Production and Operation Management

(6th semester, ME)

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PME6I101 PRODUCTION AND OPERATION MANAGEMENT

Objective : The course aims at acquainting all engineering graduates irrespective of their specializations the basic issues and tools of managing production and operations functions of an organization.

MODULE I

1. Operations Function in an Organization, Manufacturing Vrs Service Operations, System view of Operations, Strategic Role of Operations, Operations Strategies for Competitive Advantage, Operations Quality and Productivity Focus, Meeting Global Challenges of Production and Operations Imperatives. **(3 Hours)**
2. Designing Products, Services and Processes: New Product Design- Product Life Cycle, Product Development Process, Process Technology : Project, Jobshop, Batch, Assembly Line, Continuous Manufacturing; Process Technology Life Cycle, Process Technology Trends, FMS, CIM, CAD, CAM; Design for Services, Services Process Technology. **(4 Hours)**
3. Work Study: Methods Study- Techniques of Analysis, recording, improvement and standardization; Work Measurement : Work Measurement Principles using Stopwatch Time Study, Predetermined Motion Time Standards and Work Sampling, Standard Time Estimation. **(4 Hours)**

MODULE II

4. Location and Layout Planning : Factor Influencing Plant and Warehouse Locations, Impact of Location on cost and revenues. Facility Location Procedure and Models : Qualitative Models, Breakeven Analysis, location Model, centroid method.
   Layout Planning: Layout Types : Process Layout, Product Layout, Fixed Position Layout Planning, block diagramming, line balancing, computerized layout planning- overview.
   Group Technology **(4 Hours)**
5. Forecasting : Principles and Method, Moving Average, weighted Moving Average, Exponential Smoothing, Winter's Method for Seasonal Demand, Forecasting Error.**(4 Hours)**
6. Manufacturing Planning and Control : The Framework and Components : Aggregate Planning, Master Production Scheduling, Rough-cut-Capacity Planning, Material Requirements Planning, Capacity Requirements Planning. **(5 Hours)**

MODULE III

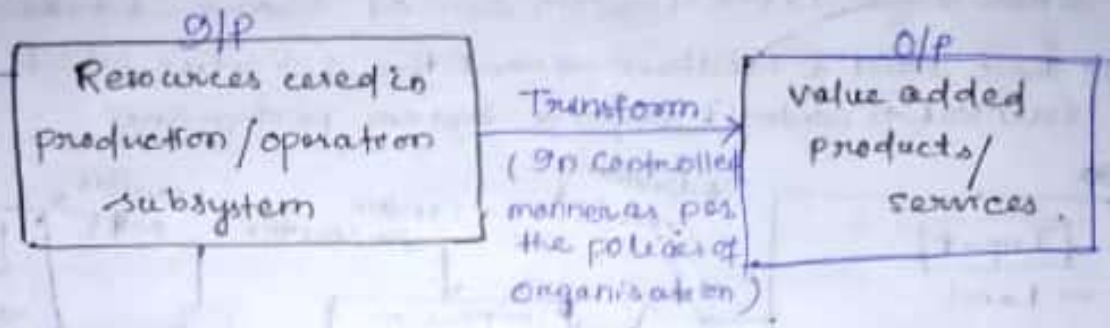
7. Sequencing and Scheduling : Single Machine Sequencing : Basics and Performance Evaluation Criteria, Methods for Minimizing Mean Flow Time, Parallel Machines : Minimization of Makespan, Flowshop sequencing : 2 and 3 machines cases : Johnson's Rule and Jobshop Scheduling : Priority dispatching Rules. **(3 Hours)**
8. Inventory Control : Relevant Costs, Basic EOQ Model, Model with Quantity discount, Economic Batch Quantity, Periodic and Continuous Review Systems, Safety Stock, Reorder Point and Order Quantity Calculations. ABC Analysis. **(4 Hours)**
9. Modern Trends in Manufacturing : Just in Time (JIT) System : Shop Floor Control By Kanbans, Total Quality Management, Total Productive Maintenance, ISO 9000, Quality Circle, Kaizen, Poka Yoke, Supply Chain Management. **(4 Hours)**

Introduction :- PRODUCTION & OPERATION MANAGEMENT :-

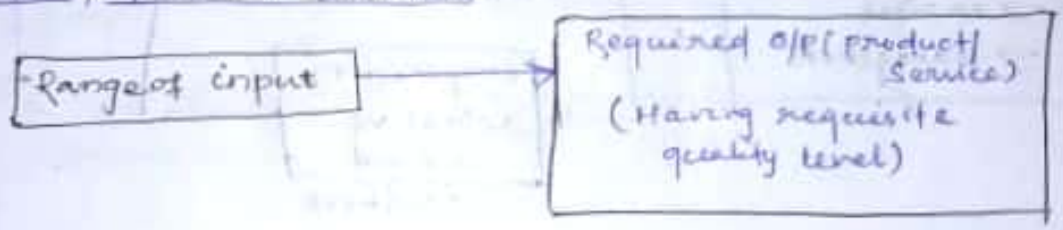
* **Defin :-**
  - P&M concerns itself with the conversion of inputs into outputs using physical resources so as to provide the desired utility to the customer while meeting other organisational objectives.

(ii) Production / operation management is the process which combines and transforms various resources used in the production / operation subsystem of organisation into value added product / services in a control manner as per the policies of organisation.

* i.e:



* **Production / operation functions :-**



* **Product & service management :-**

The set of inter-related management activities which are involved in manufacturing certain products is called production management and for service management, then corresponding set of management activities is called as operation management.

* **Examples :-**

Products / Goods	Services
- Boiler with a specific capacity	- Medical, facilities
- constructing flats, car, bus, radio, television	- Travel booking service & Hospitality.

Date :- 09.01.2020

Operation function (system) :-

→ Operation system of an organisation is the part that produces the organisation products.

→ Production is the basic activity of all organisation and all the other activity revolve around prod^n activity.

+ The o/p of production is the creation of goods or services, which satisfies, the needs of customer.

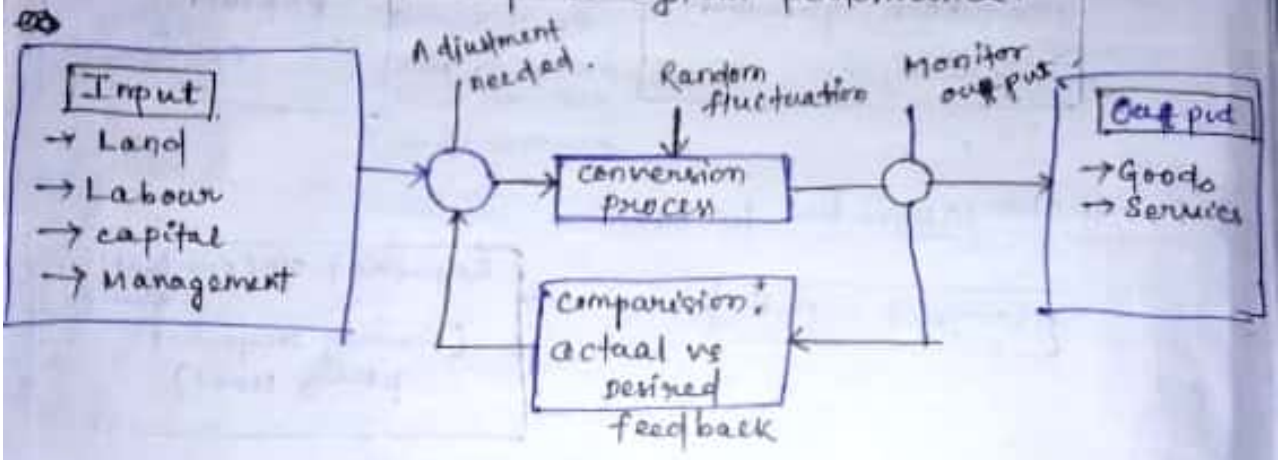
* Characteristics of a organisation function :-

a) production is an organised activity, so, every production system has an objective.

b) The system transforms, the various inputs (i/p) [Man, material, Machine, Information, Energy, money]. into useful o/p [Goods/Services].

c) production system doesn't operate in isolation from the other organisational system such as finance, marketing etc.

d) There exist a feedback about the activities which is essential to control & improve system performance.



* Role of operation manager :-

→ Operation manager are responsible for producing the supply of good services in organisation.

→ Operation manager make decisions regarding the operations function and the transformation system used

The primary role of a operation manager is :-

To meet production target & delivery schedule of goods/services planned.

To optimize utilisation of resources in the process of converting them into product / services.

Objective of production Management :-

i) ultimate objective.

ii) Intermediate objective.

gmp

Manufacturing Vs service operations — Dt: 10th JAN 2020

Manufacturing	Service
1. Manufacturing goods are physical & durable that means they are tangible products.	1. service goods are intangible and perishable in nature.
2. manufactured goods are outputs that can be produced, stored & transported in another form.	2. service goods can't stored. Hence we can't make the inventories.
3. Here minimum contact with the consumer required.	3. Higher contact with the consumers required.
4. It is a complex process.	4. It is a simple process.
5. Here the market is regional, national & international.	5. But in case of service the market is local.

System view of operations :-

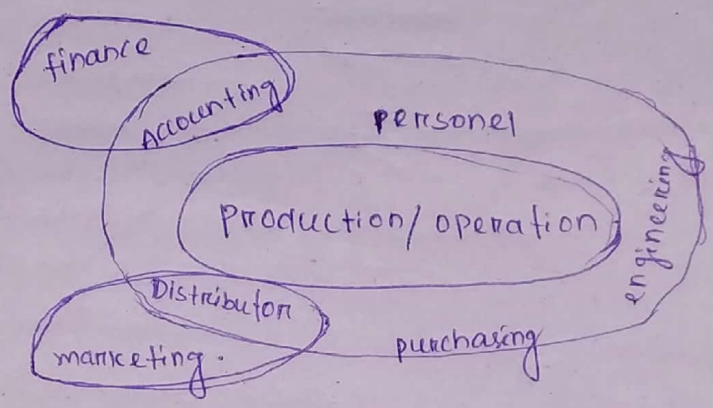
A system is a collection of objects there is a regular interaction occures between these objects.

→ A system can vary from the large nation wide communication to the local communication.

→ Models are used to represents a system. The system model can help to understand the operation that occures inside a system.

→ A system model of an organization identify the subsystem or sub components that make up the organization.

eg: Business firm.



Here the business firm is having finance, marketing, accounting personel, engineering, purchasing and physical distribution system in addition to the operation system.

→ These system are not independent but an interrelated to one another in many vital ways.

→ Decisions made in the production and operation subsystem often affect the behaviour and performance of other subsystem.

Strategic role of operations :-

Operation strategy is the overal planning for the organization future.

→ Operation strategy may be product and marketing oriented in order to take the customer and competation into account it also may be product oriented to deliver the product that customers want.

→ The production of an organization can be increased by adopting the below maintion strategy they are

(a) improved Responsiveness in terms of :-

→ minimising time to respond

→ Timely response.

→ wider produced / service choice ~~through~~ flexible operation/ manufacturing system.

→ increase productivity

(b) Reduced prices through :-

→ overall improvements in the production

→ Better designs of product / service.

(c) improved quality through :-

→ Better skill, better knowledge of all production & Service operation.

→ improve technology

→ Reduce complexity.

→ Reduce problem generation.

Dt : 14th JAN 2020

Operation strategies for competitive advantage :-

Operation strategies reflects a clear understanding of the farms long term goals.

→ It is the function of operation strategy not only to meet the competition but also to establish the firms competitive advantage through superior strategies.

→ strategies planning is the process of thinking through current misson of the organization and the current environmental condition facing it, then setting forth a guide for tomorrows decision.

→ The most important function of any strategies is to be prepared to handel competition and other external factors while meeting customer need.

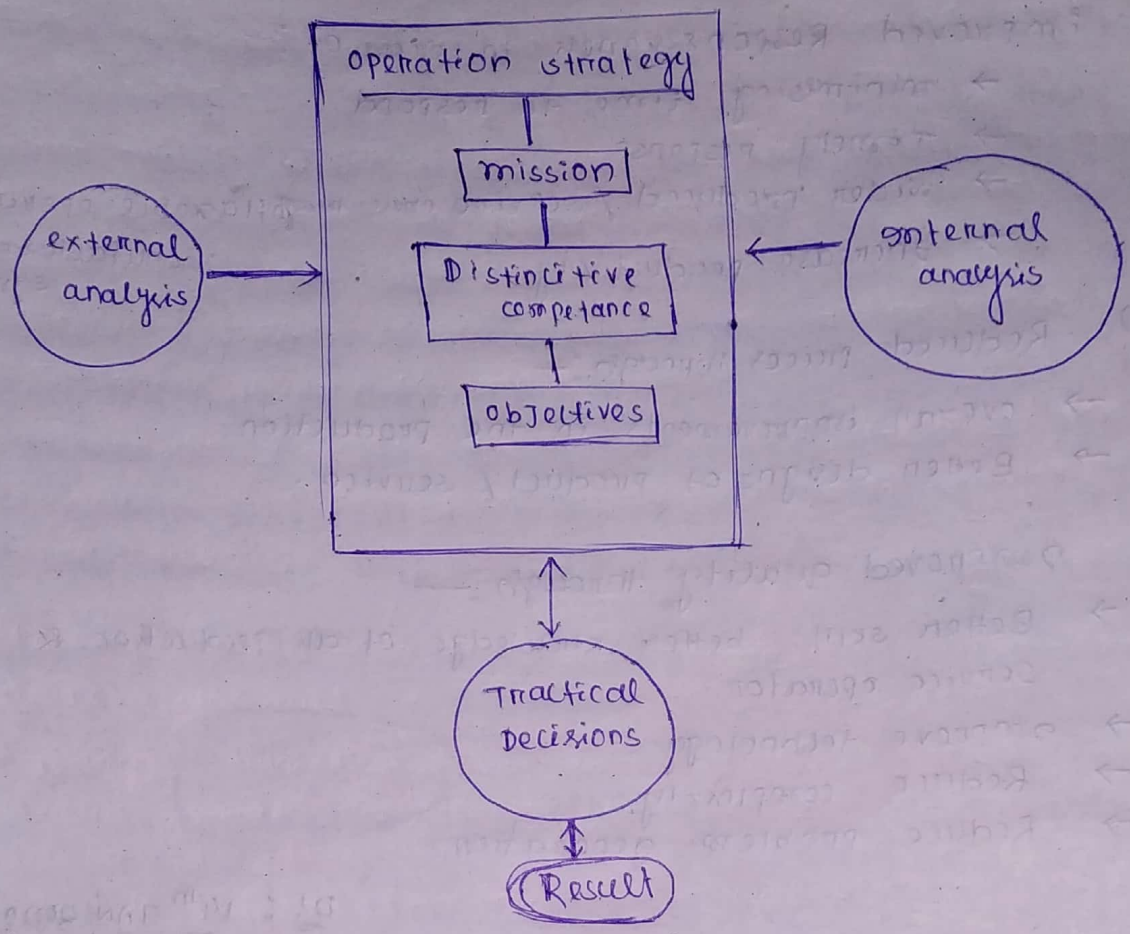
→ The four elements are heart of operation strategy

(i) mission

(ii) Distinctive competance

(iii) objectives

(iv) policies.



Objectives of the operation strategies are –

⇒ Lowering prices for in-creasing demand for the product.

⇒ High performance design.

⇒ consistant quality.

⇒ To increase the rate of return on investment

⇒ To increase sales ton over

⇒ To maximize profit.

⇒ To improve employment.

⇒ TO improve the economy of the nations.

Dt: 16th JAN' 2020

Operation quality and productivity focus :-

→ the terms production and productivity are different from each other.

→ production refers to the total output.

→ productivity refers to the output relative to the inputs.

→ productivity is the measure of the effectiveness of the use of resources to produce good & services.

→ productivity is the actual out of production, compair to the actual input of resources.

Hence

$$\text{productivity} = \frac{\text{outputs}}{\text{inputs (labour + capital + materials + other factor)}}$$

$$\therefore \text{Labour productivity} = \frac{\text{outputs}}{\text{Labour inputs}}$$

$$\therefore \text{capital productivity} = \frac{\text{output}}{\text{capital}}$$

Q Over the first year, a small resturant has averaged 224 customer served each day, hours are 6 AM to 2 PM and 3 employees make of the total staff labour what is the productivity.

