of the customers, the functional layout is better to be adopted.
3. *Basic managerial policies and decisions :* The type of layout depends very much on the decisions and policies of the management to be followed in producing a commodity with regard to size of plant , kind and quality of the product; scope for expansion to be provided for, the extent to which the plant is to be integrated, amount of stocks to be carried at any time, the kind of employee facilities to be provided etc.
4. *Nature of plant location :* The size, shape and topography of the site at which plant is located will naturally affect the type of layout to be followed in view of the maximum utilisation of space available. For example, if a site is near the railway line the arrangement of general layout for receiving and shipping and for the best flow of production in and out the plant may be made by the side of railway line. If space is narrow and the production process is lengthy, the layout of plant may.

5. *Type of industry process :* This is one of the most important factors influencing the choice of type of plant layout. Generally the types of layout particularly the arrangement of machines and work centres and the location of workmen varies according to the nature of the industry to which the plant belongs. For the purpose of layout, industry may be classified into two broad categories :

(i) intermittent and (ii) continuous. Intermittent type of industries are those which manufacture different components or different machines. Such industries may manufacture the parts, when required according to the market needs. Examples of such industries are shipbuilding plants. In this type of industry functional layout may be the best. The second type of industry in 'continuous' industry. In this type of industry raw materials are fed at one end and the finished goods are received at another end. A continuous industry may either be analytical or synthetical. As analytical industry breaks up the raw material into several parts during the course of production process or changes its form, e.g. oil and sugar refineries. A synthetic industry, on the other hand mixes the two or more materials to manufacture one product alongwith the process of production or assembles several parts to get finished product. Cement and automobile industries are examples of such industry. Line layout is more suitable in continuous process industries.

6. *Types of methods of production :* Layout plans may be different according to the method of production proposed to be adopted. Any of the following three methods may be adopted for production – (i) Job order production, (ii) batch production, and (iii) Mass Production. Under job production goods are produced according to the orders of the customers and therefore, specifications vary from customer to customer and the production cannot be standardised. The machines and equipment can be arranged in a manner to suit the need of all types of customers. Batch production carries the production of goods in batches or groups at intervals. In this type of manufacturing the product is standardised and production is made generally in anticipation of sales. In such cases functional or process layout may be adopted. In case of mass production of standardised goods, line layout is most suitable form of plant layout.

7. *Nature of machines :* Nature of machines and equipment also affects the layout of plant. If machines are heavy in weight or creates noisy atmosphere, stationary layout may reasonably be adopted. Heavy machines are generally fixed on the ground floor. Ample space should be provided for complicated machines to avoid accidents.

8. *Climate :* Sometimes, temperature, illumination and air are the deciding factors in deciding the location of machines and their establishments. For example, in lantern manufacturing industry, the spray painting room is built along the factory wall to ensure the required temperature control and air expulsion and then the process of spray painting may be undertaken.

properties of materials, quantity and quality of materials and combination of materials are probably the most important factors to be considered in planning a layout. So, materials storage and materials handling should be given due consideration. For materials storage factors such as rate of consumption of raw materials, space, volume and weight of raw materials, floor load capacity, ceiling height method of storing should be given special consideration. This will affect the space and the efficiency of the production process in the plant. It will facilitate economic production goods and prompt materials flow and a soundly conceived materials handling system.

10. *Type of machine and equipment :* Machines and equipment may be either general purpose or special purpose. In addition certain tools are used. The requirements of each machine and equipment are quite different in terms of their space, speed and material handling process and these factors should be given proper consideration while choosing out a particular type of layout. It should also be considered that each machine and equipment is used to its fullest capacity because machines involve a huge investment. For instance, under product layout, certain machines may not be used to their full capacity so care should be taken to make full use of the capacity of the machine and equipment.

production and therefore special consideration for their safety and comforts should be given while planning a layout, specific safety items like obstruction-free floor, workers not exposed to hazards, exit etc. should be provided for. The layout should also provide for the comforts to the workers such as provision of rest rooms, drinking water, lavatory and other services etc. Sufficient space is also to be provided for free movement of workers. For this, provisions of Factories Act should be followed strictly.

12. *Characteristics of the building :* Shape of building, covered and open area, number of storeys, facilities of elevators; parking area, storing place and so on also influence the layout plan. In most of the cases where building is hired, layout is to be adjusted within the space available in the building. Although miner modifications may be done to suit the needs of the plant and equipment. But if new building is to be constructed, proper care should be given to construct it according to the layout plan drawn by experts. Special type of construction is needed to accommodate huge or technical or complex or sophisticated machines and equipment.

It is clear from the above description that several factors are considered while choosing out a plan for plant layout because they affect the production and its cost to a great extent.

Costs Associated With Plant Layout

The costs associated with a decision on plant layout are :

(i) Cost of movement of materials from one work area to another.

(ii) Cost of space.

(iii) Cost of production delay, if any, which are indirect costs.

(iv) Cost of spoilage of materials, if any, when the materials are stacked or stored in conditions which deteriorate the quality of the material.

(v) Cost of labour dissatisfaction and health risks.

(vi) Cost of changes required, if the operational conditions change in the future. This is a long-term cost.

A good layout should minimize all these costs put together.

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. The interval between receiving the purchased parts and transforming them into final products varies from industries to industries depending upon the cycle time of manufacture. 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 is a must for smooth and efficient running of the production cycle with least interruptions.

Reasons for Keeping Inventories

- ***To stabilize production:*** The demand for an item fluctuates because of the number of factors, *e.g.,* seasonality, production schedule etc. The inventories (raw materials and components) should be made available to the production as per the demand failing which results in stock out and the production stoppage takes place for want of materials. Hence, the inventory is kept to take care of this fluctuation so that the production is smooth.
- ***To take advantage of price discounts:*** Usually the manufacturers offer discount for bulk buying and to gain this price advantage the materials is bought in bulk even though it is not required immediately. Thus, inventory is maintained to gain economy in purchasing.
- ***To meet the demand during the replenishment period:*** The lead time for procurement of materials depends upon many factors like location of the source, demand supply condition, etc. So inventory is maintained to meet the demand during the procurement (replenishment) period.

