Mr. A. P. Nanda, Asst. Prof. (OM)

MODULE-I

Production process:

Products are the goods and services produced and processes are the facilities, skills and technologies used to produce them. Production processes are essential to produce products and the available processes limit what products can be produced.

Production function or operations function is the primary function of an industrial enterprise**. It also known as conversion process or transformation process which transforms some of the inputs (raw materials and components) into outputs(Goods/services) which are useful for the consumers.(Exhibit-1).**

A sample production system

MANUFACTURING OPERATIONS AND SERVICE OPERATIONS.

The field of operations can be divided into manufacturing operations and service operations.

Manufacturing operations:

Manufacturing operations convert inputs like materials, labour and capital into some tangible outputs.

Manufacturing processes are the primary processes and can be grouped under three basic categories, namely forming, machining and assembly. The objectives of each process is to change the shape or physical characteristics of the raw materials.

(i) Forming processes

Include casting forging, stamping embossing, spinning etc. these processes change the shape of the work piece without necessarily removing or adding material.

(ii) Machining processes:

Involve basically metal removal, by turning, drilling, milling, grinding, shaping, boring etc., it also includes chip less machining processes such as electro discharge machining (EMD), electrochemical machining(ECM), chemical milling, laser drilling etc.

(iii) Assembly processes:

Involve the joining of component or piece parts to produce a single component that has a specific function. Some of the common assembly processes are welding, brazing, soldering, riveting, fastening with bolts and nuts and joining by use of adhesives.

SELECTION OF A PROCESS:

The selection of a manufacturing process is influenced by several factors such as the desired product quality, labour cost to be achieved and the volume of production needed. While there can be several

manufacturing methods or processes to produce an item, there is usually one best method for a given set of variables.

Some of the common manufacturing processes are briefly described in the following paragraphs.

Forming Processes:

(a) Casting:

The casting process consists of pouring of molten metal into a mould and allowing sufficient time for the metal to solidify and retain the shape of the moulded cavity. The various casting methods are sand casting, shell moulding, gravity die casting, pressure die casting centrifugal casting, investment casting etc. Casting of plastics is done by compression moulding injection moulding, transfer moulding extrusion, vacuum forming and blowing.

(b) Forging:

In forging process the metal is heated to a plastic state and then formed to the desired shape by pressure or impact. The various types of forging processes are flat die forging, drop forging, upset forging, press forging and roll forging.

(c) Extrusion:

Extrusion process consists of forcing the metal through dies so that the metal obtains cross section of the same shape as the die. Extrusion process can be direct or forward extrusion, inverted or backward extrusion and impact extrusion.

(d) Stamping:

In the stamping process, force is applied on the metal to cause plastic flow and to alter the size and shape of the metal part to the desired size and shape. It is a cold working process.

(e) Embossing and Coining:

In embossing the metal is stretched or formed as per the configuration in the dies. Coining is performed in an enclosed die and the metal flow is restricted in a lateral direction.

An impact or compressive force causes the metal to flow in the shallow configurations of the blank being coined.

(f) Spinning:

Also known as spin forming, it is a process of shaping a metal by pressing it against a form or mandrel while it is rotating on a high speed lathe.

Machining Processes:

Machining process removes the metal from the work piece during the cutting operation performed by a cutting tool. Its prime function is to alter the shape of the work piece or raw materials, provide proper surface finish and dimensional accuracy. Some of the machining processes are:

(a) Turning:

In turning operation, the work piece is held in the lathe and rotated while the cutting tool or cutter removes the metal from the work piece. The various kinds of operations that can be performed on lathe

are cylindrical turning, taper turning, facing, reaming, drilling, boring thread cutting, grinding and knurling.

(b) Drilling and boring:

In drilling operation, a hold is produced on the work piece by forcing a rotating cutter known as drill bit through the work piece.

In boring operation, an existing drilled hold is enlarged by using a cutter known as boring bit.

Reaming is the finishing of a drilled hole to an accurate size using a fluted tool called a reamer.

(c) Milling:

Milling operation removes metal by feeding the work piece against a rotating multi-point cutting tool called milling cutter.

(d) Grinding

Grinding process refers to the abrading or wearing away by friction of a material. It is accomplished by forcing the work piece against a rotating grinding wheel made of abrasive material. Extremely hard metals or metals hardened by heat treatment processes can be machined only by the grinding process.

(e) Shaping and planning

In shaping or planning, plane surfaces are produced with the use of single point cutting tools. Work pieces, castings or forgings of smaller sizes are machined by shaping process, where planning process is used for machining work pieces, castings or forgings of larger sizes.

(f) Electro-discharge machining (EMD)

It is a 'chip less' process using electrical energy for metal removal. The operation involves producing a spark between the work piece and the tool across a gap between them. The work piece melts at the contact point of the spark and the molten metal is removed by the die-electric which also cools the work piece and the tool.

(g) Electrochemical machining (ECM)

This is also a "chip less" process but it differs from EDM is that chemical energy combines with electrical energy to do the cutting operation. It is opposite of the electroplating process. In ECM the metal to be removed is dissolved off the work piece and carried away by the electrolyte.

(h) Chemical milling:

This process removes metal by chemical action. It is an etching process with carefully controlled chemical reaction. Preleasing, masking, etching and stripping are the operations that must be performed in chemical milling.

Assembly Processes:

(a) Welding processes:

In welding process, two pieces of metal are joined into a single piece by fusion due to heat or combination of heat and pressure. Various types of welding processes are gas welding arc welding,

resistance welding (spot welding and seam welding), plasma arc welding, electron beam welding and laser welding.

(b) Brazing:

Brazing is a metal joining process used for joining nonferrous alloys(either similar or dissimilar metals).The brazing alloy melts at a lower temperature than the melting point of the base metals to be joined and fills the joint between the base metals by capillary action and then solidifies on cooling.

(c) Soldering:

Soldering process is similar to brazing except that the soldering alloy is different from brazing alloy and melts at a lower temperature as compared to brazing alloy. The lead-tin base solder alloys melt and flow throughout the solder joint by the heat of the joint itself.

(d) Riveting:

It is the process of placing the river in a hole drilled through the overlapping surfaces of the work pieces to be joined and upsetting the head of the rivet using a riveting tool.

(e) Fastening by bolts and nuts

When work pieces or parts of an assembly must be disassembled and reassembled, the best method of assembly is by fastening using screws, bolts and nuts.

(f) Assembling using adhesives:

Adhesives are used to bond almost all materials such as wood, rubber, plastics and metals.

Non-manufacturing or service operations

Non-manufacturing or service operations also transform a set of inputs into a set of outputs but the outputs are not tangible. Service operations can be classified into standard services and custom services according to the degree of standardization of their outputs and/or the processes they perform.

Some non-manufacturing operations such as wholesale distribution and freight transportation deal with tangible products whereas some non-manufacturing operations such as advice, consulting or consultancy deal only in intangible products.

An operation does not necessarily provide only service or only goods. Facilitating goods may be provided with services and facilitating services may be provided with goods. For example, same goods can be bought from a grocery store or from a super bazar. Also servicing of automobiles may include the replacement of some parts(i.e., spare parts).

Some of the examples of non-manufacturing operations which provide tangible goods are mail service, library service, and wholesale and retail distribution. Some of the non-manufacturing operations which provide only services and not tangible goods are health care, hair dressing, travel service, legal advice, marriage consultancy.