Soln :

224 customer each day

employee = 3

$$\therefore \text{Labour productivity} = \frac{224 \text{ customer}}{3 \text{ employee} \times 8 \text{ hour/employee}}$$

$$= 9.3 \ \frac{\text{customer}}{\text{hour}}$$

Strategies for increasing productivity :-

The objectives of the organization is to increase productivity to the heighest possible level.

→ the strategies for increasing productivity are -

* increased output for the same input.
* Decrease inputs for the same output.
* Proportionate increase in the output is more than the proportionate increase in the input.
* proportionate decrease in the input is more than the proportionate decrease in the output.
* Simultanious increase in the output with decrease in input.

Operations quality :-

Quality is a measure of the degree to which the product meets its design standard which may relates to materials, performance, reliability, time or any quantifiable characterstic

- Total quality is the ability of good or service to satisfy customer demand.

- There is direct relationship occures between quality & productivity.
- When quality is increased waste is eleminated. The amount of inputs required to produce outputs is reduced so the productivity increases.
- Improving quality is one important way to maintain a compitative position of todays market.
- Productivity & quality are not only applied factories and product but also they can be applied to the service industories.

Dt : 17th JAN '19

Meeting Global challenges of production & operation imperatives :-

- Todays market are becoming global in nature. Globalization brakes the economic boundary and opens world economy for free trade.
- Due to expanding world wide communication system and global travel, consumer demand is more homogenized and these can be achived by implimating the following characterstic.

(i) put the customer first :-

- The principle should be followed by the entire company, not just the sales department. This can be done by eliminating the customer complain.

(ii) Be quality conscious :-

- the quality can be achived by better product design.

(iii) Involve employees :-

(iv) Pratice Just in time production.

(v) Emphasize technology.

(vi) Emphasize long term orientation.

(vii) Be action oriented.

Designing Products / Product design :-

* New product design :-

Product design is performed to determine how the product will be made.

- Product design specifies which material ~~to~~ be used determine dimension & tolerance
- It also define the appearance of the product.

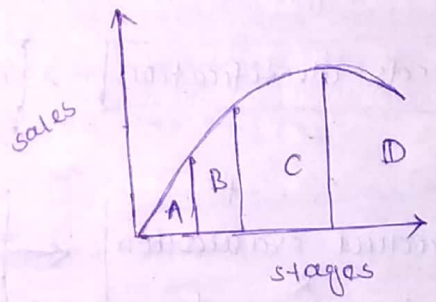
Reasons for New product design :-

- For long time continuition business.
- To statisfy the needs of the customer.
- If the companies existing product becomes saturated and sales is declining then new product design is must.
- If too much compitition in the existing product occures.
- To increase the external appearance of a manufactured product which influences the buyers to purches the product.

Dt : 22nd JAN 2020

Product life cycle :

A = Introduction
B = Growth
C = Maturity
D = Decline



Introduction stage -

This stage starts with the introduction of the product into the market.

- The product is entirely new to the market.
- ~~So~~ The demand of the product is low, as the customer do not have much more ideas about the product.
- So the organization payes a greater attention in advertisement to make the product familiar to the customer.
- The volume of sale will be low in this stage.

Growth stage - In this stage the product is greatly acceptable by the customer. Hence the sals start increasing. Here the growth rate is high because of limited compitition

Maturity stage :- Here in this stage the sales reaches a point above which it will not grow. This is because of the market share taken by the competators product.

Decline stage

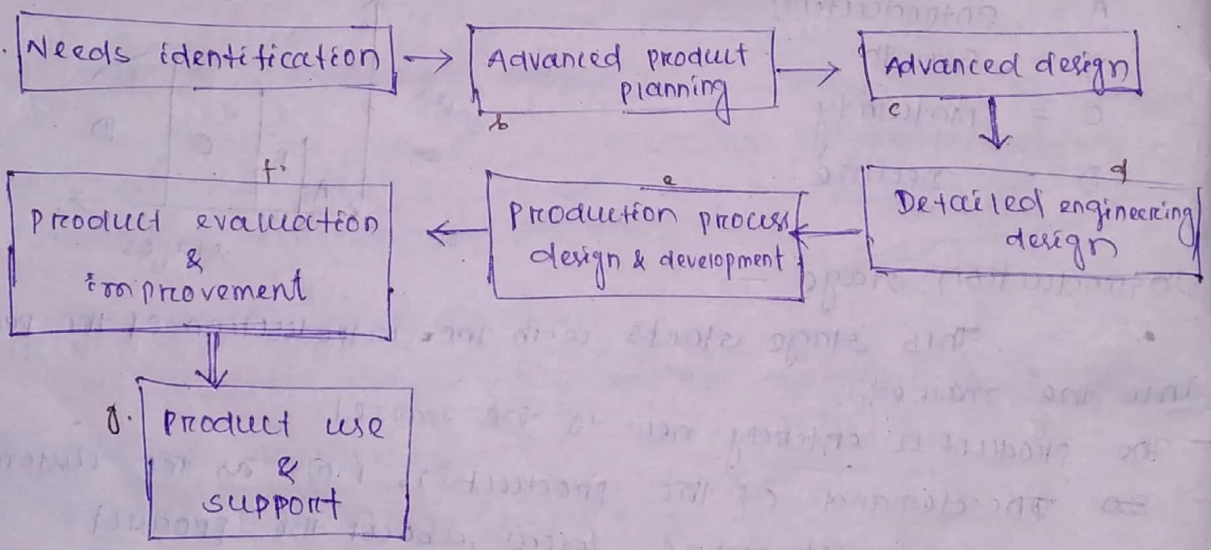
The competators will enters the market with better products, advance technology and reduced prices. This is a threat to the existance of the product. Hence sales start decline. If special cares are not taken then a stage comes when the products are to be taken back from the market.

Dt : 24th JAN 2020

Product development process :-

Product is generally capable of satisfying the need of the customer.

- A New product is generally different from the existing product because the demand of the product is low and the customer donot have much more idea about the product.
- The development of a new product passes through 7 stages the stages are



a. **Needs identification :-** identification starts with the idea generation for the development of the product. The ideas must collect from marketing staff, customers, management & production department for the growth of the product.

b. **Advance product planning :-** At this stage conceptual design of the product occures.

(conceptual design means what is the shape, size, colour, and final price of the product).

- This stage includes priliminary market analysis, requirement of the customer, maintaining & distributing product in market.

c. Advance design :- It involves detailed investication by the researchers about the technical feasibility & trade offs in product design.

d. Detailed engineering design :- This stage involves a series of designing activities these are

(i) Functional design
(ii) Reliablity design
(iii) Maintainablity design.
(iv) Design for safety of the product
(v) Design for productibility.

e. Product process design & Development :-
This stage involves planning for controlling production, Human resources & warehousing.

f. Product evaluation & improvement :- After the product has been lunched, it needs constant evaluation and improvement. This is done by means of analyzing the market condition & then necessary improvement should be taken.

g. Product use and support :- An important stage of product ~~improves~~ development is support for the customers who use the product. The support can be done by

→ providing warenty & repair service.
→ By distribution the replacement parts.
→ By upgrading the product with design improvement.

Dt:- 25th JAN 2020

Product quality:-

Date - 28.01.20

→ Product quality design refers to the methods of construction, processing, materials used style factor and safety factors etc.

→ It refers to the tightness of the specification for manufacturing the product.

→ There is difference in specification of product which have same use because of their difference in quality.

Product reliability design:-

→ Product reliability is the probability that a given part or product will perform its intended function for a specified length of time under normal conditions of use.

→ Reliability is different from quality, because a product of better quality may not be reliable according to the costumer.

→ Reliability is related to continuous performance over a period of time.

→ Normal conditions of use is also important factor in case of reliability.

Methods of improving reliability are:-

1. Improving designing of components.
2. Improving production techniques.
3. performing periodic preventive, maintainance.
4. Improving quality of production.
5. Simplify the design of the system.
6. Improve quality control.

Process Technology :-

Dt : 31st JAN 2020

- A process is a group of related task with specific inputs and outputs.

→ Process design defines what task need to be done and how they are to be co-ordinated among function, people, organization.

- process technology refers to the equipment, people & systems use to produce a firms products & services.

- Ex :- (*) capecal intensity
  - * process flexibility
  - * vertical integration
  - * customer involvement.

→ Different types of process technology -

There are 5 type of Process technology are

(i) Project
(ii) Job shop
(iii) Batch
(iv) assembly line
(v) contineous manufactering.

Project

→ project technology deals with one of a kind product that are fitted to the unique requirement of each customer.

Advantage

- Project process is flaxible in nature.
- More customer constract.

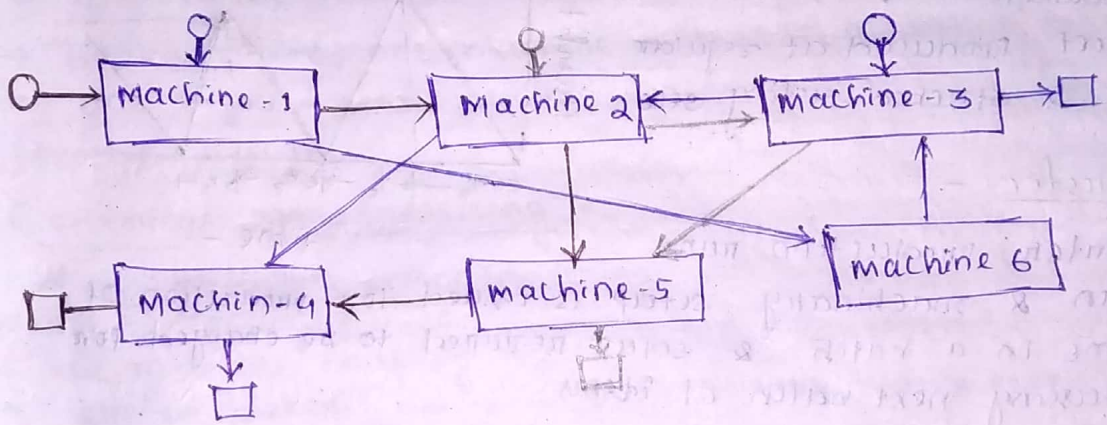
Disadvantage

- It involves large sum of money.
- It is more risk.
- It can't exploits economics of scale.

Dt : 04th Feb 2020

1. Job shop manufacturing process —

Job shop technology is appropriate for manufacturer of small batches of many different product each of which custom design and concequently requires its own unique set of processing steps or routing through the production process.



Characteristics :

→ High verity of products & low volume.
→ Use of general purpose machine & facilities.
→ Frequent changing setups.
→ process type layout for arrangement & facilities.
→ large inventories of materials, tools, parts.
→ Relative inbalance of workloads of different detferent departments & labours.

Advantages :

→ Because of general purpose facilities, verity of products can be processed.
→ operator will become more skilled.
→ opportunity to use inovative ideas & effective methods.
→ low initial cost for general purposed equipment and greater workers satisfication because of the varity of work performed.

Disadvantage –

→ Higher setup & tooling of cost due frequent setup changes.

→ Higher inventory cost

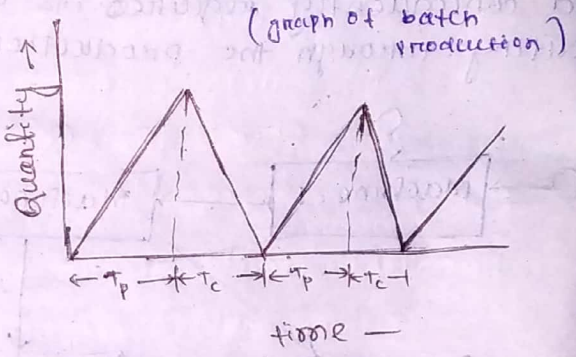
→ Production planning is complecated.

→ Highly competend and skilled man power is demanded.

→ Production cost comes to be high.

2. Batch production

Batch production is characterised by the manufacturer of limited no. of product produced at regular interval & stacked outing sells.



Characteristic –

→ shorter production runs

→ plan & machinary setup is issued for production of items in a batch & setup required to be changed for processing next batch of items.

→ more no. of setups & higher setup cost.

→ Amount of supervision required is less compair to Job order.

→ Plant & Machinary are flexible.

Advantages –

→ Better utilization of plant & machinaries.

→ cost per unit is lower as compair to Job order production.

→ lower investment in plant & machinary.

→ Job satisfication exists for operators.

Limitation –

→ material handling is complex because of irregular and longer flows.

→ production planning & control is complex

→ longer production time.

→ work is process invertory is higher compained to continious product.

Dt: 5th Feb 2020

3. Assembly line :-

→ Assembly line technology produces a narrow range of standardisation product.

→ ~~In case of a auto~~ Here flow of materials, components & part is continious.

→ Production planning & control is easy.

→ Material handling can be completely automatic.

Advantages :

→ Higher rate of production with reduced time.

→ Less skilled operator are required

→ manufactuering cost per unit is low.

Disadvantages :-

→ Breakedown of one machine will stop an entire production line

→ line layout needs measure change with the changes in the product design.

4. Continious Manufacturing :-

continious manufacturing technology are used for high volume of product.

→ the material handling system is fully automated.

→ Here the workers role is to monitor the equipments.

eg :- steel, paper, pens, chemicals are produced by continious manufacturing process.

→ product flows through a sequence of production operations from the first operation to the finished product.

Advantages :

→ Higher rate of production with reduced cycle time.

→ unit cost is lower due to high volume of production.

→ man power is not required for material handling as it is completely automatic.

Disadvantages :

→ Larger investment in plant and equipment.

→ Product differentiation is limited.

→ customer become less involved.

Process technology life cycle :-

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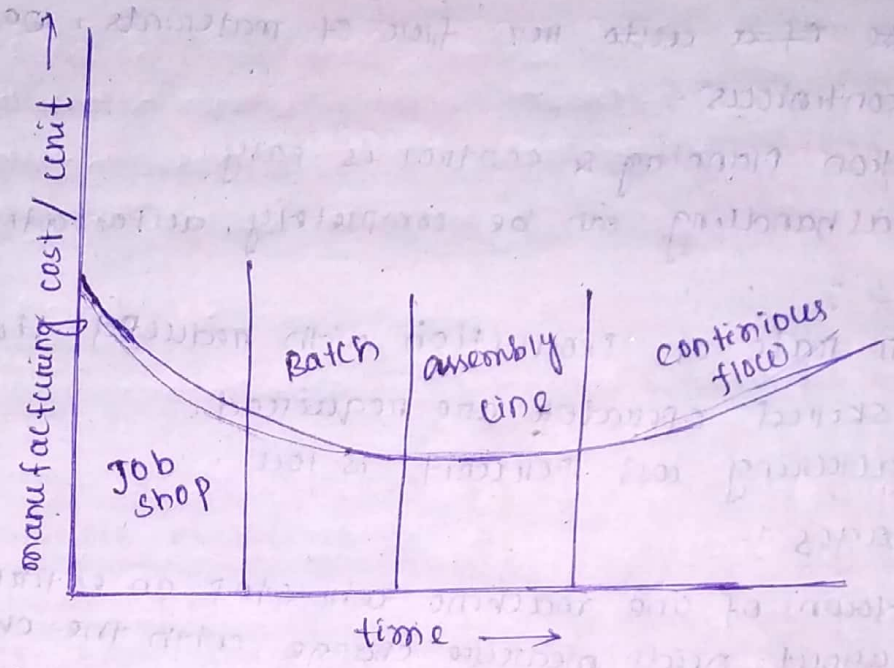


→ The process technology life cycle is related to the product life cycle.

→ As the time increases the manufacturing cost per unit decreases.

→ From start up to decline the manufacturing process in a company vary.

→ In a simple manner, the process technology is a job shop at start up and proceed towards the continious flow technology.

→ At startup the output volumes are low —

→ the application of automation is rare.

→ At maturation the output volume is high and the automation process is fully applied there.

Process technology trends -

process technology trends are —

(i) Flexible manufacturing system (FMS)

(ii) computer integrated manufacturing (CIM)

(iii) computer aided design (CAD)

(iv) computer aided manufacturing (CAM)

(v) Group technology (GT)

Flexible manufacturing Systems :- (FMS)

Dt : 07th Feb 2020

→ FMS consist of group of machines that are connected to the computer system.

→ Here the computers control the machines as well as the tool changing system and material handling system.