- ***To prevent loss of orders (sales)*:** In this competitive scenario, one has to meet the delivery schedules at 100 per cent service level, means they cannot afford to miss the delivery schedule which may result in loss of sales. To avoid the organizations have to maintain inventory.
- ***To keep pace with changing market conditions:*** The organizations have to anticipate the changing market sentiments and they have to stock materials in anticipation of non-availability of materials or sudden increase in prices.
- Sometimes the organizations have to stock materials due to other reasons like suppliers minimum quantity condition, seasonal availability of materials or sudden increase in prices.

Meaning of Inventory Control

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), and
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.

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 (*i.e.,* 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, following are the benefits of inventory control:

1. Improvement in customer's relationship because of the timely delivery of goods and service.
2. Smooth and uninterrupted production and, hence, no stock out.

3. Efficient utilization of working capital. Helps in minimizing loss due to deterioration, obsolescence damage and pilferage.
4. Economy in purchasing.
5. Eliminates the possibility of duplicate ordering.

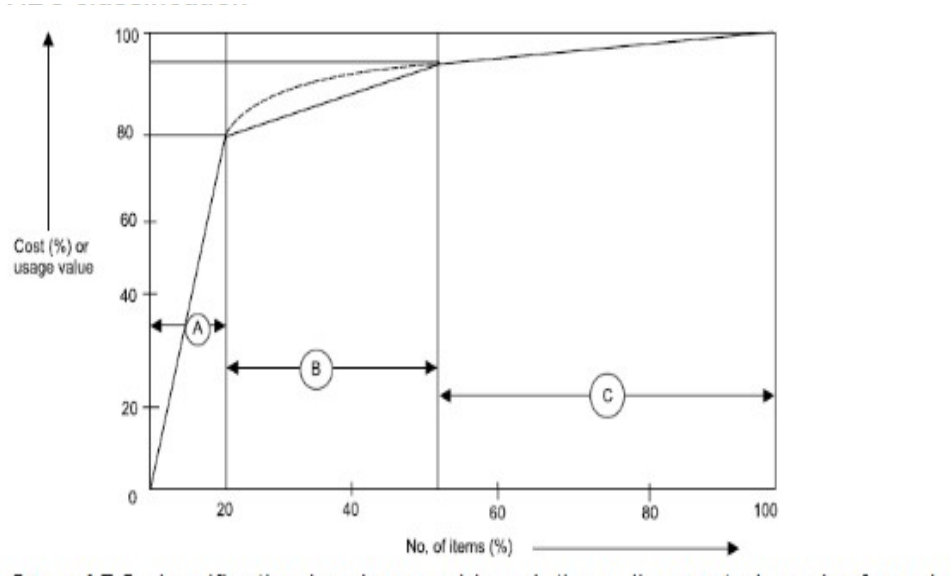
Techniques of Inventory Control: In any organization, depending on the type of business, inventory is maintained. When the number of items in inventory is large and then large amount of money is needed to create such inventory, it becomes the concern of the management to have a proper control over its ordering, procurement, maintenance and consumption. The control can be for order quality and order frequency. The different techniques of inventory control are: (1) ABC analysis, (2) HML analysis, (3) VED analysis, (4) FSN analysis, (5) SDE analysis, (6) GOLF analysis and (7) SOS analysis. The most widely used method of inventory control is known as ABC analysis. In this technique, the total inventory is categorized into three sub-heads and then proper exercise is exercised for each sub-heads.

1. ***ABC analysis:*** In this analysis, the classification of existing inventory is based on annual consumption and the annual value of the items. Hence we obtain the quantity of inventory item consumed during the year and multiply it by unit cost to obtain annual usage cost. The items are then arranged in the descending order of such annual usage cost. The analysis is carried out by drawing a graph based on the cumulative number of items and cumulative usage of consumption cost. Classification is done as follows:

Category	*Percentage of items*	*Percentage of annual consumption value*
A	10–20	70–80
B	20–30	10–25
C	60–70	5–15

The classification of ABC analysis is shown by the graph given as follows.

ABC classification



Once ABC classification has been achieved, the policy control can be formulated as follows:

1. Very tight control, the items being of high value. The control need be exercised at higher level of authority.

2. Moderate control, the items being of moderate value. The control need be exercised at middle level of authority.

3. The items being of low value, the control can be exercised at gross root level of authority, *i.e.*, by respective user department managers.

2. ***HML analysis:*** In this analysis, the classification of existing inventory is based on unit price of the items. They are classified as high price, medium price and low cost items.
3. ***VED analysis:*** In this analysis, the classification of existing inventory is based on criticality of the items. They are classified as vital, essential and desirable items. It is mainly used in spare parts inventory.
4. ***FSN analysis*:** In this analysis, the classification of existing inventory is based consumption of the items. They are classified as fast moving, slow moving and non-moving items.
5. ***SDE analysis:*** In this analysis, the classification of existing inventory is based on the items.
6. ***GOLF analysis:*** In this analysis, the classification of existing inventory is based sources of the items. They are classified as Government supply, ordinarily available, local availability and foreign source of supply items.
7. ***SOS analysis:*** In this analysis, the classification of existing inventory is based nature of supply of items. They are classified as seasonal and off-seasonal items. For effective inventory control, combination of the techniques of ABC with VED or ABC with HML or VED with HML analysis is practically used.

Inventory Model

ECONOMIC ORDER QUANTITY (EOQ)

Inventory models deal with idle resources like men, machines, money and materials. These models are concerned with two decisions: how much to order (purchase or produce) and when to order so as to minimize the total cost.