Characteristics of Manufactured Products and Services

Manufactured Products	*Services*
Tangible outputs	Intangible outputs
Products can be inventoried	Outputs cannot be inventoried
Little customer contact	Extensive customer contact
Long lead times	Short lead times
Capital intensive	Labour intensive
Product quality easily determined	Service quality determined with difficulty

****

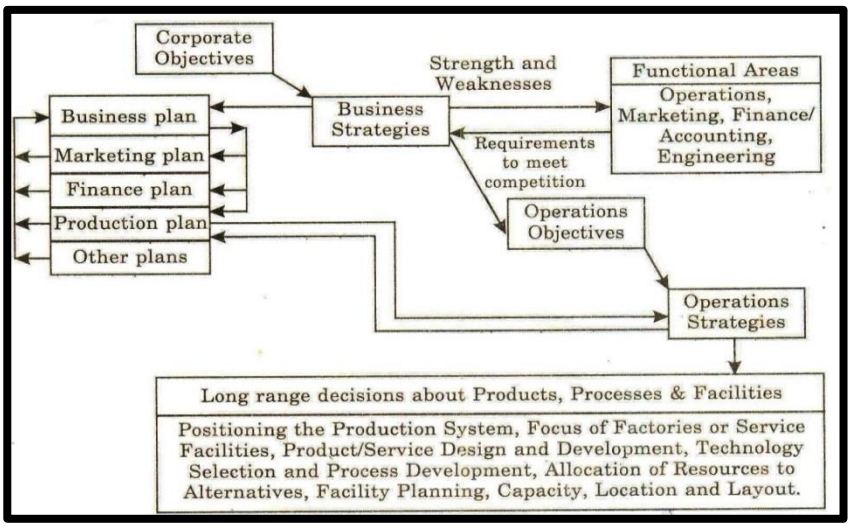
Responsibility Of Operation Manager:

He is responsible to the general manager for the accomplishment of the targeted output.The Production manager must necessarily possess the technical knowledge of the production process.He takes the assistace of staff officer like industrial engineer and production engineer for efficient production.His responsibilities are :

1.To prepare the production budget and achieved the budgeted output.
2.To receive work order from customers and to distribute the same for execution to the production control department.
3. To design the factory building and equip it with the most up to date and efficient operating plant In consultation with the chief engineer.
4. To undertake efficient designs,productive and reduction of the cost by simplification and Standardization.
5. To compare actual results of production with the targeted production and ascertain how far the Target has been attained.
6. To provide the best possible working condition to the employees in the production dept.
7. To organize a system of periodic meeting of work executives and workers so as to bring about Greater coordination and fullest co operation among all.
8. To engage in constant R & D programme , so as to discover new methods of production to mi Minimize wastage and ensure economical produion.
9. To investigate the actual running time and idle time of the machine .so that strict control could be Exercised.
10.To inspect the manufacturing process, machinery and equipment and to control the production cost.

OPERATIONS STRATEGIES

Operations strategies provide the road map for achieving the operations objectives and form the long-range game plan for production of the firm's goods and services. Operations strategies include decisions about each major product line on such issues as, what new production facilities are needed and when they are needed, what major production technologies and processes must be developed and what production schemes will be followed to produce the sales forecast, Operations objectives, and the strategies for realizing these objectives, are embodied in the production plan – the plan that will guide the operations function towards fulfilling it part of the business plan.



(Developing operations strategies)

BUILDING PRODUCTION/OPERATIONS STRATEGY ON COMPETITIVE PRIORITIES

The Production/Operations Strategy is derived from the business strategy which has a broader scope than production strategy Production /Operations strategy relates to *products, processes, methods, operating resources, quality, costs, lead times and scheduling.*

The Production/Operations strategy should be linked to the business strategy and the two should not be formulated independently. On the other hand, the business strategy should take into account the realities of the strengths and weaknesses of production; capitalizing on its strengths and dealing with its weaknesses. Likewise, production strategy must be consistent with the business strategy and formulated to support the goals of the business organization.

Production/Operations strategy may have a major influence on the competitiveness of an organization. If it is well designed and well executed, it improves the chances of success of an organization. In the 1970's and early 80's, production strategy was neglected in favour of marketing and financial strategies. But in the late 1980's and early 90's many companies began to realize the importance of operations strategy and hence they developed strategies that have *quality* or *time* as their major concern.

Strategy Formulation :

Strategy formulation is a key element of business strategy and production strategy. To formulate an effective strategy, the distinctive competencies are taken into account. The environment of the business must be scanned to determine what competitors are doing, or planning to do and take that into account. The factors that could have either positive or negative effects on the firm must be critically examined (sometimes referred to as SWOT analysis).

In formulating a successful strategy, a firm must take into account both order qualifiers and order winners. Order qualifiers are those characteristics that customers perceive as minimum standards of

acceptability to be considered as a potential for purchase. Order winners are those characteristics of a firm's goods or services that cause it to be perceived as better than the competition. Distinctive competencies are those special attributes or abilities that give a firm a competitive edge over others. Examples of distinctive competencies are given in Table.

Table: *Examples of Distinctive Competencies*

Dimension	Competency
Price	Low cost
Quality	High performance design, high quality, consistent quality
Time	Rapid delivery, on-time delivery
Flexibility	Variety, volume
Service	Superior customer service
Location	Convenience

Even though firms have tended to emphasize traditional strategies based on cost minimization or product differentiation, many firms are now adopting strategies based on quality and time which are rapidly gaining ground.

Quality - based strategies focus on satisfying the customer by integrating quality into all phases of the firm. This includes not only the final products or services offered to the customer but also the related processes such as product or service design, production and after-sales-service. Time-based strategies focus on reducing the time required to complete various activities (for examples, develop new products or services and market them, respond to change in customer demand or deliver a product or a service).

Time-based strategies focus on reducing the time needed to conduct the various activities in a process. By reducing time, costs are also reduced, productivity is increased, quality tends to be better, innovative products are launched to the market and customer service is improved.

In time based competition, the time reduction in some of the following activities have been achieved: Planning time, product/service design time, processing time, change over time, delivery time, response time to attend to customer's complaints etc.

PROCESS ANALYSIS:

Meaning and Definition of Process Analysis:

Process analysis is an approach that helps managers to improve the performance of their business activities. It can be a milestone in continuous improvement. It is the documentation and detailed understanding of how work is performed and how it can be re-designed.

Process analysis can be defined as, "Understanding process elements and the relationships between them, and identification of opportunities for improvement."

A process analysis is an examination of a process to understand its elements such as steps and actions; and the relationships between them, including:

1. The order of the steps,

2. What things can be done in parallel versus sequentially?
3. Who or what performs each of the steps, and
4. May be where they are performed.

Process analysis thus involves understanding the processes, the relationships between them and the overall operation, and how various tools can be used to analyze the process. Process analysis explains a series of steps with a predictable result. These steps are:

1. Define the individual steps in the process, the inputs into them, and the outputs they produce.
2. Construct a process flow diagram to demonstrate how the steps are related and how the inputs flow through the process.
3. Determine the capacity, efficiency and other properties of the various steps.
4. Identify any bottlenecks where a step has a lower capacity than all other steps in its sequence.
5. Determine what the impact of removing these bottlenecks would be.
6. Carry-out a cost benefit analysis of increasing flow through the bottlenecks.
7. Decide what should be done to maximize the value of the process.

Objectives of Process Analysis:

The objectives of process analysis are as follows:

1. Recognize overlaps between functional areas.
2. Minimize and eliminate bottlenecks.
3. Describe skills and knowledge necessary for process analysis.
4. Perform a process analysis.
5. Determine the correlation between system components.
6. Given results of a process analysis and draft a summary report.

Procedure of Process Analysis:

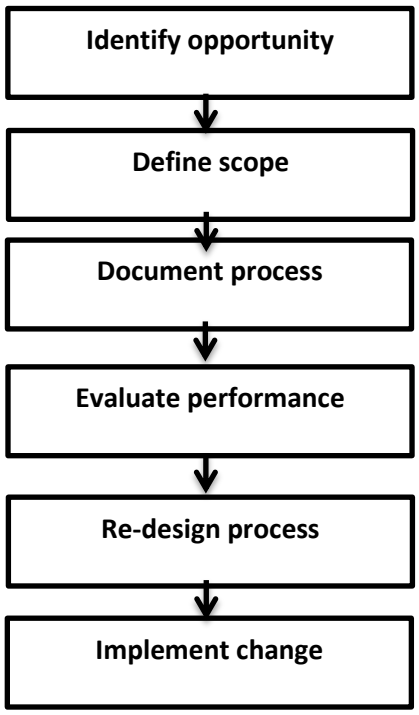
Following steps are involved in the procedure of process analysis:

***Step-1:* Identify Opportunities:**

In order to identify opportunities, managers must pay particular attention to the four core processes:

1. Supplier relationship
2. New service/product development
3. Order fulfillment, and
4. The customer relationship.

Each of these processes and the sub processes nested within them, are involved in delivering value to external customers. Are customers currently satisfied with the services or products they receive, or is there room for improvement? How about internal customers? Customer satisfaction must be monitored periodically, either with a formal measurement system or with informal checks or studies. Managers sometimes develop an inventory of their core and support processes that provide a guide for what processes need scrutiny.