→ simplest example of FMS is a CNC machine with an automative tool changer & automatic loading & unloading mechanism.

→ FMS is used for making parts such as gear, motor parts & electrical component etc.

→ Here robotic control is used for loading & unloading of tools.

→ Here the storing of the final product is also automated and no human involvement is present there.

→ Here very hard volume of products can be made with constancy in quality.

→ set up time is very short [because of automation of tool change is quick process and the set up time for machines are short.]

→ Here in this process the operator is an observer to off and on the bottom.

* Computer integrated Manufacturing — (CIM)

→ In CIM all the functions are clubbed in an integrated computer system.

→ CIM is defind as a computer system to bridge various computerised systems.

→ CIM system includes — computer numerical control (CNC), computer process control, Direct numerical control (DNC), computer integrated production management, industrial robotics Automated inspection method.

→ CIM can be viewed as an integration of

(i) product & process design
(ii) production planning & control.
(iii) production process.

→ In CIM data base about the machines are present.

→ Here the database involves ideas about the machines, tools, materials, manufacturing steps, quantities required, specified dates etc.

→ In CIM the outputs of one activity serves as input to the next activity.

Benifits

→ Increased machines utilization
→ Reduced direct & indirect labour.
→ Reduced manufacturing lead time.
→ Lower in process inventory.

Computed Aided Design (CAD) :

→ In computer aided design, computer is used for designing purpose.
→ CAD is the technology concerni with the use of digital computers to perform certain functions in design and production.
→ Traditionaly drafts man use boards to draw designs but in CAD computers are used for making different design with the helps of graphics software.
→ Here the designer can make changes rapidly as compain to the traditional design.
→ In CAD moniters helps to view the designs and the printouts are taken for getting approval of CEO.

Advantages

→ It eliminates laboriocs method of manual drafting.
→ In this method the time for the design is shorter, Hence various alternative designs can be tried.
→ Here the quality of design is good as compained to the manual drafting.
→ The most used CAD software is auto CAD, it is introduced in the year of 1982.
→ Improved accuracy design.
→

Dt: 10th Feb 2020

CAM (Computer Aided manufacturing) —

→ In CAM computer system is used for plan, manage and control the operations of a manufacturing plants.
→ CAD & CAM system combined to form CAD/CAM system.
→ This combination allows the transfer of information from design into the planning for manufacturer of a product.
→ Here the designing developed in CAD is further processed by CAM for operating and controling production machinery.

→ In CAM computers are used for production but there is no direct connection between the computer & the process.
→ The computer is used offline for planning & management production activities.
→ CAM is also used for process control, quality control, shop control & process monitoring.

Advantage

→ Here labour investment is very less. Hence production cost lowered.
→ Here quality is ensure for maximum level.
→ Here manufacturing time is lesser due to automated setting of machineries. Here cost of production is reduced.
→ By using CAM speed, accuracy, productivity & quality can be achived to a greater extent.

Group technology (GT)

→ Group technology is a type of manufacturing process in which parts having similar characteristic are identify and grouped together.
→ It will take the advantage of their similarities ~~and~~ in manufacturing and design.
→ Each family will having similar design and characterstics. Hence the processing of each member of a giving family could be similar this result in manufacturing efficiency.
→ The application of GT follows two basic steps
→ The 1st step is to determine the part familys or groups.
→ The 2nd step is to apply GT to arrange the equipments use to process a perticular family of components.

Advantage

→ Reduce setup times
→ Better scheduling.
→ Lower in process inventories.
→ Improved tool control
→ Use of standardized process plan.

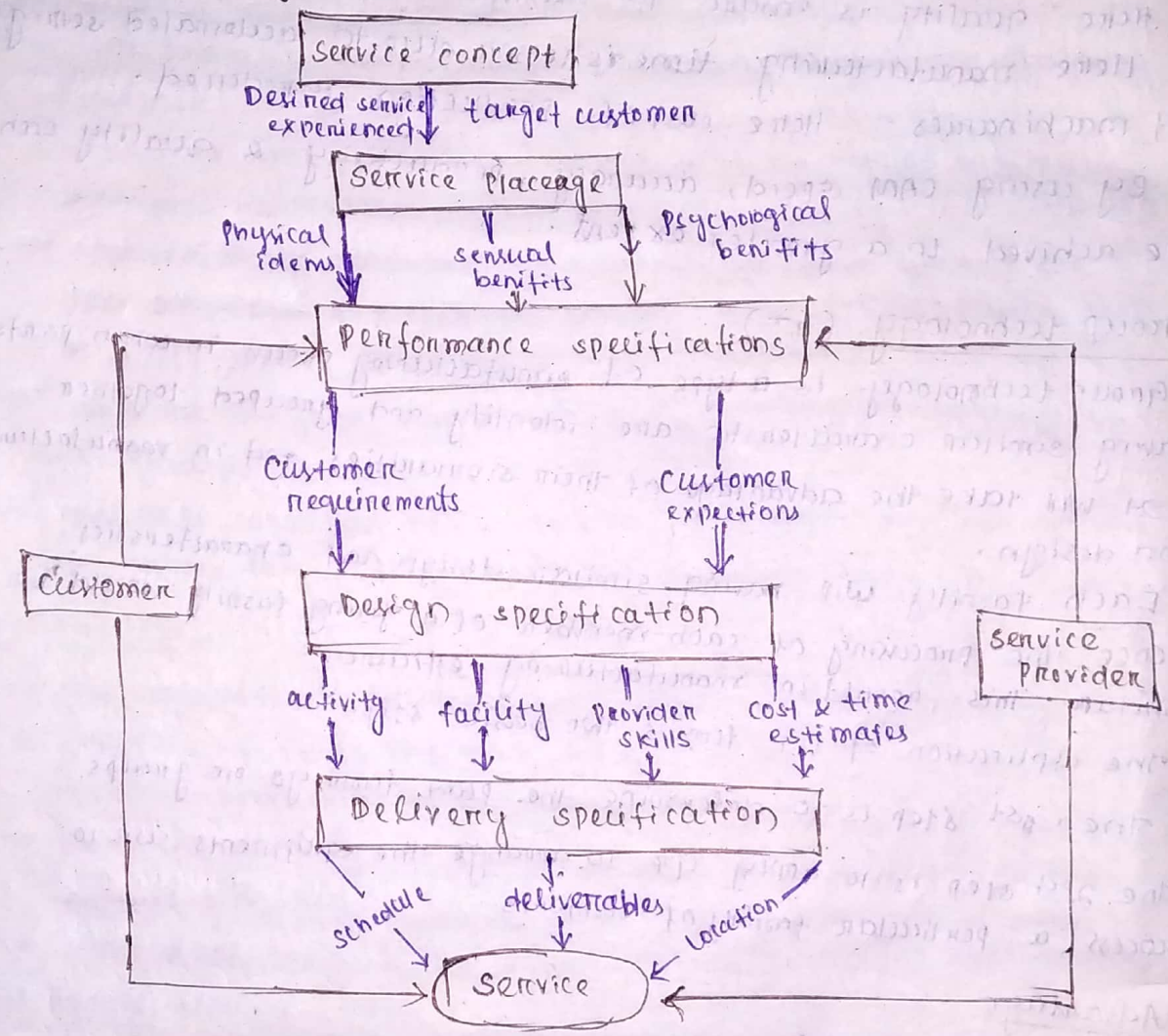
Design for service :-

→ The design of service contains the exact stages as the design of products.
→ It starts with recognizing the customer need & creating a service concept that satisfies the requirement of customer.

→ The important consideration that are taken before designing the services are

(i) To what extent will the customer be envolved in this process.
(ii) How quickly will service be provided ?
(iii) How standadized or customised will the service be ?
(iv) what verity of service will be offered ?
(v) what geographical area will be served ?

Service design Process :



→ The process that are involved in service design process are-

(i) Service concept :→ This process starts with the prior experience about the service.

(ii) Service placeage : on this process the physical items that are involved in service process are consider.

(iii) Performace specification — on this stage customer requirement & customer expectations are taken into according to make service according to the cost requirement which will lead to the sensual benifit.

Design specification :- In this stage the designing limits and tolerance values that are taken in the service process are considered.

Delivery specification :- Here in this process the suitable delivery value change will form to reduce extra cost that is involved in delivery process of service.

Dt : 11st Feb 2020

Service process technology

The process technology for service is different from that of the process technology of product.

→ There are generally 3 process occures in service process technology.

(i) Quasi - manufacturing process
(ii) customer as - participant.
(iii) " " product process.

Quasi manufacturing process — In this process the production of goods takes place along a production line with almost know customer involvement in production.

eg:- This process occures in the backrooms of fastfood outlet like magnolads. Here physical goods dominant over intangibul services and there is a little customer participation in the production & service process.

In this process the customer participation is more in the process of generating the service.

eg:- This process occures in the automated tailor machine and sells on restrunants.

The distinguished feature of this approch is that the service is provided through personal attention to the customer.

eg:- medical clinics & hair saloon.

In the service process technology contract focuses is placed on the customer.

- Here the employee training, construction building & equipments must be designed with the customer in mind.

Service automation

→ Automation is defind as a set of procedures & machinery that makes traditional human activities automatic.

→ In this process the human operator are provided with machinery to help them in their job.

eg :- welding, drilling, bending

→ Now a days service activities are made automatic by means of computer based system.

→ Some of the service sector where automation are applied are insurance, airlines, banking, realestate, Advatising, public relation, TV, broadcasting, traffic, Health care, entertenment, communication, railway service, wholeselling, printing & publishing etc.

→ Now, mechanised services such as automated banking, electronic grocery scanners and automation in the office operation is the general feature.

→ Automation process improves efficiency and help in expanding the product.

Value Engineering :-

Value means different things to different people. The designer relates value with reliability, purchase may relates value with price paid for items, production process relates value with what it cost to manufacturer & seller person relates value with what customer is willing to pay.

→ Value analysis is the systematic application of reconized techniques which identify the function of a product or service, establish a momentary for the function and provide the necessary function reliable at the lowest overal cost.

→ Value engineering is the process of determining the value of a product or service during various stages of the product life cycle.

→ Value engineering is a cost prevention technique which elimenates cost build of into the product.

→ Value engineering is applied to the product are the designing stage and thus ensures prevention rather than elimination.

Uses of value engineering

- It is a cost prevension or cost elimination technique thus reducing cost of the product.

→ Balance the cost & performance.
→ Prevents over design of components.
→ Increases the profits & deflates costs.

Steps in value engineering :

→ Identify the product
→ Collect relative information about the product.
→ Create different alternatives for the product
→ Evaluate the value of alternatives.
→ Determine the best alternative from the value of the alternatives.
→ Improve the alternatives.

When to apply value analysis

→ company's product are loosing in the market and there is a decline in scale.
→ company's products are priced higher than the competators.
→ New design of products beeing undertaken.
→ Decreasing profitability and return on investment.

Standadization

It means fixation of some appropriate size, shap, quality, manufacturing process, weight & other characteristic as standard to manufacture a product desired verity & utility.

Dt :- 12th Feb 2020

Make or buy decision :-

It is refers to the problem encocenter by an organization when deciding whether a product or service should be purchased from out side sources or manufactured internally.

→ The majority of make or buy decision are made on the basic on price. It is only the criteria which is to be evaluated in this stategic decision.
→ Theoritically every item, which is currently purchase from an outside supplier is always a condidate for internal manufacture and every item currently manufacture in jobshop in potential candicate for purchase.
→ Generally a no. of aspects are to be consider beton buying the item they are.

(i) what to buy?
(ii) How to buy?
(iii) How much to buy?
(iv) where to buy from?
(v) what price to pay?

Make or buy decision when? -

→ when the organization introduce a new product.

→ The flatuating demand for the companies product.

→ when the organization carries out value analysis & cost reduction programs.

→ factor ~~introducing~~ influencing make or buy decision.

(i) volume of production :- If the volume of production ~~production~~ is high it favours make decision. If it is low it favours buy decision.

(ii) cost analysis :- It refers to the determination of cost to make an item as well as the cost to buy it.

(iii) utilization of production capacity - The org. which having large no. of capacity.

(iv) Availability of manpower :-

(v) Fixed cost :

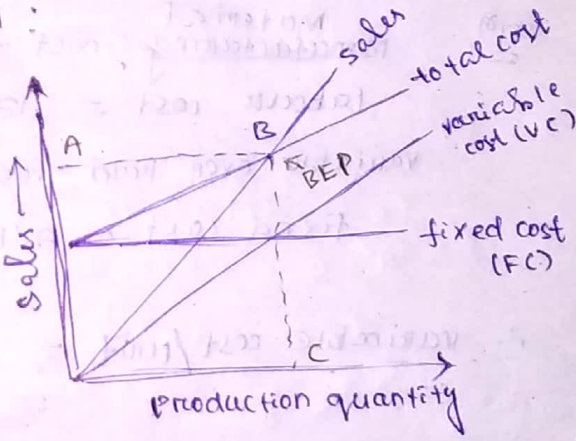
→ The market aspects have the influence on make or buy decision.
→ When there is a vast competitation, an organization tries to increase the quality and relibility of product.
→ The make decision assures the quality & relibility of parts.
→ When there is a doubt about market potential the company should go for buy decision.

Environmental feature, labour union acceptance, technical assistance vendors also influence the make or buy decision.

The make or buy decision influence by
(i) The access to the latest technology to the org.
(ii) outdating of technology.
(iii) Product life cycle.

Approches to make or Buy decision:

(i) Break even analysis :-



Where

TC = total cost = FC + VC
VC = variable cost
FC = fixed cost
B = The intersection TC & sales
= Break even point (BEP)
(No loss or gain situation)

A = Break even sales
C = Break even quantity.

$$\text{Break even point} = \frac{\text{Fixed cost}}{\text{selling price/unit} - \text{variable cost/unit}}$$

Q A manufacture of TV, buyes, TV cabinet at 500 each. In case the company makes it within the factory, the fixed and variable cost would be 400000 and 300 per cabinet. should the manufacture make or buy the cabinet if the demand is 1500 TV cabinet.

Soln selling price per unit = 500/-
Fixed cost = 400000/-
variable cost = 300/-

$$BEP = \frac{\text{Fixed cost}}{S.P - V.C} = \frac{400000}{500 - 300} = 2000$$

Since the demand is (1500 unit) less than the Break even quantity. so the company should buy the cabinet for the TV manufacture.

(ii) Simple cost analysis :

Q An automobile company has extra capacity that can be used to produce gears that the company has been buying for 300 rupees each. If the company makes gear it will incure material cost of Rs 90 per unit. Labour cost of 120 rupees per unit and variable overhead cost is 30 rupees per unit. The anual fixed cost associate with the product is 2,40,000. Demand over the next year is 4000 unit. would it profitable for company to make or buy decision.

Soln

Material ~~Manufacturing~~ cost = 90 per unit

labour cost = 120 /- " "

variable over head cost = 30 /- per unit

fixed cost = 2,40,000 /-

∴ variable cost/unit = material + labour + overhead

= 90 + 120 + 30 = 240

∴ Total variable cost = variable cost/unit × total no. of units

= 240 × 4000 = 9,60,000

∴ Total cost = FC + VC

= 2,40,000 + 9,60000

= 12,00,000 /-

∴ total purchase cost = Buying cost × total no. of units

= 300 × 4000

= 120000

∴ Hence total cost = total purchase cost + FC

= 1200000 + 2,40000

= 14,40000

∴ The total cost of making the gears is less than the total cost of buying the gears from outside. Hence it is profitable ~~to~~ for the company to make the gear.

Dt : 17th Feb 2020

Economic Analysis :

There are two models occurs in economic analysis.

(i) Purchase model (or) (ii) manufacturing model.

(i) Purchase model

$$Q_1 = \sqrt{\frac{2C_0 D}{C_c}}$$

$$T_c = D \times P + \frac{DC_0}{Q_1} + \frac{Q_2 \times C_c}{2}$$

(ii) manufacturing model

$$Q_2 = \sqrt{\frac{2C_0 D}{C_c\left(1 - \frac{\pi}{K}\right)}}$$

$$T_c = D \times P + \frac{DC_0}{Q_2} + \frac{Q_1 C_c}{2} + C_c(K-\pi) \times \frac{Q_2}{2K}$$

where

D = Demand / year

P = purchase price / year

C_c = carrying cost / unit / year

C_0 = ordering cost / order (or) setup cost / setup

K = production rate (No. of units per year)

π = Demand / year = D

Q_1 = economic order size.