For the first decision how much to order, there are two basic costs are considered namely, inventory carrying costs and the ordering or acquisition costs. As the quantity ordered is increased, the inventory carrying cost increases while the ordering cost decreases. The 'order quantity' means the quantity produced or procured during one production cycle. Economic order quantity is calculated by balancing the two costs. Economic Order Quantity (EOQ) is that size of order which minimizes total costs of carrying and cost of ordering.

i.e., Minimum Total Cost occurs when Inventory Carrying Cost = Ordering Cost

Economic order quantity can be determined by two methods:

1. Tabulation method.
2. Algebraic method.

1. Determination of EOQ by Tabulation (Trial & Error) Method

This method involves the following steps:

1. Select the number of possible lot sizes to purchase.
2. Determine average inventory carrying cost for the lot purchased.
3. Determine the total ordering cost for the orders placed.
4. Determine the total cost for each lot size chosen which is the summation of inventory carrying cost and ordering cost.
5. Select the ordering quantity, which minimizes the total cost.

The data calculated in a tabular column can plotted showing the nature of total cost, inventory cost and ordering cost curve against the quantity ordered .

2. *Determination of EOQ by Analytical Method*

In order to derive an economic lot size formula following assumptions are made:

- Demand is known and uniform.
- Let D denotes the total number of units purchase/produced and Q denotes the lot size in each production run.

- Shortages are not permitted, *i.e.*, as soon as the level of the inventory reaches zero, the inventory is replenished.
- Production or supply of commodity is instantaneous.
- Lead-time is zero.
- Set-up cost per production run or procurement cost is C3.
- Inventory carrying cost is C1= CI, where C is the unit cost and I is called inventory carrying cost expressed as a percentage of the value of the average inventory.

PRODUCTION CONTROL

All organizations irrespective of size, use production control to some degree. In small organizations, the production control may be performed by one person; but in large complex industries the production control department is normally well-organised and highly specialised. Production control presupposes the existence of production plans, and it involves the use of various control techniques to ensure production performance as per plans. Co-ordinating men and materials and machines are the task of production control.

Production control may be defined as "the process of planning production in advance of operations; establishing the exact route of each individual item, part of assembly; setting, starting and finishing dates for each important item, assembly, and the finished products, and releasing the necessary orders as well as initiating the required follow-up to effectivate the smooth functioning of the enterprise." According to Henry Fayol, "production control is the art and science of ensuring that all which occurs is in accordance with the rules established and the instructions issued". Thus, production control regulates the orderly flow of materials in the manufacturing process from the raw material stage to the finished product.

Production control aims at achieving production targets, optimum use of available resources, increased profits through productivity, better and more economic goods and services etc. An effective production control system requires reliable information, sound organisation structure, a high degree of standardisation and trained personnel for its successful operation.

A sound production control system contributes to the efficient operation of a plant. In terms of manufacturing customer's orders, production control assures a more positive and accurate completion and delivery date. Delivering an order on time is obviously important to the

customer and to the development of customer goodwill. Production control also brings plan and order to chaotic and haphazard manufacturing procedures. This not only increases the plant efficiency but also makes it a more pleasant place in which to work. Most people recognize that employees prefer to work and do better work under conditions of obvious control and plan. Morale may be considerably improved. Effective production control also maintains working inventories at a minimum, making possible a real saving in both labour and material investment. Thus, good production control helps a company operate and produce more efficiently and achieve lowest possible costs.

Objectives of Production Control

(i) Provision of raw material, equipment, machines and labour.
(ii) To organize production schedule in conformity with the demand forecasts.

(iii) The resources are used in the best possible manner in such a way that the cost of production is minimised and delivery date is maintained.

(iv) Determination of economic production runs with a view to reduce setup costs.

(v) Proper co-ordination of the operations of various sections/ departments responsible for production.

(vi) To ensure regular and timely supply of raw material at the desired place and of prescribed quality and quantity to avoid delays in production.

(vii) To perform inspection of semi-finished and finished goods and use quality control techniques to ascertain that the produced items are of required specifications.

(viii) It is also responsible for product design and development.

Thus the fundamental objective of production control is to regulate and control the various operations of production process in such a way that orderly flow of material is ensured at different stages of the production and the items are produced of right quality in right quantity at the right time with minimum efforts and cost.

Levels of Production Control

Production control starts with some particular goal and formulation of some general strategy for the accomplishment of desired objectives. There are three levels of production control namely programming, ordering and dispatching. Programming plans the output of products for the factory as a whole. Ordering plans the output of components from the suppliers and processing departments. Dispatching considers each processing department in turn and plans the output from the machine, tools and other work centres so as to complete the orders by due date.

Factors Determining Production Control Operations

The nature of production control operations varies from organisation to organisation. The following factors affect the nature and magnitude of production control methods in an organisation :

(i) Nature of production : In job-oriented manufacturing, products and operations are designed for some particular order which mayor may not be repeated in future. Here production usually requires more time, whereas in a continuous manufacturing system inventory problems are more complex but control operations are rather simple due to fixed process. In mixed stock and custom manufacturing systems the problem of control is further complicated due to simultaneous scheduling of combined process.

(ii) Nature of operations/activities : In intermittent manufacturing system the operations are markedly varied in terms of their nature, sequence and duration. Due to this the control procedure requires continuous modifications and adjustments to suit the requirements of each order.

(iii) Magnitude of operations : Centralised control secures the most effective coordination but as an organisation grows in size, decentralisation of some production control function becomes necessary. The degree to which the performance of an activity should be decentralised depends upon the scope of operations and convenience of their locations.

Planning and control are interrelated and interdependent. Planning is meaningless unless control action is taken to ensure the success of the plan. Control also provides information feedback which is helpful in modifying the existing plans and in making new plans. Similarly, control is dependent on planning as the standards of performance are laid down under planning. Therefore, production planning and control should be considered an integrated function of planning to ensure the most efficient production and regulation of operations to execute the plans successfully.