Step 2: Define the Scope:

Establishes the boundaries of the process to be analyzed. Is it a broad process that stretches across the whole organization, involving many steps and many employees. A process's scope can be too narrow or too broad. The resources that management assigns to improving or re-engineering a process should match the scope of the process. For a small nested process involving only one employee, perhaps it is being asked to re-design the process. For a project that deals with a major core process, managers typically establish one or more teams. A design team consists of knowledgeable, team oriented individuals who work at one or more steps in the process do the process analysis, and make the necessary changes. Other resources may be full-time specialist called internal or external facilitators. Facilitators know process analysis methodology, and they can guide and train the design team.

Step 3: Document Me Process:

Once scope is established, the analyst should document the process, Documentation includes making a list of the process's inputs, suppliers (internal or external), outputs, and customers (internal or external). The next part of documentation understands the different steps performed in the process, using one or more of the diagrams, tables, and charts. When breaking-down the process into steps, the analyst notes the degrees and types of customer contact and process divergence along the various steps in the process. The analyst also notes what steps are visible to the customer and where in process work is handed-off from one department to the next.

Step 4: Evaluate Performance:

It is important to have good performance measures to evaluate a process for clues on how to improve it. Metrics are performance measures for the process and the steps within it. The analyst creates multiple measures of quality, customer satisfaction, time to perform each step or the whole process, cost, errors, safety, environmental measures, on-time delivery, flexibility, and the like.

Once the metrics are identified, it is time to collect information on how the process is currently performing on each one. Measurement can be rough-cut estimates or quite extensive. Techniques for analyzing wait times and delays can provide important information.

Step 5: Re-Design the Process:

Using analytical and creative thinking, the design team generates a long list of ideas for improvements. These ideas are then shifted and analysed. Ideas that are justifiable, where benefits outweigh costs, are reflected in a newprocess design. The new design should be documented "as proposed". Combining the new process design with the documentation of the current process gives the analysts clear before and after pictures. The new documentation should make clear how the revised process will work and the performance expected for the various metrics used.

Step 6: Implement Changes:

Implementation is more than developing a plan and carrying it out. Many processes have been re-designed effectively, but never get implemented. People resist change - they have always done it that way or they tried that before. Widespread participation on process analysis is essential, not only because of the work involved but also because it builds commitment. Implementation brings to life the steps needed to bring the re-designed process online. Management or the steering committee must make sure that the implementation project goes according to schedule.

MANUFACTURING PROCESS SELECTION

Meaning of Process Selection:

Process selection refers to the way an organization chooses to produce its good or services. It takes into account selection of technology, capacity planning, layout of facilities, and design of work systems. Process selection is a natural extension after selection of new products and services. Process selections plays an important part in overall design of production and operations management system's process selection allows an organization to offer a safe and reliable product and service through pragmatic design and effective capacity planning.

With the help of process selection one can understand the different types of processing including manual, rigid, and flexible as well as various automated approaches to processing. Process selection allows an operations manager to better understand the need for management of technology. Together with capacity planning it helps an organization to develop different approaches to meet the irregular demand pattern of the customers.

An organizations process strategy would include:

1. **Make-or-Buy Decisions:** The extent to which an organization will produce goods or provide in-house as opposed to relying on an outside organization to produce or provide them.
2. **Capital Intensity:** The mix of equipment and labour will be used by the government.
3. **Process Flexibility:** The degree to which the system can be adjusted to changes in processing requirements due to such factors as changes in product or service design, changes in volume processed, and changes in technology.

Process Selection Decision:

There are many ways in which processes can be categorized. They can be categorized on the basis of their orientation, e.g., market orientation or manufacturing processes; they may also be categorized

on the basis of the production methodology or customer involvement. Given below are the various categorizations of processes commonly used:

1. Processes by Market Orientation:

Processes can also be categorized on the basis of four market orientations:

(i) Make to Stock(MTS): The goods usually are standard, mature products with few product customization options. As a general rule, 'make to stock' products compete primarily on the basis of cost and availability. For examples, such products include most retail goods such as breakfast cereals, milk, shirts, jeans, and office desks.

(ii) Assemble to Order(ATO): Assemble to order products are standard items that are assembled from in-stock subassemblies. This allows customers to specify a wide range of options. For example, many camera dealers can assemble any configuration of a single lens reflex camera from a basic body. The customer specifies the exact type of lens desired, or the viewing system etc.

(iii) Make to Order(MTO): Make to order products are made from previously engineered designs, but are made only after an order has been received. 'Make to order' products are used when a standard product is too costly to stock, have too uncertain demand, or will deteriorate if stocked on a shelf. Examples of goods made using the Make to order products market orientations are: commercial airplanes, prescription glasses, etc.

(iv) Engineer to Order(ETO): This market orientation is used to make unique products that have not been previously engineered. Extensive customization to suit the customer's need is possible, but only if the customer is willing to wait for this addition stage in the value creation process. For example, it includes specialized industrial equipment, hand-built furniture etc.

2. Processes as Production Systems:

A production system refers to how an organization organizes material flow using different process technologies. There are five major types of production systems that have been generally identified:

(i) Project (ii) Job Shop (iii) Batch Production (iv) Assembly Line (v) Continuous Flow

3. Processes and Customer Involvement:

Manu processes are designed keeping in mind that value is provided by involving the customer in the delivery of the final product. The involvement may range from self-service to the customer by deciding the time and place where the service is to be provided.

(i) Self Service:

This can be explained with the help of example. Morning store in Delhi started a new trend in buying groceries by introducing self-service. This was a change from the traditional system where the customer gave a list to the grocer who then supplied the items. Morning store found that they not only saved money by not employing people, but also they increased sales due to a high level of impulse buying. Though traditionally self-service was meant to save money and thereby provide greater value to the customer, it soon found application for other strategic considerations also.

ii) Product Selection:

Business organizations are increasingly attempting to involve their customers in the product design by providing them different options for customization. For example, Maruti Udyog Limited, the premier automobile manufacturer in India, in a bid to retain its

premier position in the market, is offering customization for its basic car model, the **Maruti 800,** even before consumers have demanded it. The customer has been offered a choice of color combinations, material and functionality add-ons. The facility is not only available on new purchases but also available for in-use cars so that the company retains the goodwill of its existing customers. This of option has implications both in product as well as process design decisions.

iii) Partnerships:

Organizations engage in an active dialogue with customers using new emerging technologies. Customers are increasingly becoming partners in creating value. Customers can now decide the time and location where the service or product is to be delivered. Pricing and billing systems are modified to customer convenience.

JOB DESIGN

Job design is defined as the process of deciding on the content of a job in terms of its duties and responsibilities; on the methods to be used in carrying out the job, in terms of techniques, systems and procedures and on the relationships that should exist between the job holder and his superiors, subordinates and colleagues. Thus in a way, job design great affects how an employee feels about a job, how much authority an employee has over the work, how much decision-making the employee has on the job and how many tasks the employee has to complete.

Factors Affecting Job Design:

Job design is affected by the following factors:

1. Organizational Factors: Organizational factors that affect job design can be work nature or characteristics, work flow, organizational practices and ergonomics.

(i) Work Nature: There are various elements or a job and job design is required to classify various tasks may be planning, executing, monitoring, controlling, etc. and all these are to be taken into consideration while designing a job.

(ii) Ergonomics: Ergonomics aims at designing jobs in such a way that the physical abilities and individual traits of employees are taken into consideration so as to ensure efficiency and productivity.

(iii) Workflow: Product and service type often determines the sequence of work flow. A balance is required between various product or service processes and a job design ensures this.

(iv) Culture: Organizational culture determines the way tasks are carried out at the work places. Practices are methods or standards laid out for carrying out a certain task. These practices often affect the job design especially when the practices are not aligned to the interests of the unions.

2. Environmental Factors:

Environmental factors affect the job design to a considerable extent. These factors include both the internal as well as external factors,. They include factors like employee skills and abilities, their availability, and their socio economic and cultural prospects.

(i) Employee Availability and Abilities: Employee Skills, abilities and time of availability play a crucial role while designing of the jobs. The above mentioned factors of employees who will actually perform the job are taken into consideration. Designing a job that is more demanding and above their skill se twill lead to decreased productivity and employee satisfaction.

(ii) Socio-economic and Cultural Expectations: Jobs are now-a-days becoming employee centered rather than process centered. They are therefore designed keeping the employees into

consideration. In addition the literacy level among the employees is also on the rise. They now demand jobs that are their liking and competency and which they can perform the best.

(3) Behavioural Factors:

Behavioural factors or human factors those that pertain to the human need and that need to be satisfied for ensuring productivity at workplace. They include the elements like autonomy, diversity, feedback etc. a brief explanation of some is given below:

(*i*) *Autonomy:* Employees should work in an open environment rather than one that contains fear. It promotes creativity, independence and leads to increased efficiency.