Q_2 = Economic production size.

T_c = Total cost per year.

Q An item has a yearly demand of 2000 units. The different cost associated with making and ~~by~~ buying the product are

	Buy	make
Item cost / unit	Rs 8.00	Rs 5.00
(C_0) procurement cost/order	120/-	
setup cost / setup		60/-
carrying cost/unit/year	1.60/-	1.00/-
production rate / year		8000 unit

Determine the best option.

Sol^n Demand / year (D) = 2000 units/year.

Procurement cost/order (C_o) = ordering cost/order = Rs 120/- per order

carrying cost/unit/year (C_c) = Rs 1.60/- unit/year.

Cost to Buy

$$Q_1 = \sqrt{\frac{2C_oD}{C_c}} = \sqrt{\frac{2\times 120\times 2000}{1.60}} = 547.72 \simeq 548 \text{ units}$$

Purchase price/units = Rs 8.00/-

$$T_c = D\times P + \frac{D\times C_o}{Q_1} + \frac{Q_1\times C_c}{2}$$

$$= 2000\times 8 + \frac{2000\times 12}{548} + \frac{548\times 1.60}{2}$$

$$\boxed{T_c = 16876.35/-}$$

cost to make

$$Q_2 = \sqrt{\frac{2C_oD}{C_c\left(1-\frac{r}{K}\right)}}$$

C_o = setup cost = 60/-

$r = D$ = 2000 units/year.

C_c = 1.00/-

production rate → K = 8000 units

$$Q_2 = \frac{2\times 60\times 2000}{1\left(1-\frac{2000}{8000}\right)} = 565.68 \simeq 566 \text{ units.}$$

Purchase price/unit = 5/-

$$T_c = D\times P + \frac{D\times C_o}{Q_2} + C_c(K-r)\times\frac{Q_2}{2K}$$

$$\Rightarrow T_c = (2000\times 5) + \left(\frac{2000\times 60}{566}\right) + 1(8000-2000)\times\frac{566}{2\times 8000}$$

$$\Rightarrow \boxed{T_c = 10424.26/-}$$

Hence the cost of making is less than the cost of buying therefore the firm should go in for the making option.

Job Design & Work measurement —

Job: A job is a group of related task or activities that need to be performed to meet organizational objectives.

Job Design: - The job design is a function ~~with~~ which should specify what task will be done, who will do them & what results are expected.

→ The objectives of job design is to develop job structure that meet the requirements of the organization.

Factor influencing job design:

(i) workers pre idea about the job
(ii) Multiskilling of workers.
(iii) workers involvement in designing & organizing work.
(iv) Extensive use of temporary or contract labour.
(v) Education of workforce
(vi) Automation of hazardous work.

Work study: - work study is the method of investigating the workdone in an organization and the aim of work study is to find the best and most efficient way of using the available resources i.e man, material, money & machinary.

→ In general the use of work study is to examine the human work and to eliminate the factors which will reduce the efficiency of the work force.

→ work study is performed by two methods or techniques they are

(i) Method study
(ii) work measurement.

Advantages of work study -

(i) It helps to achive the smooth production.
(ii) It help to reduce the cost of the product by eliminating waste & unnecessary operations.
(iii) Better worker management relation.
(iv) meets the delivery commitments.
(v) Higher utilization of the resources of the organization.
(vi) Helps to achive better working conditions.
(vii) Helps to establish the standard time for the operation of job.

Method study :- (motion study)

Method study is the systematic recording & critical examination of existing and purposed way of doing the work and developing ~~and~~ an easier and more effective method of doing the work & reducing the cost.

→ Generally method study involves in the ~~breakdown~~ breakdown of an operation or procedure into its component elements and their systematic analysis.

Dt : 18th Feb 2020

Steps or techniques in method study :-

(i.) **Select** : Select the work to be studied.

(ii.) **Record** : Record the rele-vant facts about the job by direct observation and collect information about the job.

(iii) **Examine** : examine the way the job is being performed by using critical examination methods.

(iv) **Develop** : Develop the most pratical, economic and most effective method of doing the job.

(v) **Evaluate** : Evaluate the most effectiveness of the selected method with the current method of performing the job.

(vi) **Define** : Define the new method in a clear manner and present it to the management.

(vii) **Install** : Install the new method as a standard pratice and train the persons involved in the job with that view method

(viii) **Maintain** : Maintain the new method and introduce control procedures to prevent a drifting back to the previous method of work.

Scope of method study :-

→ To improves work methods & work procedures.

→ To determine the best sequence of doing the work.

→ To improve the working conditions and hence to improve labour efficiency.

→ Elimination of waste and unproductive operation.

→ To reduce the manufacturing cost through reducing cyclic time of operation.

Symbols used in method study –

(i) operation – (O) → ~~An operation~~ An operation occures when the object changed in one or more on its characterstic.

eg:- turning, welding, driling, milling, unloading, loading, brazing.

(ii) Inspection (□) → An inspection occures when an object is examined and compained with standard for quality and quantity.

eg:- visual observations for finish, count of quantity of incoming materials, checking the dimensions

(iii) Transportation (→) :- A transportation indicates movement of workers, material or equipment from one place to another.

eg:- movement of materials from one work station to another work station.

(iv) Delay (D) → A delay occures when the immidiate performance of the next plant think doesn't take place.

eg: work waiting between consecutive operations.

(v) storage (▽) – storage occures when the object is kept in an authorisized custody and is protected against authorized removal.

eg:- material kept in stores to be distributed to various work.

Time study :

TIME STUDY

- It was proposed by Frederick Taylor and later modified to include a performance rating (PR) adjustment.
- Once the method is established, the next objective is to set the standard time for the work. This aspect of work study is called Time study (or Work measurement).
- The main objectives of time study are:

1) To determine the standard time for various operations which helps in fixing wage rates and incentives.
2) To estimate the cost of product accurately.
3) To predict accurately the duration for a particular work and customer is promised accordingly.
4) To determine the number of machines an operator can run.
5) To determine the optimum number of men and machine.
6) To provide information for planning and scheduling.
7) To balance the work of all workers working in a group.
8) To compare the work efficiency of different workers/operators.

Work measurement techniques

1. Time study using stop watch.
2. Predetermined motion time system (PMTS).
3. Work sampling.
4. Analytical estimating.

The following table shows the application of each technique and unit of measurement.

Technique	Application	Unit of measurement
Time study using stop watch	Short cycle repetitive jobs	Centiminute (0.01 min)
PMTS	Manual operations confined to one work centre	TMU (I TMU = 0.006 min)
Work sampling	Long cycle jobs/ Heterogeneous operation	Minute
Analytical estimating	Short cycle non-repetitive job	Minute

Time study using stop watch is the most popular technique for determining standard time. The first task of the analyst is to divide the work/job into smaller work elements in such a way that the time for each element should not be less than 3 seconds because for such elements, recording time is difficult. The steps of time study are as follows:

Step 1: First select the job to be studied. Breakdown the work content of the job into smallest possible elements. Then, inform the worker and define the best method.

Step 2: Observe the time for appropriate number of cycles (such as 25 to 50).
Step 3: Determine the average cycle time (CT)

$$CT = \frac{\sum \text{Times}}{\text{No. of cycles}}$$

Step 4: Determine the normal time (NT)

NT = CT (PR)

Where, PR is the performance rating.

Step 5: Determine the standard time using the following formula.

$$ST = NT\ (AF) \text{ where } AF = \frac{1}{1 - \%\ \text{Allowance}}$$

AF being the allowance factor.

Selection of job for Time Study:-

Time Study is conducted on a job

- which has not been previously time-studied.
- for which method change has taken place recently.
- for which worker(s) might have complained as having tight time standards.

Selection of Worker for Time Study:-

The worker on which time study should be conducted must

- have necessary skill for the job.
- have sufficient experience with the given method on the job (that is, he should have crossed the learning stage).
- be an ‘average' worker as regards the speed of working.
- be temperamentally suited to the study (those who can't work in normal fashion when watched, are not suitable for the study).
- have knowledge about the purpose of study.

Time Study Equipment:-

The following equipment is needed for time study work.

- Timing device
- Time study observation sheet
- Time study observation board
- Other equipment

Timing Device. The stop watch is the most widely used timing device used for time study, although electronic timer is also sometimes used. The two perform the same function with the difference that electronic timer can measure time to the second or third decimal of a second and can keep a large volume of time data in memory.

Time Study Observation Sheet. It is a printed form with spaces provided for noting down the necessary information about the operation being studied, like name of operation, drawing number, and name of the worker, name of time study person, and the date and place of study. Spaces are provided in the form for writing detailed description of the process (element-wise), recorded time or stop-watch readings for each element of the process, performance rating(s) of operator, and computation. Fig. 5.1 shows a typical time study observation sheet.

OBSERVATION SHEET

SHEET 1 OF 1 SHEETS	DATE
OPERATION	OP.NO.
PART NAME	PART NO.
MACHINE NAME	MACH.NO.
OPERATOR'S NAME & NO.	MALE ☐ FEMALE ☐
EXPERIENCE ON JOB	MATERIAL
FOREMAN	DEPT.NO.

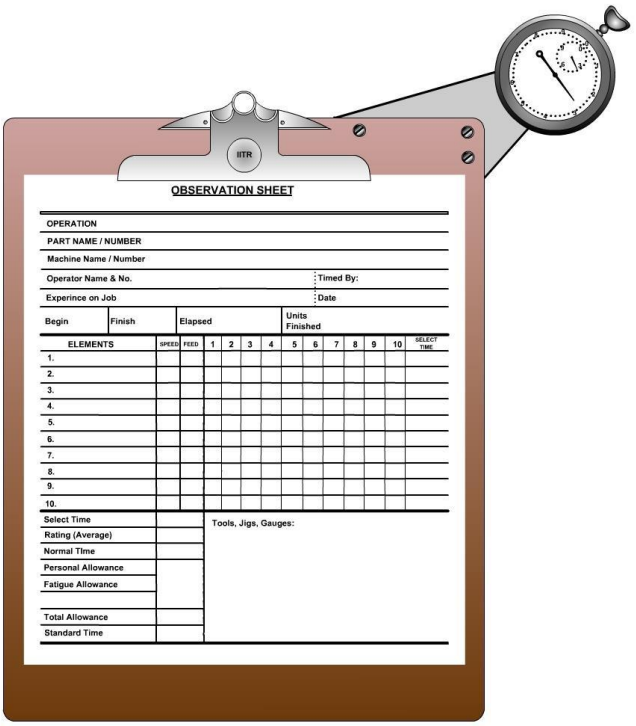
BEGIN	FINISH	ELAPSED	UNITS FINISHED	ACTUAL TIME PER 100	NO. MACHINES OPERATED

ELEMENTS	SPEED	FEED		1	2	3	4	5	6	7	8	9	10	SELECTED TIME
1.			T											
			R											
2.			T											
			R											
3.			T											
			R											
4.			T											
			R											
5.			T											
			R											
6.			T											
			R											
7.			T											
			R											
8.			T											
			R											
9.			T											
			R											
10. (1)			T											
			R											
11. (2)			T											
			R											
12. (3)			T											
			R											
13. (4)			T											
			R											
14. (5)			T											
			R											
15. (6)			T											
			R											
16. (7)			T											
			R											
17. (8)			T											
			R											
18.			T											
			R											

SELECTED TIME	RATING	NORMAL TIME	TOTAL ALLOWANCE	STANDARD TIME

SKETCH OF COMPONETS:	TOOLS.JIGS.GAUGES:
	TIMED BY:

Time Study Board. It is a light -weight board used for holding the observation sheet and stopwatch in position. It is of size slightly larger than that of observation sheet used. Generally, the watch is mounted at the center of the top edge or as shown in Figure near the upper right-hand corner of the board. The board has a clamp to hold the observation sheet. During the time study, the board is held against the body and the upper left arm by the time study person in such a way that the watch could be operated by the thumb/index finger of the left hand. Watch readings are recorded on the observation sheet by the right hand.



Other Equipment. This includes pencil, eraser, device like tachometer for checking the speed, etc.

Why Dividing Work into Short Elements is essential?

For the purpose of time study, the task is normally broken into short elements and each element is timed separately for the following reasons:

To separate unproductive part of task from the productive one.
To improve accuracy in rating. The worker may not work at the same speed throughout the cycle. He may perform some elements faster and some slower. Breaking of task into short elements permits rating of each element separately which is more realistic than just rating once for the complete cycle.
To identify elements causing high fatigue. Breaking of task into short elements permits giving appropriate rest allowances to different elements.
To have detailed job specifications. This helps in detection of any variation in the method that may occur after the time standard is established.
To prepare standard data for repeatedly occurring elements.

The following guidelines should be kept in mind while dividing a task into elements.

(1) The elements should be of as short duration as can be accurately timed.

(This in turn, depends on the skill of the time study man, method of timing and recording, and many other factors. Generally, with the stop watch, elements of duration less than 0.03 to 0.05 minute are difficult to time accurately. The elements should not normally be longer than 0.40 min.).

(2) Manually performed elements should be separated from machine paced elements.

(Time for machine paced elements can be determined by calculation). Machine elements are not rated against a normal. This rule also helps in recognition of delays.

(3)Constant elements should be separated from variable elements.

(Constant elements are those elements which are independent of the size, weight, length, or shape of the workpiece. For example, the time to pick screw driver from its place and bring it to the head of a screw is constant, whereas the time to tighten or loosen the screw is a variable, depending upon the length and size of the screw).

(4) The beginnings and endings of elements should be easily distinguishable. These should preferably be associated with some kind of sound.

(5) Irregular elements, those not repeated in every cycle, should be separated from regular elements. For example, if the jig is cleaned off after every ten parts produced, "cleaning" is an irregular element, and its time should be spread over ten cycles.

(6) Unnecessary motions and activities should be separated from those considered essential.

(7) Foreign or accidental elements should be listed separately. Such elements are generally of non-repetitive type.

Number of cycles to be timed:-

The following general principles govern the number of cycles to get the representative average cycle time.

(1) Greater the accuracy desired in the results, larger should be the number of cycles observed.

(2) The study should be continued through sufficient number of cycles so that occasional elements such as setting-up machine, cleaning of machine or sharpening of tool are observed for a good number of times.

(3) Where more than one operator is doing the same job, short study (say 10 to 15 cycles) should be conducted on each of the several operators than one long study on a single operator.

It is important that enough cycles are timed so that reliable average is obtained.

Following techniques are used to determine the number of cycles to be timed:-

(i) Use of Tables: On the consideration of the cost of obtaining the data and the desired accuracy in results, most companies have prepared their own tables for the use of time study, which indicate the number of cycles to be timed as a function of the cycle time and the frequency of occurrence of the job in the company.

(ii) Statistical methods: On the basis of the requirements of the particular situation involved, *accuracy* and *confidence level* are decided (An accuracy of a confidence level of 95% is considered reasonable in most cases). A preliminary study is conducted in which some (say *N)* cycles are timed. Standard deviation o of these *(N)* observations is calculated as

$$\sigma = \sqrt{\left[\frac{1}{N}(t-T)^2\right]} = \frac{1}{N}\sqrt{N(\Sigma t^2) - (\Sigma t^2)}$$

Where t = each watch reading

T = average of N watch reading

n = number of watch readings in the preliminary study.

Now, to find M.the number of cycles to time. the following statistical method can be used.

calculated standard error of mean ε from the equation

$$X.\varepsilon = A.T$$

Where A = accuracy desired

t = average of N watch reading

X = a factor corresponding to confidence level desired. Its values is 1 for 68%, 2 for 95%, and 3 for 99% confidence level.

Determine the required sample size M from the equation

$$\varepsilon = \frac{\sigma}{\sqrt{M}}$$

Performance Rating:-

It is a process of comparing the performance rate of a worker against standard performance. The standard performance is different for different jobs. Te rating factor is used to convert the observed time into normal time.

$$\text{Normal time} = \text{Observed time} \times \frac{\text{Performance level of worker}}{\text{Standard performance level}}$$

Allowances:-

Allowances are added to normal time in order to arrive at standard time. The various allowances are:

1. **Process allowance:** This is an allowance provided to compensate for enforced idleness during a process. This includes loss of time due to (i) no work (ii) power failure (iii) faculty material (iv) faculty tool or equipment.