Production planning and control may be defined as the direction and coordination of the firm's material and physical facilities towards the attainment of pre-specified production goals in the most efficient available way. It is the process of planning production in advance of operations, establishing the exact route of each individual item, part or assembly, setting starting and finishing dates for each important item or assembly and finished products, and releasing the necessary orders as well as initiating the required follow up to effectuate the smooth functioning of the enterprise. Thus, production planning and control involves planning, routing, scheduling, dispatching and expediting to coordinate the movements of materials, machines and manpower as to quantity, quality, time and place. It is based upon the old adage of "first plan your work and then work your plan".

Objectives of Production Planning and Control

The main objective of production planning and control is to ensure the coordinated flow of work so that the required number of products are manufactured in the required quantity and of required quality at the required time at optimum efficiency. In other words, production planning and control aims at the following purposes :

(i) Continuous Flow of Production : It tries to achieve a smooth and continuous production by eliminating successfully all sorts of bottlenecks in the process of production through well-planned routing and scheduling requirements relating to production work.

(ii) **Planned Requirements of Resources :** It seeks to ensure the availability of all the inputs i.e. materials, machines, tools, equipment and manpower in the required quantity, of the required quality and at the required time so that desired targets of production may be achieved.

(iii) Co-ordinated work Schedules : The production activities planned and carried out in a manufacturing organizations as per the master schedule. The production planning and control tries to ensure that the schedules to be issued to the various departments/ units/supervisors are in co-ordination with the master schedule.

(iv) Optimum Inventory : It aims at minimum investment in inventories consistent with continuous flow of production.

(v) Increased Productivity : It aims at increased productivity by increasing efficiency and by being economical. This is achieved by optimising the use of productive resources and eliminating wastage and spoilage.

(vi) Customer Satisfaction : It also aims at satisfying customers requirements by producing the items as per the specifications or desires of the customers. It seeks to ensure delivery of products on time by co-ordinating the production operations with customers' orders.

(vii) Production and Employment Stabilization : Production planning and control aims at ensuring production and employment levels that are relatively stable and consistent with the quantity of sales.

(viii) Evaluation of Performance : The process of production planning and control is expected to keep a constant check on operations by judging the performance of various individuals and workshops and taking suitable corrective measures if there is any deviation between planned and actual operations.

Importance of Production Planning and Control

The system of production planning and control serves as the nervous system of a plant. It is a co-ordinating agency to co-ordinate the activities of engineering, purchasing, production, selling and stock control departments. An efficient system of production planning and control helps in providing better and more economic goods to customers at lower investment. It is essential in all plants irrespective of their nature and size. The principal advantages of production planning and control are summarized below :

(i) Better Service to Customers : Production planning and control, through proper scheduling and expediting of work, helps in providing better services to customers in terms of better quality of goods at reasonable prices as per promised delivery dates. Delivery in time and proper quality, both help in winning the confidence of customers, improving relations with customers and promoting profitable repeat orders.

(ii) Fewer Rush Orders : In an organisation, where there is effective system of production planning and control, production operations move smoothly as per original planning and matching with the promised delivery dates. Consequently, there will be fewer rush orders in the plant and less overtime than, in the same industry, without adequate production planning and control.

(iii) Better Control of Inventory : A sound system of production planning and control helps in maintaining inventory at proper levels and, thereby, minimising investment in inventory. It requires lower inventory of work-in-progress and less finished stock to give efficient service to customers. It also helps in exercising better control over raw-material inventory, which contributes to more effective purchasing.

(iv) **More Effective Use of Equipment :** An efficient system of production planning and control makes for the most effective use of equipment. It provides information to the management on regular basis pertaining to the present position of all orders in process, equipment and personnel requirements for next few weeks. The workers can be communicated well in advance if any retrenchment, lay-offs, transfer, etc. is likely to come about. Also, unnecessary purchases of equipment and materials can be avoided. Thus, it is possible to ensure proper utilization of equipment and other resources.

(v) Reduced Idle Time : Production planning and control helps in reducing idle time i.e. loss of time by workers waiting for materials and other facilities; because it ensures that materials and other facilities are available to the workers in time as per the production schedule. Consequently, less man-hours are lost, which has a positive impact on the cost of production.

(vi) Improved Plant Morale : An effective system of production planning and control co-ordinates the activities of all the departments involved in the production activity. It ensures even flow of work and avoids rush orders. It avoids ‘speeding up’ of workers and maintains healthy working conditions in the plant. Thus, there is improved plant morale as a by-product.

(vii) Good Public Image : A proper system of production planning and control is helpful in keeping systematised operations in an organisation. Such an organisation is in a position to meet its orders in time to the satisfaction of its customers. Customers satisfaction leads to increased sales, increased profits, industrial harmony and, ultimately, good public image of the enterprise.

(viii) Lower Capital Requirements : Under a sound system of production planning and control, everything relating to production is planned well in advance of operations. Where, when and what is required in the form of input is known before the actual production process starts. Inputs are made available as per schedule which ensures even flow of production without any bottlenecks. Facilities are used more effectively and inventory levels are kept as per schedule neither more nor less. Thus, production planning and control helps, in minimising capital investment in equipment and inventories.

Limitations of Production Planning and Control

Undoubtedly, the system of production planning and control is a must for efficient production management; but in, practice, sometimes, it fails to achieve the expected results because of the following limitations :

(i) Lack of Sound Basis : Production planning and control is based on certain assumptions or forecasts about availability of inputs like materials, power, equipment etc. and customers orders. In case these assumptions and forecasts do not go right, the system of production planning and control will become ineffective.

(ii) Rigidity in Plant's Working : Production planning and control may be responsible for creating rigidity in the working of the plant. Once the production planning has been completed, any subsequent change may be resisted by the employees.

(iii) Time consuming Process : Production planning is a time consuming process. Therefore, under emergencies it may not be possible to go through the process of production planning.