(ii) Feedback: Feedback should be an integral part of work. Each employee should receive proper feedback about his work performance.

(iii) Diversity: Repetitive jobs often make work monotonous which leads to boredom. A job should carry sufficient diversity and variety so that it remains as interesting with every passing day. Job variety / diversity should be given due importance while designing a job.

(iv) Use of Skills and Abilities: Jobs should be employee rather than process centered. Though due emphasis needs to be given to the latter but jobs should be designed in a manner such that an employee is able to make full use of his abilities and perform the job effectively.

****

Product And Service Design

Summary:

When planning on producing a new product and/or service, the key factor is the product and service design. Successful designs come down to these basic principles: **translate customers' wants and needs, refine existing products and services, develop new products and services, formulate quality goals, formulate cost targets, construct and test prototypes, document specifications, and translate products and service specification into process specification**s. The process of design has certain steps that include motivation, ideas for improvement, organizational capabilities, and forecasting. In the product process innovations, research and development play a significant role. Because of the influence a product and service design can have on an organization, the design process is encouraged to be tied in with the organization's strategy and take into account some key considerations.

Technological changes, the competitive market, and economic and demographic changes are some market opportunities and threats that all organizations must be aware of when planning a product and service design. ***Computer-aided design*** **(CAD)** and ***Computer-aided manufacturing*** **(CAM)** are important tools in the design process because they can anticipate what the design will look like, as well as allow for better manufacturing. Businesses also must take in account environmental and legal concerns when designing a new product. Most importantly, the manufacturing process must ensure the product's safety.

Product and Service Design

Companies choose various ways to design their products and the type of services they provide. Which include: ***standardization, mass customization, delayed differentiation,***

modular design, and robust design. Deciding which method to use is very important along with deciding the company's target market. Deciding the right method, establishes good productivity and efficient way fo operations.

Service design is an activity of organizing and planning people, communication and material components in order to improve service quality. It is the interaction between the service provider and customers and the customers' experience. A service is anything that is done to or for a client and is created and delivered simultaneously. The two most important issues in service design are the **degree of variation** in requirements and the **degree of customer contact** in which determines how standardized the service can be. The greater the degree of customer contact, the greater the opportunity for selling. In addition, concepts and ideas generated are captured in sketches or in service prototypes. The strong visual element, combined with the opportunity to test and rapidly change services and interfaces, delivers real value in today's competitive markets.

Product Design combines ergonomics with product and business knowledge to generate ideas and concepts and convert them into physical and usable objects or services. The discipline covers the entire range of activities from concept, manufacturing, testing to product launch. Product Designers conceptualize and evaluate ideas and themes they find profitable. The designers make these ideas tangible through products using a systematic approach.

Difference between service design and product design: Service design is an intangible aspect while product design is tangible. Services are generally created and delivered at the same time and can not be held in inventory like actual products. Also, services (especially quality one) are highly visible to customers.

Product and Service Life Cycle

During their useful life, many services and products go through four stages. Since the demand can vary for each of these 4 stages, different strategies should be applied to achieve optimum product/service performance during each stage.

The Four stages are:

1. Introduction: During the first stage, the product is introduced into the market. Proper research and forecasting should be done to ensure the product/service is adequate for a specific market and for a specific time. It is crucial to have a proper amount of supply that can meet the expected demand for the product/service.
2. Growth: The second stage involves the increase in demand for the product/service. Reputation for the product grows and an accurate forecast of demand is needed to determine the length of time the product/service will remain in the market. Enhancements and improvements are common in this stage.
3. Maturity: This third stage deals with the product reaching a steady demand. Few or no improvements or product changes are needed at this stage. Forecasting should provide an

estimate of how long it will be before the market dies down, causing the product to die out.
4. Decline: The last stage involves choosing to discontinue the product/service, replacing the product with a new product, or finding new uses for the product.

Standardization may be great for a company creating products like mops because there are not many things you can do to make them unique and keep the price down. Standardization products have interchangeable parts, which increases productivity and lowers the costs of production. Standardization has many important benefits and certain disadvantages. Some advantages are the design costs for standardization products are low. The scheduling of work inventory handling, purchasing, and accounting activities are routine, making the quality more consistent. The disadvantages with standardization are that they decrease variety offered to consumers leading to less of an appeal. Also, the high cost of design change makes it relentless to improve.

Mass customization is a strategy that some companies can use to incorporate customization while practicing standardization. This strategy keeps costs low while adding variety to a product. The two tactics that make mass customization possible is ***delayed differentiation*** and ***modular design***. Some companies may consider *delayed differentiation* if the company chooses to not finish a product due to unknown customer preferences. However, another tactic of modular design is a form of standardization in which components' parts are grouped into modules to allow easy replacement or interchangeability. Producing a computer is an example of modular design.

Companies will also have to consider what their competitors are doing in order to be successful. There are 3 ways of idea generation: *supply based, competitor based, and research based*. Which ever a company chooses, they must consider who is competing against them and what else is going on in the marketplace. Product design is key to the success of the company.

Customer Satisfaction and Sustainability

Product and service design are very important factors to customer satisfaction. Organizations need to continually satisfy their customers to be successful in the marketplace. They are able to do this by improving current products or by designing new ones. The design consists of the following: research, design, production, life cycle, safety in use, reliability, maintainability, regulatory and legal issues. Organizations also need to look at "sustainability" when designing their product/service.

The four aspects of **Sustainability** are:
(1) Life Cycle Assessment
(2) Value Analysis
(3) Remanufacturing
(4) Recycling.

Life cycle assessment focuses on the environmental impact the specific product will have over the course of its life. **Value analysis** looks at the parts within a product and seeks to minimize the cost. **Remanufacturing** has become more important over the past few years and involves replacing worn-out and defective products. This is common practice in high price machinery industries. **Recycling** involves recovering older materials for future use. This not only saves money, but satisfies environmental concerns. **The Kano Model** includes three aspects: *Basic quality, performance quality, and excitement quality*. **Basic quality** is the requirements placed on a product that do not lead to customer satisfaction when present, but can lead to dissatisfaction if absent. **Performance quality** is the middle ground and can either lead to satisfaction or dissatisfaction depending on their usefulness. **Excitement quality** is the notion that an unexpected feature can cause customer excitement.

Reliability

Reliability is a measure of the ability of a product, a part, or service, or an entire system to perform its intended function under a prescribed set of conditions. Reliability can have an impact on repeat sales and reflect positively on a product's image. However, if the product is faulty, it can create legal problems. The term "failure" is used to describe a situation in which an item does not perform as intended. Reliabilities are always specified with respect to certain conditions, called normal operating conditions. These conditions can include load, temperature, and humidity ranges in addition to operating procedures and maintenance schedules. To improve reliability, manufacturers should improve the reliability of individual components or use back up components. A few other suggestions include improving testing, improving user education, and improving system design. The optimal level of reliability is the point where the incremental benefit received equals the incremental cost.

Legal and Ethical Consideration

Many organizations are regulated by governmental agencies and these regulations are responsible for preventing harmful substances from being used in product design. Harm caused by the product is the responsibility of the manufacturers. Manufacturers are liable for any injury or damages caused by their product due to its design or workmanship, also known as product liability. When the product is defective and potentially causes harm, manufacturers have several options to remedy the situation. They may have to recall their products or fix the problem in the manufacturing stage. It is also possible that they may face lawsuits if their products cause injury to consumers. Managers must ask themselves if there is demand for their organization's product or service. If the company develops its products or services according to the customers' demands, their product will be successful.

WORK MEASUREMENT:

Method Study and work measurement are two techniques of work study. Whereas method study or Methods Analysis is a tool for standardizing the methods of doing a job, work measurement establishes the work content of a job.

Both, method study and work measurement are important elements in achieving higher labour productivity. To overall productivity of an organization is the result of the productivity achieved by all components of the organization such as capital assets, labour, material, and plant and equipment.

Defination *of Work Measurement:*

Work measurement is defined as the application of techniques designed to establish the work content of a specified task by determining the time required for carrying out the task at a defined standard or performance by a qualified worker.

Qualified Worker:

"A qualified worker is one who is accepted as having the necessary physical attributes, possessing the required intelligence and education and having acquired the necessary skill and knowledge to carry out the work in hand to satisfactory standards of safety, quantity and quality". Work measurement may be defined as the techniques applied to determine the amount of time necessary for a qualified worker to perform a particular task.