2. **Personal and Rest allowance**: This is allowed to compensate for the time spent by worker in meeting the physical needs, for instance a periodic break in the production routine. The amount of personal time required by operator varies with the individual more than with the kind of work, though it is seen that workers need more personal time when the work is heavy and done under unfavorable conditions.

   The amount of this allowance can be determined by making all-day time study or work sampling. Mostly, a 5 % allowance for personal time (nearly 24 minutes in 8 hours) is considered appropriate.

   Rest allowance is a relaxation allowance to a worker to overcome fatigue incurred during working. Excessive fatigue badly affects the performance of worker. This rest/relaxation may vary from 12% to 20% of normal time from light to heavy.

3. **Special Allowances**: These allowances are given under certain special circumstances. Some of these allowances and the conditions under which they are given are:

   Policy Allowance: Some companies, as a policy, give an allowance to provide a satisfactory level of earnings for a specified level of performance under exceptional circumstance. This may be allowed to new employees, handicap employees, workers on night shift, etc. The value of the allowance is typically decided by management.

   Small Lot Allowance: This allowance is given when the actual production period is too short to allow the worker to come out of the initial learning period. When an operator completes several small-lot jobs on different setups during the day, an allowance as high as 15 percent may be given to allow the operator to make normal earnings.

   Training Allowance: This allowance is provided when work is done by trainee to allow him to make reasonable earnings. It may be a sliding allowance, which progressively decreases to zero over certain length of time. If the effect of learning on the job is known, the rate of decrease of the training allowance can be set accordingly.

   Rework Allowance: This allowance is provided on certain operation when it is known that some percent of parts made are spoiled due to factors beyond the operator's control. The time in which these spoiled parts may be reworked is converted into allowance.

4. **Policy allowance:** It depends on the policy of an organization controlled by workers union.

Problem 1: In a welding shop, a direct time study was done on a welding operation. One inexperienced industrial engineer and one experienced industrial engineer conducted the study simultaneously. They agreed precisely on cycle time but their opinion on rating the worker differed. The experienced engineer rated the worker 100% and the other engineer rated the worker 120%. They used a 10% allowance.

Cycle time (in minutes)	Number of times observed
20	2
24	1
29	1
32	1

From the above statement,

(a) Determine the standard time using the experienced industrial engineer's worker rating.
(b) Find the standard time using the worker rating of inexperienced industrial engineer.

Solution:

(a) Rating of worker at 100% by the experienced industrial engineer

Cycle time (CT) = (20×2+24×1+29×1+32×1)/5 = 25 min

Normal time (NT) = CT×PR = 25×100% = 25 min

Standard time (ST) = NT/(1-%A) = 25/(1-0.10) = 27.78 min

(b) Rating of worker at 120% by the inexperienced industrial engineer

Cycle time (CT) = (20×2+24×1+29×1+32×1)/5 = 25 min

Normal time (NT) = CT×PR = 25×120% = 30 min

Standard time (ST) = NT/(1-%A) = 30/(1-0.10) = 33.33 min

Module - II

Dt: 19th Feb 2020

Location & layout planning

Introduction :

A plant is a place where men, machinery, material, money and equipments are brought together for manufacturing produ

→ The problem of plant location arrises when starting a new plant or during the expansion of the existing plant.

→ Plant location means deciding a suitable location, area, place etc where the plant or factory will start functioning.

→ Plant location involve two major activities

(i) First to select a proper geographic region, and second, selecting a specific side with in the region.

Dt: 20th Feb 2020

Factor influencing plant location :-

(i) Nearest to raw material :- It will reduce the cost of transporting raw material from the vendors end to the plant.

(ii) Transportation facilities :- A lot of money is to spend both in transporting the raw material & 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 at according to the plant location is decided.

(iii) Nearst to markets :- It reduce the cost of transportation as well as the chances of the finished product getting damaged & spoiled in the way

(iv) Availability of labour : A stable labour force of right time, of adiquate size and at reasonable rate with it proper attitude towards work are a few factors which governed plant location to a major extend.

(v) Availability of fuel & power : Because of the wide spread huge of electric power in most cases fuel (coal, oil etc) has not remained a deciding factor for plant location.

→ Even the steel industry are location near source of fuel (coal) to cut down the fuel transportation cost.

(vi) 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 plant water should be availab in adiquate quantity & proper quality. Hence availability of water plays a vital role in plant location.

(vii) Climatic condition : with the developments in the field of heating, ventilating and air conditioning, climate of the region doesn't present

much problem. Upcoming control of climate needs money.

(viii) Financial and other ends : Certain states give aids to loans, feed money, machinary etc to attract industry.

(ix) Land : Topography, area, shape of site, cost, drainage & other facilities, probability of floods, earth quake etc influence the selection of plant location.

(x) community attitude : success of an industry depends very much on the attitude of the local people and whether they want work on not

(xi) presence of relative industries.

(xii) Existance of hospital, marketing centers, schools, Banks, post offices, club etc

(xiii) Housing facilities.

(xiv) securities

(xv) Facilities for expansion.

(xvi) ~~expect~~

Dt : 24th Feb 2020

Impact of location on cost & Revenues –

- An ideal location is one which result in lowest production cost & least distribution cost per unit.
- Revenue is the value that the producer on industry gets by selling the product.

Revenue (R) = selling price per 1 unit (P) × selling quantity (Q)

- cost are two type they are

(i) Fixed cost (ii) variable cost.

total cost = total fixed cost + total variable cost.

Q. From the following data selected the most advantage location for setting a plant for making a transistor radios.

	site X	site Y	site Z
1. total initial investment	200000	200000	200000
2. total expected sales	2,50000	300000	250000
3. Distribution expenses	40 000	40000	75000
4. Raw material "	70 000	80000	90000
5. power & water supply "	40000	30000	20000
6. wages & salaries	20000	25000	20000
7. other expenses	25000	40000	30000
8. community attitude	indifferent	poor business	indifferent
9. employing housing activity	poor	excellent	good

Soln Total expenses for site X = 40000 + 70000 + 40000 + 20000 + 25000 = 1,95,000 /-

" " " site Y = 40000 + 60000 + 30000 + 25000 + 40000 = 2,15,000 /-

" " " site Z = 75000 + 90000 + 20000 + 20000 + 30000 = 2,35000 /-

Rate of Return (ROR) % = $\frac{\text{total sale} - \text{total expenses}}{\text{total investment}}$

" " " for site (X) = $\frac{250000 - 1,95000}{200000}$ = 27.5%

" " " for site (Y) = $\frac{300000 - 215000}{200000}$ = 42.5%

" " " for site (Z) = $\frac{250000 - 235000}{200000}$ = 7.5%

Facility location procedures & models :-

(1) Qualitative models :- The steps involved in qualitative model are

(a) Develop a list of relevant factor.

(b) Assign weight to each factor (weight may total upto 1.0)

(c) Assign a score to each location in accordance to relevant factors.

(d) multiply the score with assigned weight & determine the weighted score for each location.

(e) choose the location which is having heighest weighted score.

Q

relevant factors	Assigned weight	score for location A	B	C	D
Production cost	0.35	50	40	60	30
raw material supply	0.25	70	80	80	60
labour availability	0.20	60	70	60	50
cost of living	0.05	80	70	40	80
environments	0.05	50	60	70	90
markets	0.1	70	90	80	50

Soln

Factors	weighted score for location A	B	C	D
Production cost	17.5	14	21	10.5
Raw material supply	17.5	20.0	20.0	15.0
Labour availability	12	14.0	12.0	10.0
cost of living	4	3.5	2	4
environment	2.5	3	3.5	4.5
markets	7.0	9.0	8.0	5.0

$\Sigma A = 60.5$

$\Sigma B = 63.5$

$\Sigma C = 66.5$

$\Sigma D = 49.0$

location 'r' is preferred because of highest weighted score.

(ii) Single facility location model :-

Q consider the location of new plant which will supply raw material to a set a existing plants in a group of companies suppose that there are five existing plants, which have a ~~mate~~ materials movement relationship with the new plant. Let the existing plant have location of (400, 200)[1], (800, 500)[2], (1100, 800)[3], (200, 900)[4] & (1300, 300)[5] fourthen more, suppose that the no. of tonnes of material transported per year from the new plant to various existing plants are 450[1], 1200[2], 300[3], 800[4] & 1500[5]. Determine the optimum location for the new plant such that the cost is minimized.

Dt: 25th Feb

Soln: let (x, y) are co-ordinate of new plant

The x-co-ordinate of the plant is determined as

existing plants	x-co-ordinate	weight (tonns)	cumulative weight
4	200	800	800
1	400	450	1250
2	800	1200	2450
3	1100	300	2750
5	1300	1500	4250

total weight = 4250 tons.

The median location corresponding to a cumulative weight of 4250 tons

$= \frac{4250}{2} = 2125$

From the table corresponding to x-coordinate value is 800.

similarly the y-coordinate of plant is determined -

Estimating plant	y-coordinate	weight tons	cumulative weight
1	200	450	450
5	300	1500	1950
2	500	1200	3150
3	800	300	3450
4	900	800	4250

total weight = 4250 tonns

the median location corresponding to cumulative weight to 4250 tons $= \frac{4250}{2} = 2125$

From the table the corresponding y-co-ordinate value is 500.

Hence, the coordinate of new plant $= (800, 500)$ (Ans)

Mini-Max Location model :

Let us assume there are m-existing facilities which are located at $(a_1, b_1), (a_2, b_2), (a_3, a_4) \ldots\ldots (a_i, b_i) \ldots\ldots (a_m, b_m)$ in x, y plane so (a_i, b_i) is the location of the 'i th' existing facility in the x-y plane.

→ Sets for determining the mini-max location.

Step 1. Find c_1, c_2, c_3, c_4 & c_5 by using the formula

$$c_1 = \min_{1 \le i \le m} (a_i + b_i)$$

$$c_2 = \max_{1 \le i \le m} (a_i + b_i)$$

$$c_3 = \min_{1 \le i \le m} (-a_i + b_i)$$

$$c_4 = \max_{1 \le i \le m} (-a_i + b_i)$$

$$c_5 = \max_{1 \le i \le m} (c_2 - c_1, c_4 - c_3)$$

2. Find the point P_1 & P_2 by using the formula

$$P_1 = \left[\frac{1}{2}(c_1 - c_3), \frac{1}{2}(c_1 + c_3 + c_5)\right]$$

$$P_2 = \left[\frac{1}{2}(c_2 - c_4), \frac{1}{2}(c_2 + c_4 - c_5)\right]$$

3. Any point (x^*, y^*) on the line segment joining P_1 & P_2 is a min max location.

Q In a foundary there are 7 shops whose coordinates are given below.

Sl NO	existing facilities	co-ordinates of centroid
1	sand plant	[10, 20]
2	Moulding shop	[80, 40]
3	pattern shop	[10, 120]
4	melting shop	[10, 60]
5	Felling shop	[30, 100]
6	Gassing shop	[30, 140]
7	Annalising shop	[20, 190]

The company is intrested in locating a new costly fire fighting equipment in the foundary. Determine the minmax location for the new equipments.

Sol^n The co-ordinates of the centroid of the existing shop are

$(a_1, b_1) = (10, 20)$

$(a_2, b_2) = (30, 40)$

$(a_3, b_3) = (10, 120)$

$(a_4, b_4) = (10, 60)$

$(a_5, b_5) = (30, 100)$

$(a_6, b_6) = (30, 140)$

$(a_7, b_7) = (20, 190)$

Step-1

$$C_1 = \min_{1 \le i \le m} [a_i + b_i] = \min [(10+20), (30+40), (10+120) (10+60) (30+100) + (30+140) + (20+190)]$$

$$= \min [30, 70, 130, 70, 130, 170, 210]$$

$$\Rightarrow \boxed{C_1 = 30}$$

$$C_2 = \max_{1 \le i \le m} [a_i + b_i] = \max [(10+20), (30+40), (10+120), (10+60) (30+100) (30+140), (20+190)]$$

$$= \max [30, 70, 130, 70, 130, 170, 210]$$

$$\Rightarrow \boxed{C_2 = 210}$$

$$C_3 = \min_{1 \le i \le m} [-a_i + b_i] = \min [(-10+20), (-30+40), (-10+120), (-10+60) (-30+100), (-30+140), (-20+190)]$$

$$= \min [10, 10, 110, 50, 70, 110, 170]$$

$$\boxed{C_3 = 10}$$

$$C_4 = \max_{1 \le i \le m} [-a_i + b_i] = \max [(-10+20), (-30+40), (-10+120), (-10+60), (-30+100), (-30+140), (-20+190)]$$

$$= \max [10, 10, 110, 50, 70, 110, 170]$$

$$\boxed{C_4 = 170}$$

$$C_5 = \max_{1 \le i \le m} (C_2 - C_1, C_4 - C_3)$$

$$= \max [(210-30), (170-10)]$$

$$= \max [(180)(160)] = 180$$

Step-2

$$P_1 = \left[\frac{1}{2}(c_1 - c_3),\ \frac{1}{2}(c_1 + c_3 + c_5)\right]$$

$$= \left[\frac{1}{2}(30-10),\ \frac{1}{2}(30+10+180)\right] \Rightarrow P_1[10, 110]$$

$$P_2 = \left[\frac{1}{2}(c_2 - c_1),\ \frac{1}{2}(c_2 + c_4 - c_5)\right]$$

$$= \left[\frac{1}{2}(210-170),\ \frac{1}{2}(210+170-180)\right] \Rightarrow P_2 = [20, 100]$$

Any point (x^*, y^*) on the line segment joining points $[20, 110]$ & $[20, 100]$ is a minmax location for the firefighting equipment.

Dt: 26th Feb

Forecasting

Def^n: Forecasting is a process of estimating a future event by casting forward past data. The past data are systematically combined in a predetermined way to obtained the estimate of future.

Needs for forecasting -

→ Majority of the activities of the industries depend upon the future sales.

→ forcasting is going to provide a future trend which is very much essential for product design & development.

→ To schedule the production activity to ensure optimum utilization of plant's capacity.

→ To prepair a material planning to make the material available at right time & right quantity.

Period of forecasting —

Depending upon the period for which the forecasting is made, it is classified as

(i) Long term forcasting

(ii) short term forcasting.

Short term forecasting :

Forecasting that cover the periods less than 1 yr is termed as short term forecasting.

→ Short range forecasting period may be 1 week, two week or couple of months.

→ Short term forcasting are made for the purpose of material control, scheduling & budgeting.

Long term forecasting

→ Long term forecasting period varies from 1 yr to any period.

→ In long term forecasting the normal period used is generally 5 years. In some cases it may be extended 10 to 15 years also.

→ Long term forecast are made for the purposes of capacity planning, investment planning, advertising budget, product diversification and sales.

Methods used in finding out forecasting -

1. Moving average method.
2. Double moving average method.
3. Exponential smoothing method.
4. Double exponential smoothing method.
5. Winter's method for seasonal demand.

Moving average method :-

$$\text{Simple moving avg. } (m_t) = \frac{1}{n}\left[D_{t-(n-1)} + D_{t-(n-2)} + \cdots + D_{t-2} + D_{t-1} + D_t\right]$$

Where

m_t = moving average at the end of period t
= forcast for period $t+1$

D_t = Demand in period t

n = no. of periods involved in each average.
= Moving average period.

Q A B C company have the following demand pattern in MP during 1990 to 2001. calculate the demand forcast for 2002 by using 3 yearly moving avg. method. Also determine the mean forecasting error.

Time (year) (t)	Demand for year (D_t)
1990	97
1991	102
1992	89
1993	125
1994	92
1995	98
1996	77
1997	80
1998	108
1999	106
2000	91
2001	85

Sol^n

time (year) (t)	Demand for year (D_t)	moving avg (m_t)	forecast (f_t)	error $e = D_t - f_t$
1990	97	–	–	–
1991	102	–	–	–
1992	89	96	–	–
1993	125	105.33	96	29
1994	92	102	105.33	-13.33
1995	98	105	102	-4
1996	77	89	105	-28
1997	80	85	89	-9
1998	108	88.33	85	23
1999	106	98	88.33	17.67
2000	91	101.67	98	-7
2001	85	94	101.67	-16.67

$$\text{forecast error} = \frac{29 - 13.33 - 4 - 28 - 9 + 23 + 17.67 - 7 - 16.67}{9}$$

$$= -0.925$$

Hence the forecast for the year 2002 is $f_{2002} = M_{2001} = 94$ (Ans)

Q

Period	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Demand	10	18	29	15	30	12	16	8	22	14	15	27	30	23	15	?