(iv) Costly Device : Production planning and control is not only a time consuming process but is a costly process also. Its effective implementation requires services of specialists for performing functions of routing, scheduling, loading, despatching and

expediting. Small firms cannot afford to employ specialists for the efficient performance of these functions.

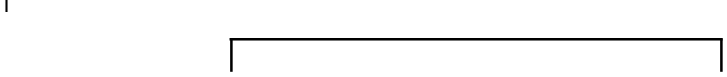
(v) External Limitations : The effectiveness of production planning and control is sometimes limited because of external factors which are beyond the control of production manager, Sudden break-out of war, government control, natural calamities, change in fashion, change in technology, etc. are factors which have a negative impact on the implementation of production planning and control.

Steps in Production Planning and Control

The function of production planning and control involves co-ordination and integration of the factors of production for optimum efficiency. Overall sales orders or plans must be translated into specific schedules and assigned so as to occupy all work centres but overload none. The job can be done formally, in which case elaborate charting and filing techniques are used; or it can be done informally with individual's thoughts and retention thereof supplanting tangible aids. In any case, the production planning and control function must be performed somehow by someone. The better the job that is done, the better the profit picture will be.

The basic phases of production planning and control are shown and discussed below :

Production Planning and Control



Planning	**Control**
(Plan your work)	(Work your plan)
1. Routing	4. Dispatching

2. Loading

3. Scheduling

5. Expediting or Follow up

6. Corrective Action

1. Routing

Production routing involves the laying de n of path which work will follow and the order in which various operations will be carried out. It consists of the determination of operations through which the product must pass and the arrangement of operations in the sequence that will require a minimum of handling, transportation, storage and deterioration through exposure.

It is the job of routing personnel to determine the production routes in the organisation. A route for the movement of a manufacturing lot through the factory results from the determination of where each operation on a component part, subassembly, or assembly is to be performed. Routing may be generalised or detailed, depending upon the quality of product to be manufactured, production system in use and other factors. Generalised routing may be established either by building or by departments such as machine shop, assembly or others. Detailed routing indicates the specific work station or machine to be used for each operation.

The aim of routing is to determine an economical sequence of operations. Efficient routing permits the best utilisation of physical human resources employed in production. Routing is an essential element of production control because other production control functions are dependent on routing function. The persons who make out a list of operations must be thoroughly familiar with all the operations and various machines in the plant so that they are able to establish routes which will ensure maximum utilisation of the plant and machinery.

The routing procedure depends on considerations of type of work stations, characteristics of individual machines, needs of personnel etc. Routing in continuous industries does not present any problem because of the product type of layout where the equipment is arranged as per the sequence of operations required to be performed on the components (from raw material to the finished products). On the other hand, in open job shops, since every time a

new job is undertaken, the route sheet will have to be revised which involves a lot of work and expertise. In general, the following routing procedure is followed :

(i) Determining What to Make and What to Buy : The product is analysed, from manufacturing point of view, to find out how many parts or components can be manufactured in the plant and how many can be purchased from outside directly. The decision to make or buy a component depends on relative cost involved, technical consideration, purchasing policies of the firm and availability of equipment, and personnel. In general during slack periods the decision is taken to undertake maximum production to keep the men and machines busy. On the other hand, during prosperity, the sub-contracts are given for any parts to relieve overburdened facilities.

(ii) Ascertaining the Requirements of Materials : After the decision to manufacture is taken, the production department decides the exact quantity and quality of materials required for the manufacture of the components or the product. A parts list and a bill of materials is prepared showing name of each part, quantity, material specifications, amount of materials required, etc. The necessary materials, thus, can be procured.

(iii) Preparation of Route Sheet : The chief paper which gives the details of what is to be done and how it will have to be done is called a route sheet. In other words, a route sheet is a tabular form on which the path that a particular item is to follow through production is recorded. Route sheets are prepared in advance of need and filed in route file. A route sheet is to be prepared for every production order showing the individual parts to be completed for each finished individual parts to be completed for each finished product before any group can be assembled.

Route sheets will contain the following details in full :

(a) The works order No.
(b) Number of pieces to be made.
(c) Symbol and classification of the part.
(d) The lot sizes for each unit of production, if put through in lots.
(e) List of operations for each part.
(f) Definite sequence of operations.
(g) Machine to be used for each operation.
(h) Materials that is necessary for a given operation.
(i) Standard time for each operation.

A separate route sheet is necessary for each part or component of a works order. It may be noted that it is not necessary that the number of pieces mentioned on the route sheet should be the same as required under any specified order; because in many cases some allowance has to be made for spoilage, and additional pieces may be needed for stock, or as reserves for repairs, or as spares.

While preparing a route sheet, it is essential to bear in mind that the route selected is the shortest and the most economical of all possible alternative routes.

(iv) Determining Lot Sizes : When the work orders are received from the customers, it is necessary to determine the lot sizes so as to keep the route free and ready for smooth operations. This must be done with due reference to length of operations, space occupied by the material while moving through the shop, and the requirements of the master schedule.

(v) **Determining Scrap Factors :** A scrap factor is the anticipated normal scrap encountered in the course of manufacturing process. The routing department should determine the amount of possible scrap and rejection in each order or lot. Usually, a margin of 5% to 10% is kept for such rejections.

(vi) Estimation of the cost of the Product : The cost of the component or product is analysed and estimated through the information obtained in steps
(i) to (v) above. The cost consists of material, wages, and other specific and indirect expenses.

(vii) Preparation of Production Control Forms : To collect detailed information relating to production control, the production department prepares the various forms such as job cards, inspection cards, move tickets, tool tickets, etc.

2. Loading

Once the route has been established, the work can be loaded against the selected machine. Loading deals with the amount of work assigned to a machine or a worker. It deals with the record of work-load of different shops. The total time required to perform the operations is computed by multiplying the unit operation time given on the standard process sheet by the number of parts to be processed. The total time is then added to the work already planned for the work station. The process results in a tabulated list or chart showing the planned

utilisation of machines or work stations in the plant. From the chart, it is easy to assess the spare capacity of the plant.