Objectives *of work measurement can be to achieve:*

1. Improved planning and control of activities or operations
2. More efficient manning of the plant
3. Reliable indices for labour performance
4. Reliable basis for labour cost control
5. Basis for sound incentive schemes.

Benefits *of Work Measurement:*

Work measurement helps

(1) To develop a basis for comparing alternate methods developed in method study by establishing the work content in each method of doing the job.

(2) To prepare realistic work schedules by accurate assessment of human work.

(3) To set standards of performances for labour utilization by establishing the labour standards for an element of worm, operation or product under ordinary working condition.

(4) To compare actual time taken by the worker with the allowed time(standard time) for proper control of labour.

(5) To provide information related to estimation of tenders, fixation of selling price and assessment of delivery schedule.

Techniques *of Work Measurement:*

The main techniques used to measure work are-

(1) Direct Time Study

(2) Synthesis Method

(3) Analytical Estimating

(4) Pre determined Motion Time System(PMTS)

(5) Work sampling or Activity Sampling or Ratio Delay Method.

***Steps** in Work Measurement:*

The various steps are-

(1) Break the job into elements.

(2) Record the observed time for each element by means of either time study, synthesis or analytical estimating.

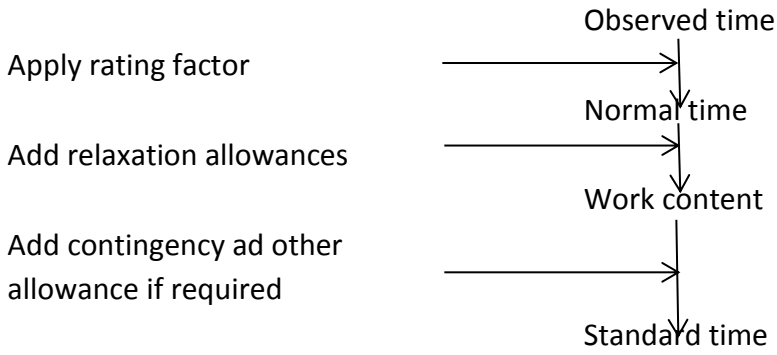
(3) Establish elemental time values by extending observed time into normal time for each element by applying a rating factor.

(4) Assess relaxation allowance for personal needs and physical and mental fatigue involved in carrying out each element.

(5) Add the relaxation allowance time to the normal time for each element to arrive at the work content.

(6) Determine the frequency of occurrences of each element in the job, multiply the work content of each element by its frequency(*i.e.,* number of time the element occurs in the job) and add up the times to arrive at the work content for the job.

The above procedure may be explained as follows:



Decision Making in Production

Production has three types of decision making process

1. Strategic Decisions
2. Operating Decisions
3. Control Decisions

Strategic Decision

It relates to products, processes and manufacturing facilities. These decisions are major ones having strategic importance and long term significance for the organization.

Types of Decisions	Areas of Involvement	Nature of Activities
I. Strategic Decisions (Planning Products Process and Facilities)	1. Production Process 2. Production Technology 3. Facility layout	Developing long range production plans including process design. Selecting and managing

	4. Allocating Resources to Strategic Alternatives 5. Long Range Capacity Planning and Facility Location	production technology. Planning for the optimal distribution of scarce resources among product lines or business units Answering the 'how much' and 'where' questions about long range production capacity
II. Operating Decisions (Planning Products to meet demand)	1. Production Planning Systems 2. Independent Demand Inventory Systems 3. Resource Requirements Planning Systems 4. Shop Floor Planning and Control at each work center. 5. Materials management	Aggregate planning and master production scheduling Planning and controlling finished goods inventories Planning materials and capacity requirements. Short range decisions about what to produce and when to produce Manageing all facets of materials systems
III. Control Decisions (Planning and Operations)	1. Productivity and Employees 2. Total Quality Control 3. Project Planning and Control Techniques 4. Maintenance Management and Reliability	Planning for the effective and efficient use of human resources in operations. Planning and controlling the quality of products and services Planning and controlling projects Planning for Maintaining the and facilities of products

MODULE-II

PLANT LAYOUT(FACILITY LAYOUT)

Plant layout refers to the arrangement of machinery, equipment and other industrial facilities-like receiving and shipping dept. ,tool rooms ,maintenance room ,employee amenities etc.- for the purpose of achieving the quickest and smoothest production at the least cost.

It is a floor plan of the physical facilities which are used in production, which refers to the generation of several possible plans for the special arrangement of physical facilities and select the one which minimizes the distance between the depts..

OBJECTIVES OF PLANT(GOOD) LAYOUT

Provide enough production capacity
Minimize investment in equipment.
Minimize overall production time.
Minimize material handling cost.
Reduce accident.
Provide for employee convenience, safety and comfort.
Utilize labour efficiently.
Utilize existing space most effectively.
Facilitate co-ordination and face to face communication among the employees.
Improve productivity.

FACTORS INFLUENCING FACILITY LAYOUT

The factors which may influence the plant layouts are material, product, worker , machinery, industry, location ,managerial policies etc.

MATERIAL:

There is a need to provide the storage and movement of raw material in a plant until they are converted into finished product.

The type of raw materials used i.e. whether the raw materials are liquid or solid, light or heavy, small or large.

The availability or scarcity of materials affected by seasonal variations and market conditions.

PRODUCT:

A layout is designed with the ultimate purpose of producing a product. The type of product, i.e. whether:

The product is heavy or light, big or small, liquid or solid

It's position in relation to plant location.

WORKER:

It also influence the plant layout. The type ,position, and requirement of employees also influence the layout. If women workers are employed, then the must be designed keeping in mind their particular requirement. The position of employees i.e. whether they remain stationary or moving, which influence the layout.

MACHINERY:

The type of raw materials, products, volume of its production, the type of process ,the management policies etc. determines the size and type of machinery to be installed which also influence the layout

LOCATION:

The site selected for the location of a plant influences its layout in different ways.

The size of the site determines the type of building, which influence the plant layout.

The location of the plant determines the mode of transportation, depending upon the source of raw materials and market to the plant.
As plant need fuel in part, so there should be a space for fuel storage.
The demand for future expansion also influence the layout.

MANAGERIAL POLICIES:

The following managerial policies significantly influence the plant layout ,are:
The volume of production and provision for expansion.
Making or buying a particular component.
Desire for rapid delivery of goods to customer
Personnel policies etc.

TYPES OF LAYOUT:

Process layout/Functional layout/Job shop layout.
Product Layout/line processing layout/flow-line layout.
Fixed position layout/Static layout.
Combined/Hybrid Layout.

PROCESS LAYOUT:

In this layout similar machines and services are located together. Different spaces are fixed for different operation dept.. Therefore (below figure) all drills will be located in one area of the plant. It is normally used when the production vol. is low.

Turning	**Shaping**	**Drilling**
Milling		**Grinding**

ADVENTAGES OF PROCESS LAYOUT:

Reduce investment of machine as they are general purpose machines.
A high degree of flexibility in terms of task allocation to existing machines.
Better utilization of men and machines.
Better and efficient supervision is possible through specialization.
The investment on equipment comparatively lower.
There is a greater incentive to individual worker to increase his performance.

DISADVENTAGES:

It requires more floor space.
There is a difficulty in production control.
Higher grade of skill are required.
Large amount of in-process inventory will produce.

PRODUCT LAYOUT:

It is used only when machines and auxiliary services are located together according to processing sequence of the product. It is normally when the production vol. is high .All the operations should be included in one line.

Turning	**Shaping**	**Milling**	**Drilling**

shaping	Grinding	Adhesive	Packing

ADVANTAGES OF PRODUCT LAYOUT:

The flow of product will be smooth and logical in flow line.

In-process inventory is less.

Operators need not be skilled.

It requires less floor area per unit of production.

There is a greater incentive to a group of worker s to raise their level of performance

DISADVENTAGES:

Any breakdown of equipment/machine along a production line can disrupt the whole system.