Estimate the forecast values, forecast error for the period given in question. by taking 3 yearly moving average.

Sol^n

Period	Demand (D_t)	moving avg	forecast (f_t)	error $e = D_t - f_t$
1	10	–	–	–
2	18	–	–	–
3	29	19	–	–
4	15	20.7	19	-4
5	30	24.7	20.7	5.3
6	12	19	24.7	-12.7
7	16	19.33	19	-3
8	8	12	19.3	-11.3
9	22	15.33	12	10
10	14	14.7	15.3	-1.3
11	15	17	14.7	0.3
12	27	18.7	17	10
13	30	24	18.7	11.3
14	23	26.7	24	-1
15	15	22.7	26.7	-11.7

Forcasting error = $\dfrac{-4+9.3-12.7-3-11.3+10-1.3+0.3+10+11.3-1-11.7}{12}$

$= -0.341$ (ans)

Dt : 28th Feb 2020

Double moving Average Method

let n = The moving avg. period.

Single moving avg. $m_1(n) = \dfrac{D_1+D_2+\cdots+D_n}{n}$

Double moving avg. $m_2(2n-1) = \dfrac{M_1(1)+M_2(2)+\cdots+M_1(2n-1)}{n}$

Forcasting for any future period Z is

* $F(t+Z) = 2M_1(t) - M_2(t) + \dfrac{2Z}{n-1}\left[M_1(t) - M_2(t)\right]$

* $F(Z) = F(t+1) = 2M_1(t) - M_2(t) + \dfrac{2}{n-1}\left[M_1(t) - M_2(t)\right]$

Q A steel plant has following sponz iron requirements between January to Nov. 2006 calculate the demand forecast for the month of december 2006 by using 3 month double moving avg. method

Sol^n

time (t) in month	Demand in item (D_t)	Single moving avg. [$M_1(t)$]	Double moving avg. $M_2(t)$	forecasting (F_t)	error
JAN	70	-			
Feb	80	-			
Mar	95	81.7			
Apr	70	81.7			
May	98	87.7	83.7		
Jun	78	82	83.8	95.7	-17.7
Jul	116	97.3	89	78.4	37.6
Aug	85	93	90.8	114	29
Sep	96	99	96.4	97.44	-1.44
Oct	134	105	99	104.11	29.89
NOV	132	120.7	108.2	117	15
Dec				145.7	

$$F_6 = F(5+1) = 2 \times M_1(5) - M_2(5) + \frac{2}{n-1}\left[M_1(5) - M_2(5)\right]$$

$$= 2 \times 87.7 - 83.7 + \frac{2}{3-1}\left[87.7 - 83.7\right]$$

$$= 95.7$$

$$F_7 = F(6+1) = 2 \times M_1(6) - M_2(6) + \frac{2}{n-1}\left[M_1(6) - M_2(6)\right]$$

$$= 2 \times 82 - 83.8 + \frac{2}{3-1}\left[82 - 83.8\right]$$

$$= 78.4$$

Similarly

$$F_{12} = F(11+1) = 2 \times M_1(11) - M_2(11) + \frac{2}{n-1}\left[M_1(11) - M_2(11)\right]$$

$$= 2 \times 120.7 - 108.2 + \frac{2}{3-1}\left[120.7 - 108.2\right]$$

$$= 145.7$$

$$\text{Forecasting error} = \frac{-17.7 + 37.6 + 29 - 1.44 + 29.89 + 15}{6}$$

$$= 15.39$$

Weighted Moving Average

While the moving average formula implies an equal weight being placed on each value that is being averaged, the weighted moving average permits an unequal weighting on prior time periods

$$WMA_t = \sum_{i=1}^{n} W_i D_i \qquad \sum_{i=1}^{n} w_i = 1$$

w_t = weight given to time period "t" occurrence (weights must add to one)

Question: Given the weekly demand and weights, what is the forecast for the 4th period or Week 4?

Week	Demand
1	650
2	678
3	720
4	

Weights:
t-1
t-2
t-3

Note that the weights place more emphasis on the most recent data, that is time period "t-1"

Week	Demand	Forecast
1	650	
2	678	
3	720	
4		693.4

INPUT
- Material
- Machines
- Labor management

Exponential Smoothing

$$F_{t+1} = \alpha D_t + (1 - \alpha) F_t$$

where:

F_{t+1} =forecast for next period

D_t =actual demand for present period

F_t = previously determined forecast for present period

α =weighting factor, smoothing constant

Effect of Smoothing Constant

0.0 a 1.0

If a = 0.20, then $F_{t+1} = 0.20\ D_t + 0.80\ F_t$

If a = 0, then $F_{t+1} = 0\ D_t + 1\ F_t = F_t$

Forecast does not reflect recent data

If a = 1, then $F_{t+1} = 1\ D_t + 0\ F_t = D_t$

Forecast based only on most recent data

Question: Given the weekly demand data, what are the exponential smoothing forecasts for periods 10th using a=0.10 and a=0.60?

Assume $F_1 = D_1$

Week	Demand
1	820
2	775
3	680
4	655
5	750
6	802
7	798
8	689
9	775
10	

Solution: The respective alphas columns denote the forecast values. Note that you can only forecast one time period into the future.

Week	Demand	*0.1*	*0.6*
1	820	820.00	820.00
2	775	820.00	820.00
3	680	815.50	793.00
4	655	801.95	725.20
5	750	787.26	683.08
6	802	783.53	723.23
7	798	785.38	770.49
8	689	786.64	787.00
9	775	776.88	728.20
10		776.69	756.28

Note how that the smaller alpha results in a smoother line in this example

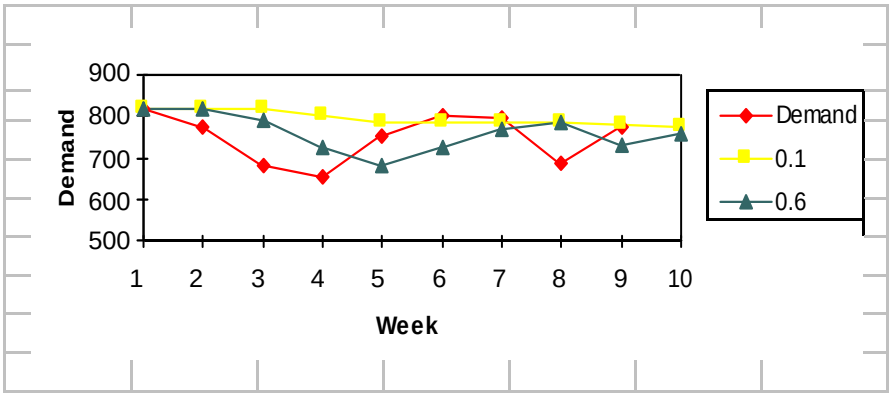


Fig. Effect of Smoothing Constant

Adjusted Exponential Smoothing

$$AF_{t+1} = F_{t+1} + T_{t+1}$$

where

T = an exponentially smoothed trend factor

$$T_{t+1} = \beta(F_{t+1} - F_t) + (1 - \beta)\, T_t$$

where

T_t = the last period trend factor

β = a smoothing constant for trend

$0 \le \beta \le 1$

$F_{t+1} = A_t + T_t$

Where,

$At = \alpha Dt + (1 - \alpha)(A_{t-1} + T_{t-1})$ and

T = an exponentially smoothed trend factor

$T_t = \beta(A_t - A_{t-1}) + (1 - \beta)T_{t-1}$

T = an exponentially smoothed trend factor

T_{t-1} = the last period trend factor

β = a smoothing constant for trend

$0 \le \beta \le 1$

Question

PM Computer Services assembles customized personal computers from generic parts. they need a good forecast of demand for their computers so that they will know how many parts to purchase and stock. They have compiled demand data for the last 12months. There is an upward trend in the demand. Use trend-adjusted exponential smoothing with smoothing parameter $\alpha = 0.5$ and trend parameter $\beta = 0.3$ to compute the demand forecast for January (Period 13).

Period	Month	Demand	Period	Month	Demand
1	January	37	7	July	43
2	February	40	8	August	47
3	March	41	9	September	56
4	April	37	10	October	52
5	May	45	11	November	55
6	June	50	12	December	54

Solution:

For Period 2,

we have F2 = A1 + T1, so to get the process started, let A0 = 37 and T0 = 0.

$A1 = \alpha D1 + (1 - \alpha)(A0 + T0) = 0.5(37) + (1 - 0.5)(37 + 0) = 37,$

and $T1 = \beta(A1 - A0) + (1 - \beta)T0 = 0.3(37 - 37) + (1 - 0.3)(0) = 0$

$F_2 = A_1 + T_1 = 37 + 0 = 37$

For Period 3,

$A2 = \alpha D2 + (1-\alpha)(A1+T1) = 0.5(40)+(1-0.5)(37+0) = 38.5$, and

$T2 = \beta(A2 - A1)+(1-\beta)T1 = 0.3(38.5 - 37) + (1 - 0.3)(0) = 0.45$.

$F3 = A2 + T2 = 38.5 + 0.45 = 38.95$.

			Expon.	Trend-Adjusted Expon.		
			Smooth..	Smooth. (α= 0.5, β = 0.3)		
Period	Month	Demand	α = 0.5	At	Tt	Ft
1	Jan	37	37.00	37.00	0.00	37.00
2	Feb	40	37.00	38.50	0.45	37.00
3	Mar	41	38.50	39.98	0.76	38.95
4	Apr.	37	39.75	38.87	0.20	40.73
5	May	45	38.38	42.03	1.09	39.06
6	Jun.	50	41.69	46.56	2.12	43.12
7	Jul.	43	45.84	45.84	1.27	48.68
8	Aug.	47	44.42	47.05	1.25	47.11
9	Sep.	56	45.71	52.15	2.41	48.31
10	Oct.	52	50.86	53.28	2.02	54.56
11	Nov.	55	51.43	55.15	1.98	55.30
12	Dec.	54	53.21	55.56	1.51	57.13
13	Jan	?	53.61			57.07

Layout planning

Plant layout means the disposition of the various facilities (equipment, material, manpower etc.) and services of the plant within the area of site located.

Objectives

Material handling and transportation is minimized and effectively controlled.
Bottlenecks and points of congestions are eliminated (by line balancing) so that the raw-material and semi-finished goods move fast from one workstation to other.
Workstations are designed suitable and properly.
Suitable spaces are allocated to production centers and service centers.
The movements made by the workers minimized.

Layout can be classified into the following four categories:

a. process layout
b. product layout
c. Group layout(combination layout)
d. Fixed position layout

a. process layout:

- It is also known as functional layout.
- Here similar machines and services located together Ex. All the lathe machines will be at one place and all milling machines at another place and so on.
- This type of layout generally employed for industries engaged in job-shop production and non-repetitive kind of production.
- When there variety of products manufactured at low volume we prefer this type of layout.
- Ex. furniture manufacturer company, restaurant etc.

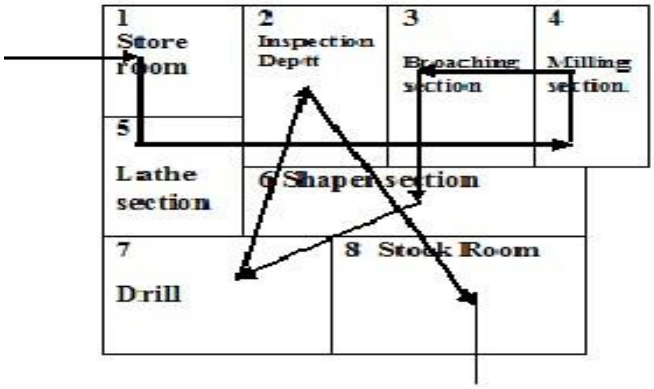


Fig. 1 process layout

b. Product layout

- It is also known as line (type) layout.
- The flow of product will smooth and logical.
- When the machines and auxiliary services are located according to the processing sequence we prefer this layout.
- It implies that various operations raw material are performed in a sequence and the machines are placed along the product flow line.
- The product layout is selected when the volume of production of a product is high such that separate production line to manufacture it can be justified.
- Assembly line production or mass production prefer this type layout. Ex. Assembly of television sets assembly of computer key-board etc.

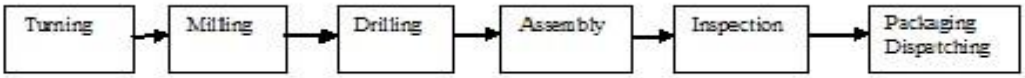


Fig. 2 product layout

c. Group layout:

- It is the combination of both process and product layout.
- In this type of layout a set of machinery or equipment is grouped together in a section so that each group of machines or equipment is used to perform similar operations to produce a family of components. These machines grouped in to cells.
- It minimizes the sum of cost of transport and the cost of equipment.

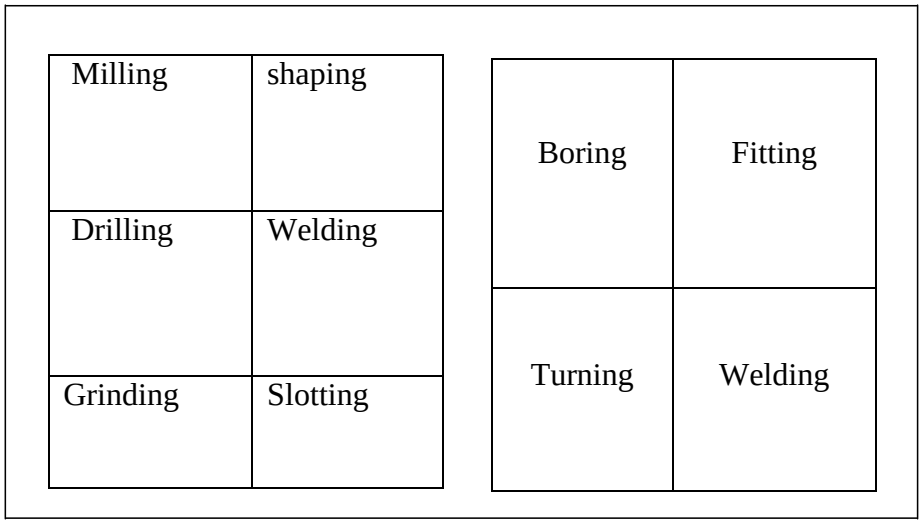


Fig 3 Group layout

d. Fixed position layout

It is also called static product layoutin which the physical characterstics of the product dictate as to which type of machine and men are brought to the product.

This type layout is inherent in ship building,aircraft manufacture and big pressure vessels fabrication.

In other type layout the product moves past stationary production equipment where as in this case men and equipment are moved to the material at one place and the product is completed at the place where the material lies.

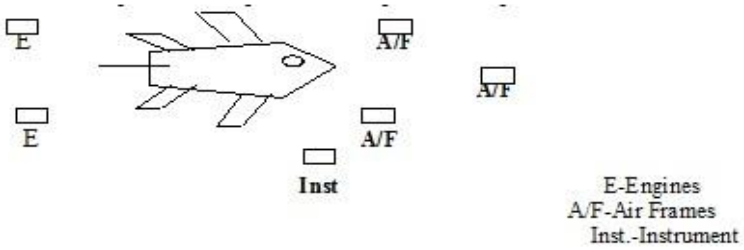


Fig. 4 Fixed position layout

MANUFACTURING PLANNING AND CONTROL

INTRODUCTION AND MEANING

Production planning and control is a tool available to the management to achieve the stated objectives. Thus, a production system is encompassed by the four factors. *i.e*., quantity, quality, cost and time. Production planning starts with the analysis of the given data, *i.e*., demand for products, delivery schedule etc., and on the basis of the information available, a scheme of utilisation of firms resources like machines, materials and men are worked out to obtain the target in the most economical way.

Once the plan is prepared, then execution of plan is performed in line with the details given in the plan. Production control comes into action if there is any deviation between the actual and planned. The corrective action is taken so as to achieve the targets set as per plan by using control techniques.

Thus production planning and control can be defined as the "*direction and coordination of firms' resources towards attaining the prefixed goals*." Production planning and control helps to achieve uninterrupted flow of materials through production line by making available the materials at right time and required quantity.