If the loading charts indicate sufficient spare capacity, efforts may be directed through the sales department to obtained more orders for the utilisation of spare capacity. Underload of certain departments may also arise from ineffective planning. In such a case, the remedy lies in proper planning. But if, on the other hand, there is an overload in any workshop, action on anyone or more of the following lines may be taken to relieve the bottleneck

(a) by arranging for overtime work;
(b) by introducing an additional shift;
(c) by transferring operations to another shop; and
(d) by sub-contracting of the excess load.

3. Scheduling

Scheduling involves fixing priorities for different items and operations

and providing for their release to the plant at the proper time. It establishes the time sequence of operations and indicates the time required for each job and operation. A schedule is a time-table of operations specifying the time and date when each job/operation is to be started and completed. Scheduling is, thus, the determination of the time that should be required to perform each operation and also the time necessary to perform the entire series, as routed making allowance for all factors concerned.

The objective of scheduling is to ensure that every job is started at the right time and it is completed before the delivery date. Scheduling and routing are inter-dependent and the two should, therefore, be integrated properly. It is difficult to prepare a schedule of production without determining the route or sequence of operations. Similarly, an efficient route for an item cannot be determined without consulting the production schedule designed for it. To be effective, scheduling should be flexible and due provision should be made for contingencies like delay in the availability of materials, breakdown of machines, absence of key personnel, etc.

4. Dispatching

Dispatching may be defined as the setting of productive activities in motion through release of orders and instructions, in accordance with previously planed timings as embodied on

operation sheet, route card and loading schedules. Dispatch provides official authorization and information for (i) Movement of materials to different work stations, (ii) movement of tools and fixtures necessary for each operation, (iii) beginning of work on each operation, (iv) recording of beginning and completion time, (v) movement of work in accordance with a routing schedule, (vi) control of progress of all operations and making of necessary adjustments in the release of operations.

Dispatching requires co-ordination among all the departments concerned. This is obtained through varied degrees of centralised control. Under centralised control, dispatch clerks, centrally located, release all orders including the movement of materials and tools necessary for the operations. Under decentralised control, this responsibility is handled by each department.

In continuous manufacturing, under normal conditions, orders may be dispatched to departments a day or more in advance of operations. Each department prepares its own instructions and sends a duplicate copy to the central office. Since duplicate copies are received by the central office considerably in advance of operations, there is sufficient time for the recommendation of changes.

If it is found that certain orders are being unduly delayed, a request may be made for adjustments. However under abnormal conditions, when a company is being pressed by impatient customers, and the plant is loaded to capacity, emergency changes are more frequent. A special rush order may required that operations start immediately and that other orders originally scheduled may be held temporarily. Under these circumstances, it is apparent that centralised control plays an important role in obtaining speed and co-ordination.

5. Expediting or Follow Up

Expediting or follow up is the last step in production planning and control. It involves determination of the progress of work, removing bottlenecks in the flow of work and ensuring that the productive operations are taking place in accordance with the plans. Follow up or expediting is that branch of production control procedure which regulates the progress

of materials and parts through the production process. It spots delays or deviations from the production plans.

It helps to reveal defects in routing and scheduling, misunderstanding of orders and instructions under loading or overloading of work etc. All problems and deviations are investigated and remedial measures are undertaken to ensure the completion of work by the planned date.

Follow up serves as a catalytic agent to fuse the separate production activities into a unified whole. It seeks to ensure that the promise is backed up by performance and the work done is upto the pre-determined standards as to quantity, quality, time and cost. The responsibility for expediting is usual1y given to a separate group of persons known as 'expeditors'. These people are 'liaison men' or 'go-betweens' who obtain information on the progress of work and attempt to achieve coordination among the different departments.

6. Corrective Action

Corrective action is needed to make effective the system of production planning and control. By resorting to corrective measures, the production manager maintains full control over the production activities. For instance, routing may be defective and the schedules may be unrealistic and rigid. The production manager should try to rectify the routes and lay down realistic and flexible schedules. Workload of machines and workers should also be determined scientifical1y. If schedules are not being met, the causes should be fully investigated. It should also be ensured that there is optimum utilisation of the plant capacity.

Sometimes, abnormal situations like strike and break-down of machinery or power may upset the work schedules. The production manager should try to make up the delays and adjust the schedules properly. Systematic investigation of activities at various stages of production may also lead the production manager to revise the production targets, loads and schedules. There is also a strong need of performance appraisal of all employees. Many a time, production schedules are not met in time or if they are met, the goods are of substandard quality. If the causes of these are due to the poor performance of the employees, certain personnel decisions like demotion, transfer and training may be essential.

Definition of Work Study:

"Work study is a generic term for those techniques, particularly method study and work measurement, which are used in all its context and which lead systematically to the investigation of all the factors, which effect the efficiency and economy of the situation being reviewed in order to effect improvement."

Meaning of Work Study:

According to ILO — International Labour Organisation — work study is **"a term used to embrace the techniques of method study and work measurement which are employed to ensure the best possible use of human and material resources in carrying out a specified activity."** In other words, "work study is a tool or technique of management involving the analytical study of a job or operation." Work study helps to increase productivity.

Objectives of Work Study:

(i) Work study brings higher productivity;

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(ii) Work study improves existing method of work for which cost becomes lower;

(iii) It eliminates wasteful elements;

(iv) It sets standard of performance;

(v) It helps to use plant and human more effectively;

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(vi) It improves by saving in time and loss of material also.

Steps Involved in Work Study:

The steps of work study are:

(i) It selects the jobs which are to be studied;

(ii) It examines critically the recorded facts which are already done;

(iii) It records from direct observations all the matters which are happened;

(iv) It defines new method;

(v) It also installs the new method;

(vi) It also maintains the new standard;

(vii) It develops most economic and appropriate methods;

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(viii) It measures the work content in the method, that is selected and compute a standard time.