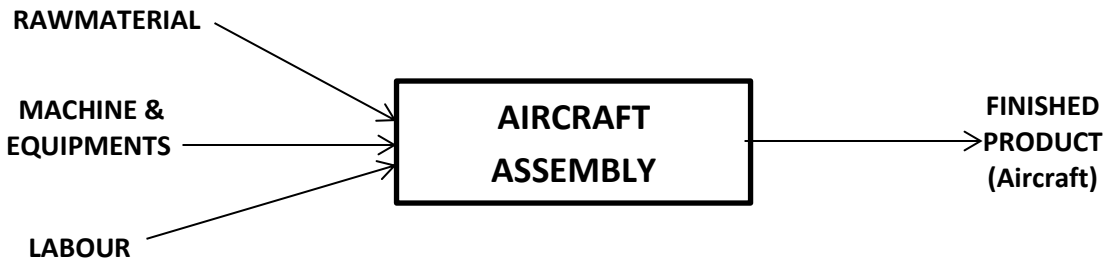
Difficulty in supervision.

Expansion is difficult.

A change in product design may require major changes in the layout.

FIXED POSITION LAYOUT:

It is also called static product layout or layout by fixed position, where the physical characteristic of the product dictate as to which type of machine and men are to be brought to the product. The ship building industry, aircraft assemblies etc. employs this type of layout.



ADVENTAGES OF FPL:

- Men and Machines can be used for a variety operations for different product.
- The investment on this layout is very small.
- The high cost and difficulty in transporting a bulky product are avoided.

DISADVENTAGES:

It has a limited scope.

HYBRID LAYOUT:

It is the combination of both product and process layout. It combines the advantages of both layout systems. If there are 'm' machines and 'n' components,in this layout the no. of machines and component will be divided into distinct no. of machine-component cells(groups) such that all the component assigned to a cell are almost processed within the cell itself and objective is to minimize inter cell movement.

MILLING	PAINTING	BORING	FITTING
DRILLING	WELDING	TURNING	WELDING
GRINDING	SLOTTING		

Group Layout with Two Cells

ADVENTAGES:

- Realiability of estimates increses.
- Effective machine operation increases.
- Improve productivity.
- More costing accuracy.
- Planning effort decreases.
- No/less need of Paper work.
- Down time decreases.
- WIP decreases.
- Work movement decrease.
- Overall production time decreases.

DISADVENTAGES:

This type of layout may not be feasible for all situations and basically when the product mix is dissimilar. More expenditure.

MODULE-III

AGGREGATE PLANNING:

It involves planning the best quantity to produce during time period in the intermediate-range horizon.e 6 month to 18 month (often 3 month to 1 year) and planning the lowest cost method of providing the adjustable capacity to accommodate the production requirements.

Planning of workforce size, production rate and inventory levels etc. are some of examples of aggregate planning.

OBJECTIVES OF AGGREGATE PLANNING:

- It is to balance work force stability, cost and profit analysis etc.
- To establish co. wide strategic plan for allocating resources.
- To develop an economic strategy to meet customer demand.

NATURE OF AGGREGATE PLANNING:

- REGULAR TIME PRODUCTION CAPACITY: Regular time production capacity may not be sufficient to cope with the demands of various products. So it is necessary to decide what rate of production is to operate.
- SUBCONTRACTING CAPACITY: Apart from regular production capacity ,there is a scope to bring the extra unit from outside to cope up with the requirement.
- OVERTIME CAPACITY: Overtime production sometimes full fill the requirement as by the need of the customer.
- HIRING AND FIRING CAPACITY: As by the situational fluctuation there is need to hire people and machinery at peak demand and fire of the above when there is a less demand.

AGGREGATE PLANNING STRATEGIES:

Two Type of strategies are adopted during aggregate plan for smoothing fluctuation in demand, are:

I. Pure strategy
II. Mixed strategy

PURE STRATEGY: When a single strategy of the following s is used to meet the demand .then it is called as a pure strategy.

- Building and utilizing inventory through constant work force
- Varying the size of the work force
- Overtime utilization
- Subcontracting
- Making changes in demand pattern

MIXED STRATEGY: By taking more than two strategies of the above at a time is called mixed strategy.

a. BUILDING AND UTILIZINGINVENTORY THROUGH CONSTANT WORKFORCE SIZE :
Since the demand is not a constant quantity, there may be mismatch between the production quantity and the demand of each period. So the company can use constant work force during the planning horizon, which will result into a constant output during each period in the planning horizon. The excess production in a period can be carried as inventory for use in future periods.
b. VARYING THE SIZE OF THE WORKFORCE:
This pure strategy can be implemented through hiring and firing of employees. During periods of increased demand, the co. can hire employees and during period of decreased demand ,the co. can fire employees s.t there is an exact match between the production quantity and the demand of each period in the planning horizon.
c. SUBCONTRACTING:
In this strategy order can be placed with a subcontractor or a set of subcontractors depending on the demands of various products and It is generally used when a there is a peak demand period to increase the capacity.
d. MAKING CHANGES IN DEMAND PATTERN:
To even out the fluctuation in demand of products, the co. can offer some discount scheme during off-seasons or during period with fewer loads on some service system, which is nothing but influencing demand pattern. Ex: Giving discount on the items like refrigerator, air cooler, air conditioner etc. during winter season.

e. OVERTIME UTILIZATION:
To meet the demand sometimes, the co. may ask to the men for overtime utilization and over time utilization of machinery.

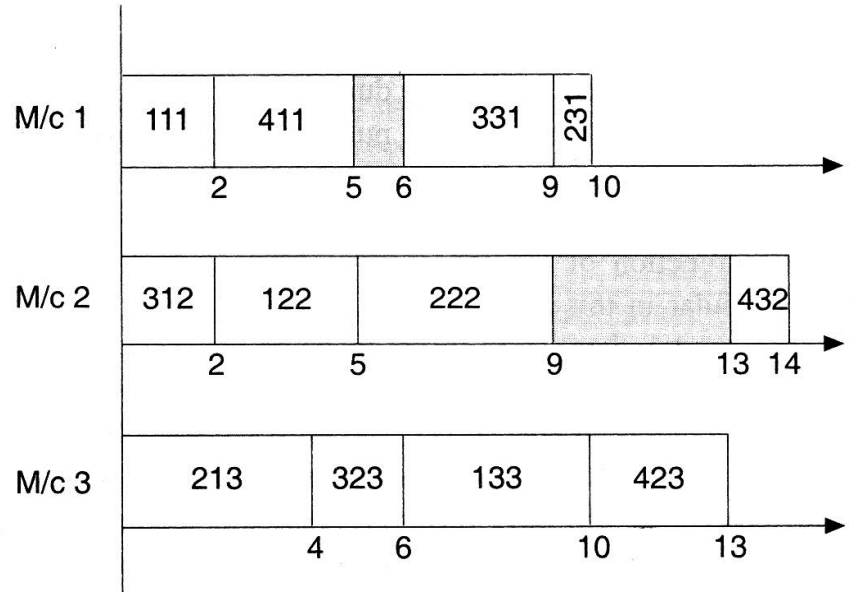
JOB SHOP SCHEDULING:

In this case we assume that each job has m different operations.If some of the jobs are having less than m operations, required no. of dummy operations with zero process times are assumed.In a jobshop problem different jobs will have different sequences. So a straight flow can not be assumed for the job -shop problem.

Ex:

Processing Times (Hrs)			
	Operations		
	1	2	3
Job 1	2	3	4
Job 2	4	4	1
Job 3	2	2	3
Job 4	3	3	1

Routing			
	Operations		
	1	2	3
Job 1	1	2	3
Job 2	3	2	1
Job 3	2	3	1
Job 4	1	3	2



TYPES OF SCHEDULES:

Infinite number of feasible schedules are possible for any job-shop problem, because one can insert any arbitrary amount of idle time at any machine between any adjacent pairs of operation. This idle time lead to non-optimal solution. To avoid the non-optimality some schedules are used, and these are:

1. All The Schedule(All)
2. Semi active Schedule(SA)
3. Active Schedule(A)
4. Non-Delay chedule(ND)

MODULE-IV

SUPPLY CHAINS

A supply chain consists of all stages involved, directly or indirectly, in fulfilling a customer's request. It not only includes the manufacturer and suppliers, but also transporters, warehouses, retailers and customers themselves. Within a manufacturing organization, the supply chain includes functions such as new product development, marketing, operations, distribution, finance and customer service.

A supply chain is dynamic and involves the constant flow of information, product and funds between different stages. Each stage of the supply chain performs different processes and interacts with other stages of the supply chain.

Various stages of supply chain:

- Customers
- Retailers
- Wholesalers / distributors
- Manufacturers and
- Component / raw material suppliers.