NEED FOR PRODUCTION PLANNING AND CONTROL

The present techno-economic scenario of India emphasize on competitiveness in manufacturing. Indian industries have to streamline the production activities and attain the maximum utilisation of firms' resources to enhance the productivity. Production planning and control serves as a useful tool to coordinate the activities of the production system by proper planning and control system. Production system can be compared to the nervous system with PPC as a brain. Production planning and control is needed to achieve:

1. Effective utilisation of firms' resources.
2. To achieve the production objectives with respect to quality, quantity, cost and timeliness of delivery.
3. To obtain the uninterrupted production flow in order to meet customers varied demand with respect to quality and committed delivery schedule.
4. To help the company to supply good quality products to the customer on the continuous basis at competitive rates.

Production planning is a pre-production activity. It is the pre-determination of manufacturing requirements such as manpower, materials, machines and manufacturing process.

Ray wild defines "*Production planning is the determination, acquisition and arrangement of all facilities necessary for future production of products."* It represents the design of production system. Apart from planning the resources, it is going to organize the production.

Based on the estimated demand for company's products, it is going to establish the production programme to meet the targets set using the various resources.

Production Control

Inspite of planning to the minute details, most of the time it is not possible to achieve production 100 per cent as per the plan. There may be innumerable factors which affect the production system and because of which there is a deviation from the actual plan. Some of the factors that affect are:

1. Non-availability of materials (due to shortage, etc.);
2. Plant, equipment and machine breakdown;
3. Changes in demand and rush orders;
4. Absenteeism of workers; and
5. Lack of coordination and communication between various functional areas of business.

Thus, if there is a deviation between actual production and planned production, the control

function comes into action. Production control through control mechanism tries to take corrective action to match the planned and actual production. Thus, production control reviews the progress of the work, and takes corrective steps in order to ensure that programmed production takes place. The essential steps in control activity are:

1. Initiating the production,
2. Progressing, and
3. Corrective action based upon the feedback and reporting back to the production planning.

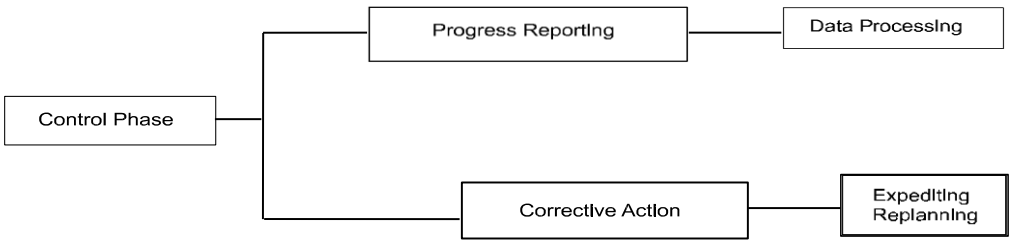
OBJECTIVES OF PRODUCTION PLANNING AND CONTROL

Following are the objectives of production planning and control:

1. Systematic planning of production activities to achieve the highest efficiency in production of goods/services.
2. To organize the production facilities like machines, men, etc., to achieve stated production objectives with respect to quantity and quality time and cost.
3. Optimum scheduling of resources.
4. Coordinate with other departments relating to production to achieve regular balanced and uninterrupted production flow.
5. To conform to delivery commitments.
6. Materials planning and control.
7. To be able to make adjustments due to changes in demand and rush orders.

PHASES OF PRODUCTION PLANNING AND CONTROL

Production planning and control has three phases
namely: A. Planning Phase
B. Action Phase
C.Control Phase



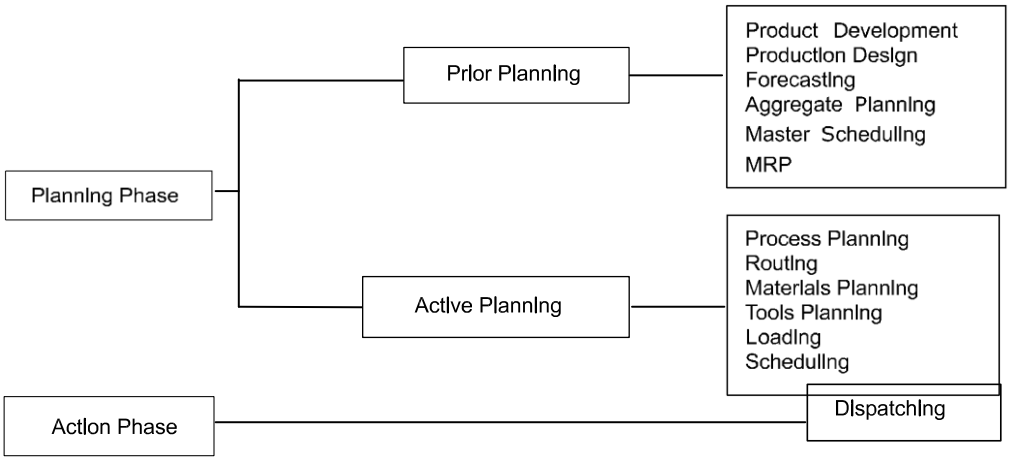


Fig. *Phases of production planning and control*

Planning Phase

Planning is an exercise of intelligent anticipation in order to establish how an objective can be achieved or a need fulfilled in circumstances, which are invariably restrictive. Production planning determines the optimal schedule and sequence of operations economic batch quantity, machine assignment and dispatching priorities for sequencing.

It has two categories of planning namely

1. Prior planning
2. Active planning.

PRIOR PLANNING

Prior planning means pre-production planning. This includes all the planning efforts, which are taking place prior to the active planning.

Modules of pre-planning

The modules of prior planning are as follows:

1. **Product development and design** is the process of developing a new product with all the features, which are essential for effective use in the field, and designing it accordingly. At the design stage, one has to take several aspects of design like, design for selling, design for manufacturing and design for usage.
2. **Forecasting** is an estimate of demand, which will happen in future. Since, it is only an estimate based on the past demand, proper care must be taken while estimating it. Given the sales forecast, the factory capacity, the aggregate inventory levels and size of the work force, the manager must decide at what rate of production to operate the plant over an intermediate planning horizon.
3. **Aggregate planning** aims to find out a product wise planning over the intermediate planning horizon.
4. **Material requirement planning** is a technique for determining the quantity and timing for the acquisition of dependent items needed to satisfy the master production schedule.

ACTIVE PLANNING

The modules of active planning are: Process planning and routing, Materials planning. Tools planning, Loading, Scheduling etc.

1. **Process planning and routing** is a complete determination of the specific technological process steps and their sequence to produce products at the desired quality, quantity and cost. It determines the method of manufacturing a product selects the tools and equipments, analyses how the manufacturing of the product will fit into the facilities. Routing in particular prescribes the flow of work in the plant and it is related to the considerations of layout, temporary locations for raw materials and components and materials handling systems.
2. A **material planning** is a process which determines the requirements of various raw materials/subassemblies by considering the trade-off between various cost components like, carrying cost, ordering cost, shortage cost, and so forth.

3. **Tools' planning** determines the requirements of various tools by taking process specification (surface finish, length of the job, overall depth of cut etc.), material specifications (type of material used, hardness of the material, shape and size of the material etc.) and equipment specifications (speed range, feed range, depth of cut range etc.).
4. **Loading** is the process of assigning jobs to several machines such that there is a load balance among the machines. This is relatively a complex task, which can be managed with the help of efficient heuristic procedures.
5. **Scheduling** is the time phase of loading and determines when and in what sequence the work will be carried out. This fixes the starting as well as the finishing time for each job.

Action Phase

Action phase has the major step of **dispatching.** Dispatching is the transition from planning phase to action phase. In this phase, the worker is ordered to start manufacturing the product. The tasks which are included in dispatching are job order, store issue order, tool order, time ticket, inspection order, move order etc.

The **job order** number is the key item which is to be mentioned in all other reports/orders. **Stores issue order** gives instruction to stores to issue materials for manufacturing the product as per product specifications. As per tooling requirements for manufacturing the product, the **tool order** instruct the tool room to issue necessary tools. **Time ticket** is nothing but a card which is designed to note down the actual time taken at various processes. This information is used for deciding the costs for future jobs of similar nature and also for performing variance analysis, which helps to exercise control.

Job order is the official authorization to the shop floor to start manufacturing the product. Generally, the process sequence will contain some testing and inspection. So, these are to be instructed to inspection wing in the form of inspection order for timely testing and inspection so that the amount of rework is minimized. The manufacture of product involves moving raw materials/subassemblies to the main line. This is done by a well-designed materials handling system. So, proper instruction is given to the materials handling facilities for major movements of materials/subassemblies in the form of a move order. Movements which involve less distance and fewer loads are managed at the shop floor level based on requests from operators.

Control Phase

The control phase has the following two major modules:

1. Progress reporting, and
2. Corrective action.

1. Progress Reporting

In progress reporting, the data regarding what is happening with the job is collected. Also, it helps to make comparison with the present level of performance. The various data pertaining to materials rejection, process variations, equipment failures, operator efficiency, operator absenteeism, tool life, etc., are collected and analyzed for the purpose of progress reporting. These data are

used for performing variance analysis, which would help us to identify critical areas that deserve immediate attention for corrective actions.

2. CORRECTIVE ACTION

The tasks under corrective action primarily make provisions for an unexpected event. Some examples of corrective actions are creating schedule flexibility, schedule modifications, capacity modifications, make or buy decisions, expediting the work, pre-planning, and so on. Due to unforeseen reasons such as, machine breakdown, labour absenteeism, too much rejection due to poor material quality etc., it may not be possible to realize the schedule as per the plan. Under such condition, it is better to reschedule the whole product mix so that we get a clear picture of the situation to progress further. Under such situation, it is to be re-examined for selecting appropriate course of action. Expediting means taking action if the progress reporting indicates deviations from the originally set targets. Pre-planning of the whole affair becomes essential in case the expediting fails to bring the deviated plan to its right path.

FUNCTIONS OF PRODUCTION PLANNING AND CONTROL

Functions of production planning and controlling is classified into:

1. Pre-planning fuction
2. Planning function
3. Control function

The functions of production planning and controlling are depicted in the Figure.

1. PRE-PLANNING FUNCTION

Pre-planning is a macro level planning and deals with analysis of data and is an outline of the planning policy based upon the forecasted demand, market analysis and product design and

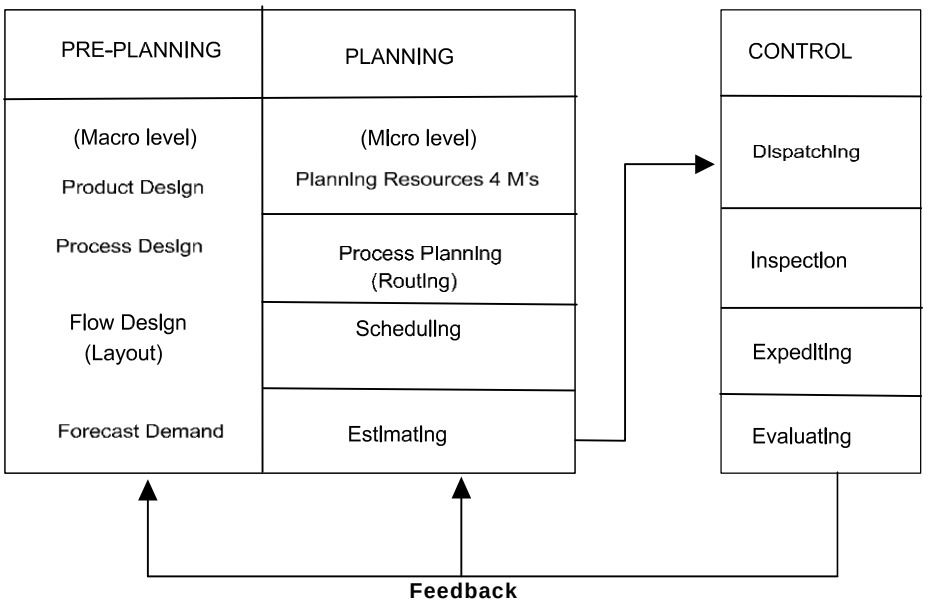


Fig. *Functions of production planning and control*

development. This stage is concerned with process design (new processes and developments, equipment policy and replacement and work flow (Plant layout). The pre-planning function of PPC is concerned with decision-making with respect to methods, machines and work flow with respect to availability, scope and capacity.

2.Planning Function

The planning function starts once the task to be accomplished is specified, with the analysis of **four M's**, *i.e.*, Machines, Methods, Materials and Manpower. This is followed by process planning (routing). Both short-term (near future) and long-term planning are considered. Standardisation, simplification of products and processes are given due consideration.

3.Control Function

Control phase is effected by dispatching, inspection and expediting materials control, analysis of work-in-process. Finally, evaluation makes the PPC cycle complete and corrective actions are taken through a feedback from analysis. A good communication, and feedback system is essential to enhance and ensure effectiveness of PPC.

Parameters for PPC

The functions of PPC can be explained with the following parameters:

1. **Materials:** Raw materials, finished parts and bought out components should be made available in required quantities and at required time to ensure the correct start and end for each operation resulting in uninterrupted production. The function includes the specification of materials (quality and quantity) delivery dates, variety reduction (standardisation) procurement and make or buy decisions.

2. **Machines and equipment:** This function is related with the detailed analysis of available production facilities, equipment down time, maintenance policy procedure and schedules. Concerned with economy of jigs and fixtures, equipment availability. Thus, the duties include the analysis of facilities and making their availability with minimum down time because of breakdowns.

3. **Methods:** This function is concerned with the analysis of alternatives and selection of the best method with due consideration to constraints imposed. Developing specifications for processes is an important aspect of PPC and determination of sequence of operations.

4. **Process planning (Routing):** It is concerned with selection of path or route which the raw material should follow to get transformed into finished product. The duties include:

(*a*) Fixation of path of travel giving due consideration to layout.

(*b*) Breaking down of operations to define each operation in detail.

(*c*) Deciding the set up time and process time for each operation.

5. **Estimating:** Once the overall method and sequence of operations is fixed and process sheet for each operation is available, then the operations times are estimated. This function is carried out using extensive analysis of operations along with methods and routing and a standard time for operation are established using work measurement techniques.

6. **Loading and scheduling:** Scheduling is concerned with preparation of machine loads and fixation of starting and completion dates for each of the operations. Machines have to be

loaded according to their capability of performing the given task and according to their capacity. Thus the duties include:

(*a*) Loading, the machines as per their capability and capacity.

(*b*) Determining the start and completion times for each operation.

(*c*) To coordinate with sales department regarding delivery schedules.

7. **Dispatching:** This is the execution phase of planning. It is the process of setting production activities in motion through release of orders and instructions. It authorises the start of production activities by releasing materials, components, tools, fixtures and instruction sheets to the operator. The activities involved are:

(*a*) To assign definite work to definite machines, work centres and men.

(*b*) To issue required materials from stores.

(*c*) To issue jigs, fixtures and make them available at correct point of use.

(*d*) Release necessary work orders, time tickets, etc., to authorise timely start of operations.

(*e*) To record start and finish time of each job on each machine or by each man.

8. **Expediting**: This is the control tool that keeps a close observation on the progress of the work. It is logical step after dispatching which is called 'follow-up'. It coordinates extensively to execute the production plan. Progressing function can be divided into three parts, *i.e*., follow up of materials, follow up of work-in-process and follow up of assembly. The duties include:

(*a*) Identification of bottlenecks and delays and interruptions because of which the production schedule may be disrupted.

(*b*) To devise action plans (remedies) for correcting the errors.

(*c*) To see that production rate is in line with schedule.

9. **Inspection:** It is a major control tool. Though the aspects of quality control are the separate function, this is of very much important to PPC both for the execution of the current plans and its scope for future planning. This forms the basis for knowing the limitations with respects to methods, processes, etc., which is very much useful for evaluation phase.

10. **Evaluation:** This stage though neglected is a crucial to the improvement of productive efficiency. A thorough analysis of all the factors influencing the production planning and control helps to identify the weak spots and the corrective action with respect to pre-planning and planning will be effected by a feedback. The success of this step depends on the communication, data and information gathering and analysis.