Types of Work Study:

1. Method Study:

According to ILO, method study is **"the systematic recording, analysis and critical examination of existing and proposed ways of doing work and the development and application of easier and more effective method".**In short, it is a systematic procedure to analyse the work to eliminate unnecessary operations.

Objectives:

The objectives of method study are:

(i) It improves the proper utilisation of manpower, machine and materials;

(ii) It also improves the factory layout, work place, etc.;

(iii) It also improves the process and procedure;

(iv) It develops better physical working environment;

(v) It reduces undesirable fatigue.

Steps:

The steps of method study are:

(i) At first select the proper work which are to be studied;

(ii) Record all the facts of existing method;

(iii) Examine the facts very critically;

(iv) Develop the most practical, economic, and effective method;

(v) Install the method and the same should be maintained.

2. Time And Motion Study:

According to ILO, Time Study means **"a technique for determining as accurately as possible from a limited number of observations the time necessary to carry out a given activity at a different standard of performance".** In other words, "time study is the art of observing and recording time required to do each detailed element of an individual operation." Practically, it studies the time taken on each element of a job.

Motion study, on the other hand, is the study of the body motion used in performing an operation, with the thought of improving the operation by eliminating unnecessary motion and simplifying necessary motion and thus establishing the most favourable motion sequence for maximum efficiency.

So, in short, 'Time Study' means the determination of standard time that is taken by a worker of average ability under normal working conditions for performing a job. But 'Motion Study'

determines the correct method of doing a job to avoid wasteful movements, for which the workers are unnecessarily tired.

Steps:

1. Time and Motion studies eliminate wasteful movements;

2. They examine the proposed method critically and determine the most effective one;

3. They determine for each element having a stop-watch;

4. They record all the parts of a job which are done by the existing method;

5. They install the method as standard one;

6. They critically observe the workers who are engaged with the work;

7. They assess the proper speed of the operator who is working.

Method Study Procedure

This procedure involves seven basic steps as follows :

1. SELECT

Select the work to be studied and define its boundaries. There are three factors that should be kept in mind when selecting a job.

i. Economic Factor

It is obviously a waste of time to start or to continue a long investigation if the economic importance of a job is small,or if it is one that is not expected to run for long. The economic importance of the job must be of such magnitude that it is worthwhile to begin a method, study of the job or to continue it. Bottlenec1cs in production, too much movement of materials in the operation, idle machines, idle operators and high costs of operations are the usual. choices. The preferences should be given to the job with the greatest potential savings. No job should be selected for the method study, if it is expected to run only for a short time.

ii. Technical Factor

One of the important considerations is the desire by management to acquire more advanced technology,whether in equipment or in processes.Thus management may want to computerize its office paperwork or its inventory system,or to introduce automation in the production operations.

ii. Human Factor

Certain operations are often a cause of dissatisfaction by workers.They may induce fatigue or monotony or may be unsafe or clumsy to operate.The level of satisfaction should point to a need for method study.Thus an operation which may be perceived as effective by management may,on the other hand,generate a great deal of resentment by the workforce.If such operations are addressed by work study specialists as part of an overall work study programme,the benefits of work study can become more apparent to the workforce. In selecting a job. human reactions should be given due-consideration. The relation between management and the workers must not be strained. Unpopular and tiresome jobs should be studied with improved functions. The workers will eventually accept method study if the unpleasant features of these unpopular jobs are removed from them by the application of method study

2. RECORD

Record all the relevant facts about the present method by direct observation and collect such additional data as may be needed from appropriate sources.The main aims of recording are:

i. To obtain adequate and accurate information.

ii. To present the facts in a concise and comprehensible form for analysis.

iii. To submit proposals to management in a way which is easily understood.

iv. To provide,eventually,detailed operating instructions for the use of supervisors and operators.

Types of Recording Techniques

The recording techniques generally used are as follows :

(a) The Operation Process Chart

(b) The Outline Process Chart

(c) The Flow Process Chart (material)

(d) The Flow Process Chart (man)

(e) The Multiple Activity Chart

(f) The -Two Handed Process Chart

(g) The Simultaneous Motion Cycle Chart (8IMO Chart)

(h) The Flow Diagram

(i) The String Diagram

(j) The Travel Chart

3. EXAMINE

Examine the way the job is being performed and challenge its purpoe,place,sequence and method of performance. When the details of the existing method have been recorded through a, suitable process chart, the next step in' the study procedure is to examine all the facts. Critical Examination. of the recorded, data is the crux of method study. I t is at this stage that the possible alternatives for each activity are evolved for later development. Each activity is questioned and challenged thoroughly with a view to improving the situation. Critical Examination consists of a well designed questioning pattern in an impartial and objective manner.

4. DEVELOP

Develop the most practical, economic and effective method having due regard to all contingent circumstances. various alternatives would have. been evolved for each activity during the examination stage and depending on the implications, some of the alternatives be chosen for development. Under each governing considerations like purpose, means, ' ,sequence, place and person there may be any number of suitable alternatives generated. In developing the new method the economics and productivity of these suggestions when the job is viewed as a whole must be determined. Each of the developed methods' would have to be again evaluated and the best chosen for implementation. In determining the best method, economic considera- 40 tion such as, cost of implementation and expected savings, feasibility; acceptance and reaction of employees would all have to be taken into account.

5. DEFINE

Define the new method in a clear manner and present it to those concerned,i.e management,supervisors and workers.After the proposal plan is finalized,it is reduced to writing to provide continous guidance to the key persons in the organization. The written standard practice should give a clear description of

(I) the diagram of work place layout and if possible, the sketches of special tools, jigs or fixtures

(2) the tools and equipments to be used,

(3) general operating conditions

(4) a description of new method. The. details of description of new method will depend on the nature of the job and the volume of production

6. INSTALL

Install the method as standard practice and train the persons involved in applying it.The implementation is successful if the top management has developed faith and interest in the new plan and can motivate the personnel down the line. Installation will require the active support of all concerned and it is by no means a simple job.