Objectives of a Supply Chain:

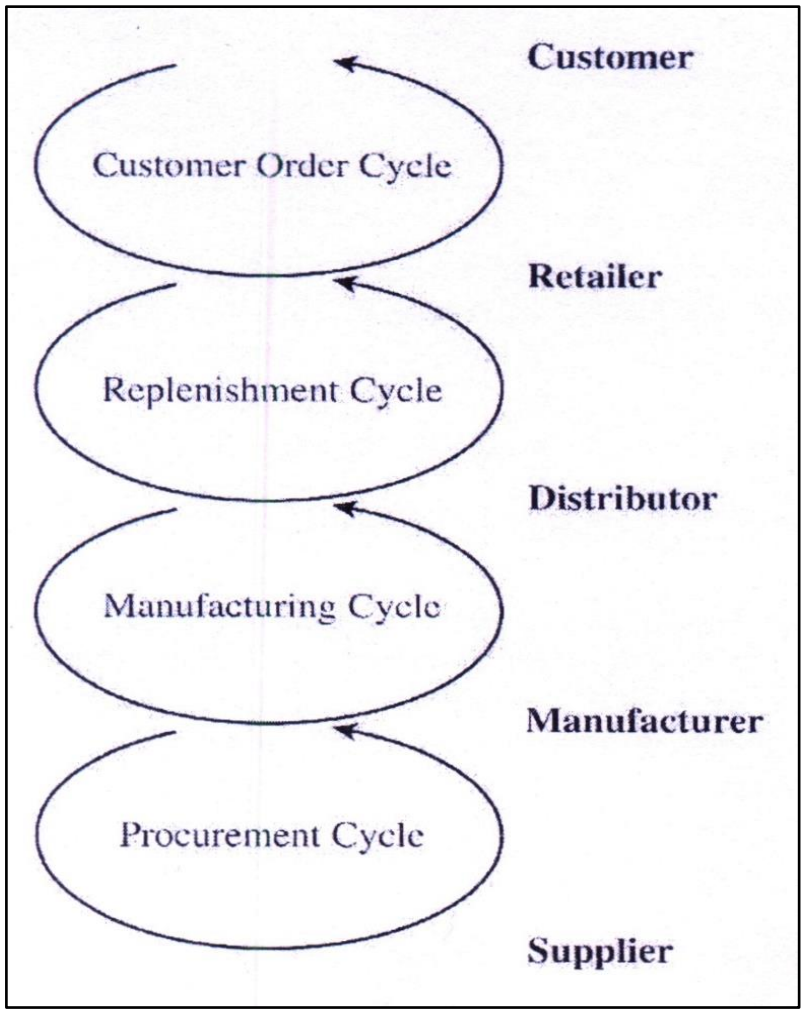
The objectives are:

(i) To maximize the overall value generated. The value a supply chain generates is the difference between what the final product is worth to the customer and the effort the supply chain expends in filling the customer's request.

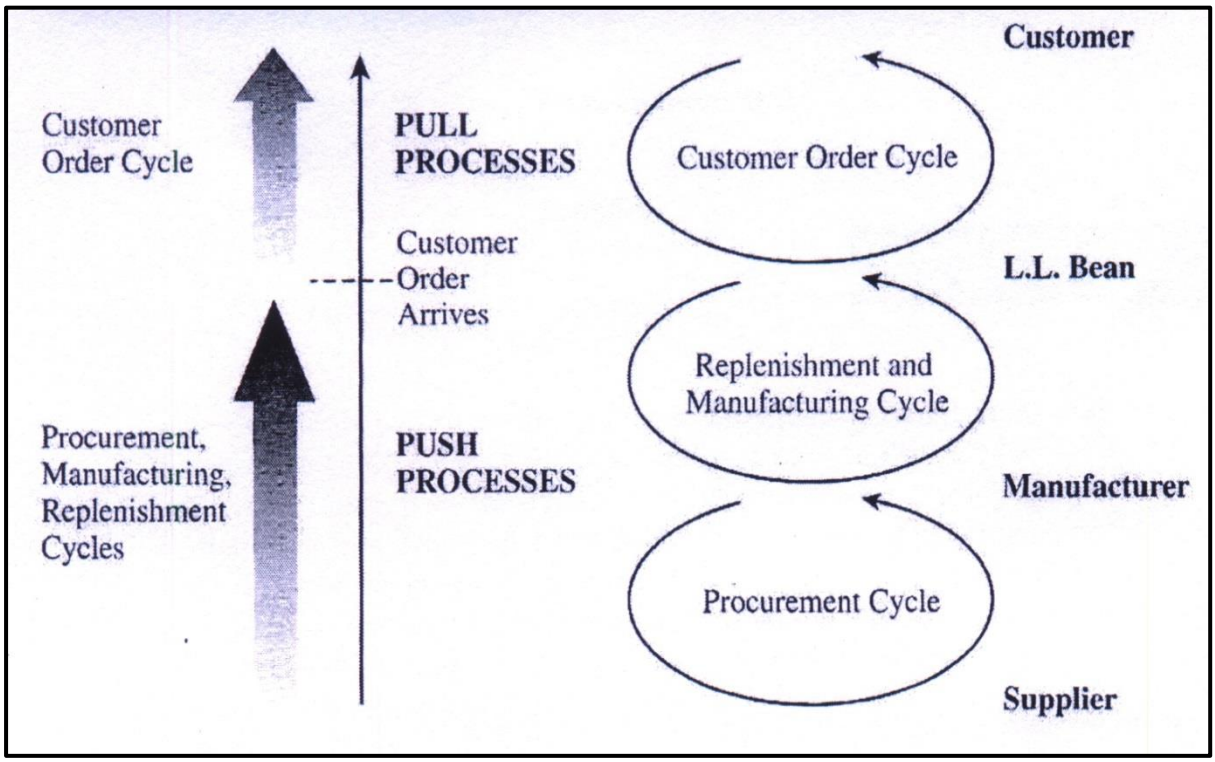
(ii) To achieve maximum supply chain profitability. Supply chain profitability is the total profit to be shared across all supply chain stages.

(iii) To reduce the supply chain costs to the minimum possible level.

Supply chain management involves the management of flo9ws between and among stages in a supply chain to maximize total profitability.



(Figure for Supply Chain Process Cycle)



(Figure for Push / Pull processes for the L.L. Bean Supply Chain)

Deming's Philosophy on TQM

To plan, Deming counsels that businesses should design quality products and services that customers want, develop processes and systems that reduce waste and increase quality and decrease the cost of production.

Next, the businesses must **do** the work by putting the plan into action. As processes and systems are running, they must continually seek ways to do things better. Deming's crew knew exactly what to do

As work moves through the processes and systems, **check** points will monitor changes that need to take place - changes like removing barriers to quality by providing employees with the tools needed to do the job right the first time.

Finally, managers take action. Management may make changes. Deming tweaked a few things to speed up the process by placing more people on the line. Customers received their burgers on time, and they were tasty, too! **The Juran Philosophy**

Juran defined quality as
(1) product performance that results in customer satisfaction;
(2) freedom from product deficiencies, which avoids customer dissatisfaction-- simply summarized as "fitness for use."

This definition can be broken down into four categories:

(1) quality of design,
(2) quality of conformance,
(3) availability and
(4) field service.

Quality of design concentrates on market research, the product concept, and design specifications.Quality of conformance includes technology, manpower, and management. Availability focuses on reliability, maintainability, and logistical support.
Field service quality comprises promptness, competence, and integrity.

The pursuit of quality is viewed on two levels:

(l) The mission of the firm as a whole is to achieve high product quality; and

(2) The mission of each department in the firm is to achieve high production quality.

Juran's prescriptions focus on three major quality processes, called the Quality Trilogy:

(1) **quality planning** --the process of preparing to meet quality goals;
(2) **quality control**-- the process of meeting quality goals during operations; and
(3) **quality improvement** --the process of breaking through to unprecedented levels of performance.

Quality planning begins with

(1) identifying customers, both external and internal,
(2) determining their needs and
(3) developing product features that respond to those needs at a minimum combined cost.
(4) the process that can produce the product to satisfy customers' needs and meet quality goals under operating conditions must be designed.
(5) compares results with previous plans, and meshes the plans with other corporate strategic objectives.

Quality control involves

(1) determining what to control,
(2) establishing units of measurement to evaluate data objectively,
(3) establishing standards of performance,
(4) measuring actual performance,
(5) interpreting the difference between actual performance and the standard and
(6)taking action on the difference.

Quality improvement program involves

(1) proving the need for improvement,
(2) identifying specific projects for improvement,
(3) organizing support for the projects,
(4) diagnosing the causes,
(5) providing remedies for the causes,
(6) proving that the remedies are effective under operating conditions and
(7) providing control to maintain

7QC Tools

Seven QC tools are fundamental instruments to improve the quality of the product. They are used to analyze the production process, identify the major problems, control fluctuations of product quality, and provide solutions to avoid future defects. Statistical literacy is necessary to effectively use the seven QC tools. These tools use statistical techniques and knowledge to accumulate data and analyze them.

Seven QC tools are utilized to organize the collected data in a way that is easy to understand and analyze. Moreover, from using the seven QC tools, any specific problems in a process are identified.

7QC tools always include :

- ***Check Sheet*** is used to easily collect data. Decision-making and actions are taken from the data.
- ***Pareto Chart*** is used to define problems, to set their priority, to illustrate the problems detected, and determine their frequency in the process.
- ***Cause-and-Effect Diagram*** (Fishbone Diagram) is used to figure out any possible causes of a problem. After the major causes are known, we can solve the problem accurately.
- ***Histogram*** shows a bar chart of accumulated data and provides the easiest way to evaluate the distribution of data.
- ***Scatter Diagram*** is a graphical tool that plots many data points and shows a pattern of correlation between two variables.
- ***Flow Chart*** shows the process step by step and can sometimes identify an unnecessary procedure.
- ***Control Chart*** provides control limits which are generally three standard deviations above and below average, whether or not our process is in control

Crosby's response to the quality crisis was the principle of *"doing it right the first time"* (DIRFT). He also included four major principles:[6]

1. *The definition of quality is conformance to requirements (requirements meaning both the product and the customer's requirements)*
2. *The system of quality is prevention*
3. *The performance standard is zero defects (relative to requirements)*
4. *The measurement of quality is the price of nonconformance*

His belief was that an organization that established a quality program will see savings returns that more than pay off the cost of the quality program: "*quality is free*".

Qualit audit (Meaning)

Running a small business is sometimes complicated and overwhelming when you consider the many duties, yet it's still a rewarding experience. Part of managing a successful business involves setting standards for the way the company operates. One way to take your business to the "next level" is to perform regular quality audits.

Identification

A quality audit is a process by which you review and evaluate an element of your business to ensure that you're meeting certain standards. The standards vary—you can set them or you can follow standards set by your industry.

Types

A quality audit can apply to various aspects of a business, but a few types stand out. You can perform a quality audit of your inventory or service to assure that it's acceptable for consumption by the public. This is particularly important in the case of a product or service that could pose a threat to public safety. Some business owners perform quality audits on employees, or rather the way employees perform. This is particularly important in an atmosphere where workers must interact directly with customers. The business may also perform quality audits on management, which would require a third-party evaluator in the case of a small company managed by the owner. Finally, if the company has to maintain information in databases, you can also perform data quality audits.

ISO 9000 and ISO 14000

The International Organization of Standardization (ISO) is a worldwide federation consisting of member bodies from 91 countries, which promotes the development of international manufacturing, trade and communication standards.

ISO 9000 refers to a generic series of standards published by the ISO that provide quality assurance requirements and quality management guidance. ISO 9000 is a quality system standard, not a technical product standard. The ISO 9000 series currently contains four standards - ISO 9001, ISO 9002, ISO 9003 and ISO 9004. Firms select the standard that is most relevant to their business activities. However, these four standards will be revised in late 2000. More information is provided later in this paper under ISO 9000:2000.

ISO 14000 refers to a series of standards on environmental management tools and systems. ISO 14000 deals with a company's system for managing its day-to-day operations and how they impact the environment. The Environmental Management System and Environmental Auditing address a wide range of issues to include the following:

1. Top management commitment to continuous improvement, compliance, and pollution prevention.

2. Creating and implementing environmental policies, including setting and meeting appropriate targets.

3. Integrating environmental considerations in operating procedures.

4. Training employees in regard to their environmental obligations.

5. Conducting audits of the environmental management system.

ISO 9000 and ISO 14000 are tools to assist business and government to insure the quality of their products and services, and to manage the impact of their activities on the environment. Like all ISO standards, their use is voluntary unless a business sector makes them a market requirement or a government issues regulations making their use obligatory. Organizations that implement ISO 9000 and ISO 14000 voluntarily do so to improve operations and provide real benefits.

STATISTICAL QUALITY CONTROL

SQC is the application of statistical techniques to accept or reject product already produced, or to control the process and therefore product quality while the part is being made.

If it controls the process it is called process control and accepts or rejects the product is called acceptance sampling.

SQC for process control

It is used for controlling quality during production in mass production industries which produce standard products.

SQC for process control is based on the probability theory.

When several identical products/parts are manufactured, some may deviate a little but most of the pasts will be approximately.

FIGURE

Example: Let the standard size is 1.000 inches, then there are variations in size between 0.995 inches to 1.005 inches with measuring 1.000 inches are due to chance causes.

Chance causes are inherent and cannot be controlled chance causes are ignored.

But if the size measures beyond these two limits (i.e. below 0.995" or above 1.005") are due to assignable cause.

Assignable cause include internal temperature and wear and tear of machine parts, improper dimension of raw material, setting of the machine.

In practice SQC for process control manifests through control charts. These are the horizontal extension of bell shaped curve.

FIGURE

Central line is corresponding to Average Quality.

ACCEPTANCE SAMPLING

When 100% inspection is not practical(i.e.: either too costly, time consuming or when the inspection is destructive in nature). Sampling inspection is the best way of estimating the quality of incoming and out-going lots.
Acceptance sampling inspection can be either sampling by attributes or sampling by variables.

Acceptance sampling by attributes:

Acceptance sampling by attributes involves extracting a random sample from the lot to determine whether to accept or reject the entire on the quality of sample.

Acceptance sampling plans have two important concepts:

(a) Average Out-going Quality (AOQ) curves (b) Operating Characteristic curves.

(a) Average Out-going Quality(AOQ) curves:

(Figure)

Acceptance sampling plans provide managers with the assurance that the average quality level or percent defectives going outside will not exceed a certain limit.

(b) Operating Characteristics (OC) Curve:

In acceptance sampling plans following can happen:

1- We accept good lots.
2- We reject bad lots
3- We may accept bad lots
4- We may reject good lots

In vast majority cases, we do accept good lots and reject bad lots when we apply acceptance sampling plans. On rare occasions, we may accept bad lots on the basis that sample shows good quality. On the other hand we may reject a good lot as bad lots based on the sample evidence.

Producer's risk and consumer's risk should be kept as low as possible.

In this figure, let us say we define a good lot as any lot having no more than 1% defective. This is called Acceptance Quality Level (AQL).
If there is 1% actual defective in a lot, the probability of acceptance is 95%. So the probability of rejecting a good lot is 5%. So here producer's risk **(α)**=5%.

Similarly, let us define a bad lot if it has 5% or more defectives. This is known as Lower Tolerance Percent Defectives. The probability of accepting a lot with 5% defective is should be as low as 10%. This is called consumers risk **(β).**

Type of Acceptance Sampling Plan:

1. *Single Sampling*: A sampling plan for a single sample is specified by two numbers '*n*' and '*c*'.
   n= Sample size
   c= Maximum no. of defectives that can be accepted.

   If the number of defective in the sample is more than '*c*', then the entire lot will be rejected or inspected 100%.
2. *Double Sampling Methods:* In double sampling, one small sample is drawn initially. Two acceptance numbers c_1 , and c_2 ($c_2 > c_1$) are selected.
   If the no. of defectives (c_1') in the first sample of size(n_1) is less than or equal to c_1, the lot is accepted.
   If $c_1' > c_2$ → Lot is rejected.
   If $c_1' > c_1$ but $c_1' < c_2$ a larger sample of size n_2 (*i.e.*: $n_2 > n_1$) is taken and inspected.
   Let the no. of defectives found be c_2'.
   If $(c_1' + c_2') > c_2$ the lot is rejected.

3. *Sequential sampling:* Units are randomly selected from the lot and tested one by one. After each one is tested a reject, accept or continuous sampling is made. This process continues until the lot is accepted or rejected.

Suppose when, units are randomly drawn, and inspected, the first defective is the 15^{th} unit, which is in continuous sampling zone in the figure. So we continue to sample further units from the lot. If the second defective is the 25^{th} unit, which is again in the continuous sampling zone, we continue sampling. If 4^{th} defective is the 40^{th} unit which put us in reject lot zone, therefore the lot is rejected.