7. MAINTAIN

Maintain the method by regular routine checks.Introduce control procedures to prevent a drifting back to the previous method of work.The top leaders must learn the art of dealing with the interest groups and the pressure groups,who may oppose the running of the new method on flimsy grounds. e, when the new method is operating. detailed supervision is necessary until managements are satisfied that the scheme is operating satisfactorily. Unless the new method is observed for some time after installation the expected results may not be reused. Changes may creep in which lead to. a less of efficiency and external conditions may alter. On the other hand some changes may improve efficiency and will show up in operation. Therefore, during the 'maintain' period reviews are carried out at the necessary frequency in order to see that the planned results are achieved and if possible improved.

METHOD STUDY SYMBOLS

Distance in metre	*Symbol*	*Process description*
10	⇨	Move to cabinet
-	○	Get loaf of bread
-	○	Remove two slices of bread
-	○	Lay slices on counter-top
-	○	Close loaf of bread
	○	Replace loaf of bread on shelf
-	○	Open butter
-	○	Spread butter on top slice of bread
-	□	Inspect sandwich
10	⇨	Move to serving area
-	○	Serve sandwich

Operation

An operation occurs when an object is intentionally changed in one or more of its characteristics (physical or chemical). This indicates the main steps in a process, method or procedure.

An operation always takes the object one stage ahead towards completion. Examples of operation are:

- Turning, drilling, milling, etc.
- A chemical reaction.
- Welding, brazing and riveting.
- Lifting, loading, unloading.
- Getting instructions from supervisor.

Inspection

An inspection occurs when an object is examined and compared with standard for quality and quantity. The inspection examples are:

- Visual observations for finish.
- Count of quantity of incoming material.
- Checking the dimensions.

Transportation

A transport indicates the movement of workers, materials or equipment from one place to another.

Example:

Movement of materials from one work station to another. Workers travelling to bring tools.

Delay D: Delay (Temporary Storage)

A delay occurs when the immediate performance of the next planned thing does not take place.

Example:

- Work waiting between consecutive operations.
- Workers waiting at tool cribs.
- Operators waiting for instructions from supervisor.

Storage

Storage occurs when the object is kept in an authorized custody and is protected against unauthorized removal. For example, materials kept in stores to be distributed to various work.

The micro-motion group of techniques is based on the idea of dividing human activities into division of movements or groups of movements (Therbligs) according to purpose for which they are made. Gilbreth differentiated 17 fundamental hand or hand and eye motions. Each Therbligs has a specific color, symbol and letter for recording purposes. The Therbligs are micro-motion study involves the following steps:

1. Filming the operation to be studied.

2. Analysis of the data from the film.
The recording of the data through ***SIMO chart*** is done as micro motion chart.

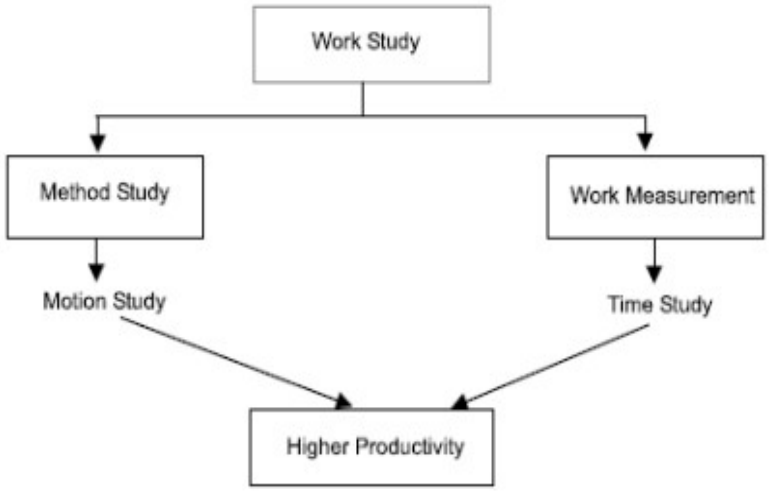
SIMO Chart

Simultaneous motion cycle chart (SIMO chart) is a recording technique for micro-motion study. A SIMO chart is a chart based on the film analysis, used to record simultaneously on a common time scale the Therbligs or a group of Therbligs performed by different parts of the body of one or more operators.

It is the micro-motion form of the man type flow process chart. To prepare SIMO chart, an elaborate procedure and use of expensive equipment are required and this study is justified when the saving resulting from study will be very high.

"**Work study** is a generic term for those techniques, method study and work measurement which are used in the examination of human work in all its contexts. And which lead systematically to the investigation of all the factors which affect the efficiency and economy of the situation being reviewed, in order to effect improvement."

Framework of work study



Work study is a means of enhancing the production efficiency (productivity) of the firm by elimination of waste and unnecessary operations. It is a technique to identify non-value adding operations by investigation of all the factors affecting the job. It is the only accurate and systematic procedure oriented technique to establish time standards. It is going to contribute to the profit as the savings will start immediately and continue throughout the life of the product. Method study and work measurement is part of work study. Part of method study is motion study, work measurement is also called by the name 'Time study'.

Advantages of Work Study

Following are the advantages of work study:

- It helps to achieve the smooth production flow with minimum interruptions.
- It helps to reduce the cost of the product by eliminating waste and unnecessary operations.
- Better worker-management relations.
- Meets the delivery commitment.
- Reduction in rejections and scrap and higher utilization of resources of the organization.
- Helps to achieve better working conditions.
- Better workplace layout.
- Improves upon the existing process or methods and helps in standardization and simplification.
- Helps to establish the standard time for an operation or job which has got application in manpower planning, production planning.