OPERATIONS PLANNING AND SCHEDULING SYSTEMS

Operations planning and scheduling systems concern with the volume and timing of outputs, the utilisation of operations capacity at desired levels for competitive effectiveness. These systems must fit together activities at various levels, form top to bottom, in support of one another, as shown in Fig. 5.3. Note that the time orientation ranges from long to short as we progress from top to bottom in the hierarchy. Also, the level of detail in the planning process ranges from broad at the top to detail at the bottom

Components of Operations Planning and Scheduling System

1. THE BUSINESSPLAN

The business plan is a statement of the organization's overall level of business activity for the coming six to eighteen months, usually expressed in terms of outputs (in volume of sales) for its various product groups, a set of individual products that share or consume common blocks of capacity in the manufacturing process. It also specifies the overall inventory and backlog levels that will be maintained during the planning period. The business plan is an agreement between all functional areas—finance, production, marketing, engineering, R & D—about the level of activity and the products they are committed to support. The business plan is not concerned with all the details and specific timing of the actions for executing the plan. Instead, it determines a feasible general posture for competing to achieve its major goals. The resulting plan guides the lower-level, more details decisions.

2. AGGREGATE PRODUCTION (OUTPUT) PLANNING

The process of determining output levels of product groups over the coming six to eighteen months on a weekly or monthly basis. It identifies the overall level of outputs in support of the business plan. The plan recognizes the division's existing fixed capacity and the company's overall policies for maintaining inventories and backlogs, employment stability and subcontracting.

3. AGGREGATE CAPACITY PLANNING

It is the process of testing the feasibility of aggregate output plans and evaluating overall capacity utilisation. A statement of desired output is useful only if it is feasible. Thus, it addresses the supply side of the firm's ability to meet the demand. As for aggregate output plans, each plant, facility, or division requires its own aggregate capacity plan. Capacity and output must be in balance, as indicated by the arrow between them in Fig. A capacity plan translates an output plan into input terms, approximating how

4. MASTER PRODUCTION SCHEDULING (MPS)

MPS is a schedule showing week by week how many of each product must be produced according much of the division's capacity will be consumed. Although these basic capacities are fixed, management can manipulate the short-term capacities by the ways they deploy their work force, by subcontracting, or by using multiple work shifts to adjust the timing of overall outputs. As a result, the aggregate planning process balances output levels, capacity constraints, and temporary capacity adjustments to meet demand and utilise capacity at desired levels during the coming months. The resulting plan sets limits on the master production schedule.to customer orders and demand forecasts. Its purpose is to meet the demand for individual products in the product group. This more detailed level of planning disaggregates the product groups into individual products and indicates when they will be produced. The MPS is an important link between marketing and production. It shows when incoming sales orders can be scheduled into production, and when each shipment can be scheduled for delivery. It also takes into account current backlogs so that production and delivery schedules are realistic

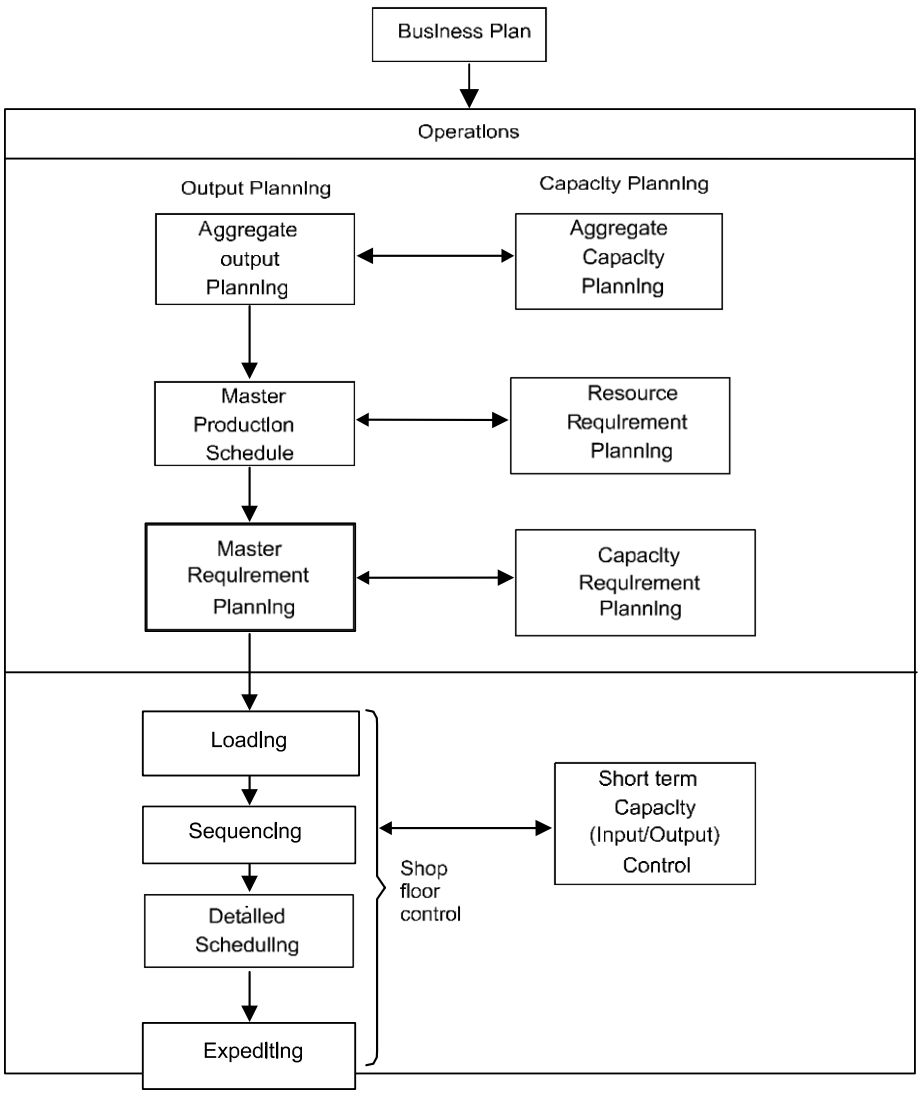


Fig. *Operations planning and scheduling system*

5. Resource Requirement Planning

Resource requirement planning (rough-cut capacity planning) is the process of testing the feasibility of master production schedule in terms of capacity. This step ensures that a proposed MPS does not inadvertently overload any key department, work centre, or machine, making the MPS unworkable.

6. Material Requirement Planning

Material requirement planning (MRP) is a system of planning and scheduling the time phased material requirements for releasing materials and receiving materials that enable the master production schedule to be implemented. Thus, the master production schedule is the driving force

for material requirements planning. MRP provides information such as due dates for components that are subsequently used for shop floor control. Once this information is available, it enables managers to estimate the detailed requirements for each work centres.

7. Capacity Requirement Planning

Capacity requirement planning (CRP) is an iterative process of modifying the MPS or planned resources to make capacity consistent with the production schedule. CRP is a companion process used with MRP to identify in detail the capacity required to execute the material requirement planning. At this level, more accurate comparisons of available and needed capacity for scheduled workloads are possible.

8. Shop Floor Control

Shop floor control involves the activities that execute and control shop operations namely loading, sequencing, detailed scheduling and expediting jobs in production. It coordinates the weekly and daily activities that get jobs done. Individual jobs are assigned to machines and work centres (loading), the sequence of processing the jobs for priority control is determined, start times and job assignments for each stage of processing are decided (detailed scheduling) and materials and work flows from station to station are monitored and adjusted (expediting).

9.Loading

Each job (customer order) may have its unique product specification and, hence, it is unique through various work centres in the facility. As new job orders are released, they are assigned or allocated among the work centres, thus establishing how much of a load each work centre must carry during the coming planning period. This assignment is known as loading (sometimes called shop loading as machine loading).

10.Sequencing

This stage establishes the priorities for jobs in the queues (waiting lines) at the work centres. Priority sequencing specifies the order in which the waiting jobs are processed; it requires the adoption of a priority sequencing rule.

11. Detailed Scheduling

Detailed scheduling determines start times, finish times and work assignments for all jobs at each work centre. Calendar times are specified when job orders, employees, and materials (inputs), as well as job completion (outputs), should occur at each work centre. By estimating how long each job will take to complete and when it is due, schedulers can establish start and finish dates and develop the detailed schedule.

12. Expediting

Expediting is a process of tracking a job’s progress and taking special actions to move it through the facility. In tracking a job’s progress, special action may be needed to keep the job moving through the facility on time. Manufacturing or service operations disruptions-equipments breakdowns, unavailable materials, last-minute priority changes, require managers to deviate from plans and schedules and expedite an important job on a special handling basis.

13. Input/Output Control

Input/output control related to the activities to monitor actual versus planned utilisation of a work centre's capacity. Output plans and schedules call for certain levels of capacity at a work centre, but actual utilisation may differ from what was planned. Actual versus planned utilisation of the work centre's capacity can be monitored by using input-output reports and, when discrepancies exist, adjustments can be made. The important components of operations planning and scheduling system has been explained in detail in the following paragraphs.

AGGREGATE PLANNING

Aggregate planning is an intermediate term planning decision. It is the process of planning the quantity and timing of output over the intermediate time horizon (3 months to one year). Within this range, the physical facilities are assumed to –10 be fixed for the planning period. Therefore, fluctuations in demand must be met by varying labour and inventory schedule. Aggregate planning seeks the best combination to minimise costs.

Aggregate Planning Strategies

The variables of the production system are labour, materials and capital. More labour effort is required to generate higher volume of output. Hence, the employment and use of overtime (OT) are the two relevant variables. Materials help to regulate output. The alternatives available to the company are inventories, back ordering or subcontracting of items.

These controllable variables constitute pure strategies by which fluctuations in demand and uncertainties in production activities can be accommodated by using the following steps:

1. *Vary the size or the workforce*: Output is controlled by hiring or laying off workers in proportion to changes in demand.
2. *Vary the hours worked*: Maintain the stable workforce, but permit idle time when there is a slack and permit overtime (OT) when demand is peak.
3. *Vary inventory levels*: Demand fluctuations can be met by large amount of inventory.
4. *Subcontract*: Upward shift in demand from low level. Constant production rates can be met by using subcontractors to provide extra capacity.

Aggregate Planning Guidelines

The following are the guidelines for aggregate planning:

1. Determine corporate policy regarding controllable variables.
2. Use a good forecast as a basis for planning.
3. Plan in proper units of capacity.
4. Maintain the stable workforce.
5. Maintain needed control over inventories.
6. Maintain flexibility to change.
7. Respond to demand in a controlled manner.
8. Evaluate planning on a regular base.

MASTER PRODUCTION SCHEDULE (MPS)

Master scheduling follows aggregate planning. It expresses the overall plans in terms of specific end items or models that can be assigned priorities. It is useful to plan for the material and capacity requirements.

Flowchart of aggregate plan and master production schedule is shown in Figure.

Time interval used in master scheduling depends upon the type, volume, and component lead times of the products being produced. Normally weekly time intervals are used. The time horizon covered by the master schedule also depends upon product characteristics and lead times. Some master schedules cover a period as short as few weeks and for some products it is more than a year.

Functions of MPS

Master Production Schedule (MPS) gives a formal details of the production plan and converts this plan into specific material and capacity requirements. The requirements with respect to labour, material and equipment is then assessed.

The main functions of MPS are:

1. *To translate aggregate plans into specific end items*: Aggregate plan determines level of operations that tentatively balances the market demands with the material, labour and equipment capabilities of the company. A master schedule translates this plan into specific number of end items to be produced in specific time period.

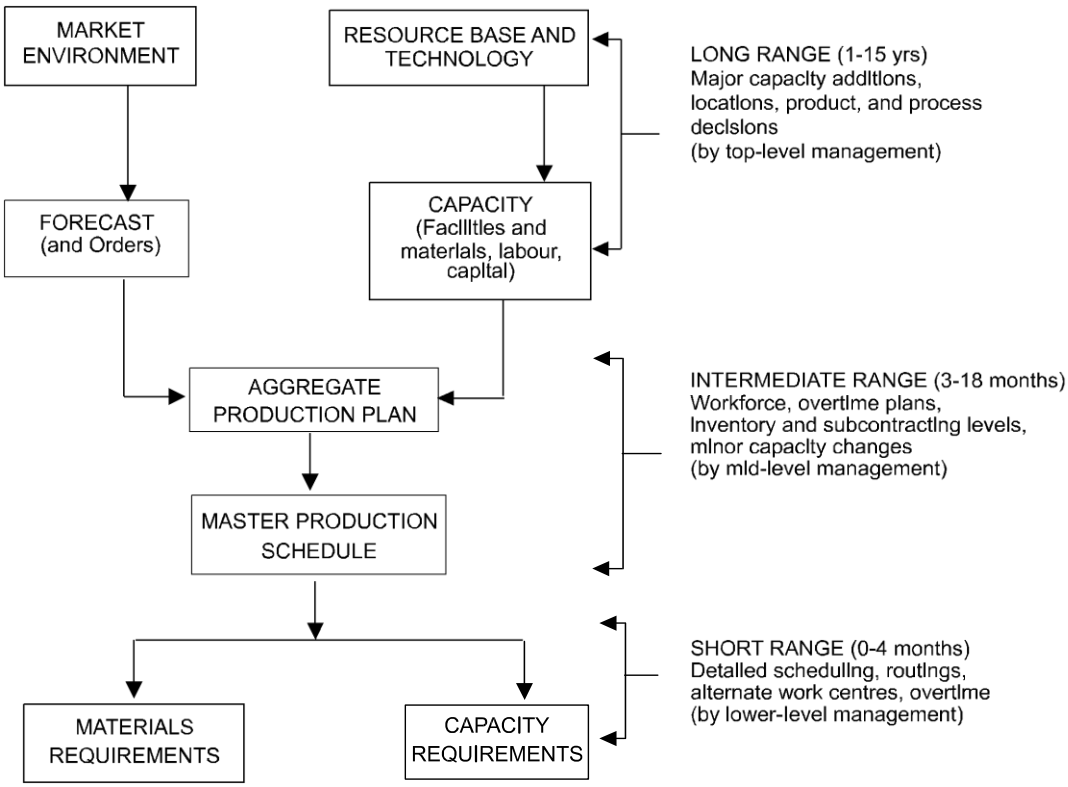


Fig. *Flowchart of aggregate plan and master schedule*

2. *Evaluate alternative schedules*: Master schedule is prepared by trial and error. Many computer simulation models are available to evaluate the alternate schedules.
3. *Generate material requirement*: It forms the basic input for material requirement planning (MRP).
4. *Generate capacity requirements*: Capacity requirements are directly derived from MPS. Master scheduling is thus a prerequisite for capacity planning.
5. *Facilitate information processing*: By controlling the load on the plant. Master schedule determines when the delivery should be made. It coordinates with other management information systems such as, marketing, finance and personnel.
6. *Effective utilization of capacity*: By specifying end item requirements schedule establishes the load and utilization requirements for machines and equipment.

MATERIAL 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 centres 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.

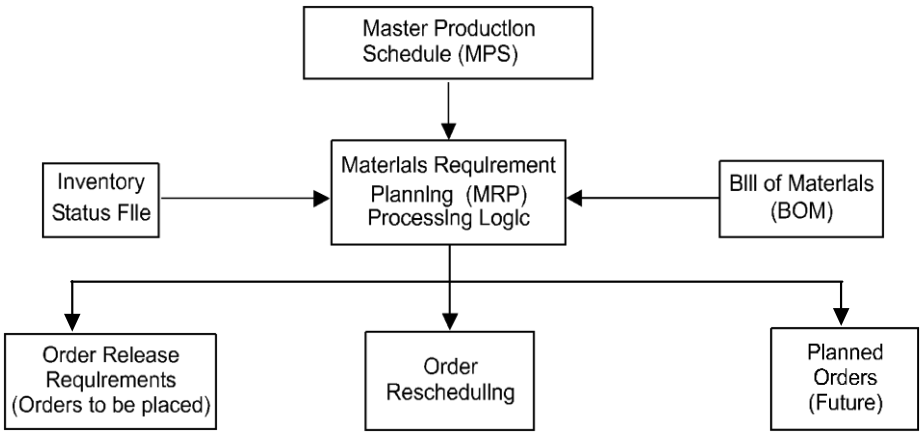


Fig. *MRP system*

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 centres performing the build up sequence. This information is obtained from product design documents, workflow analysis and other standard manufacturing information.

CAPACITY PLANNING

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.
- 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 is shown in Fig.

1. **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.

2. **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, unauthorised absenteeism.

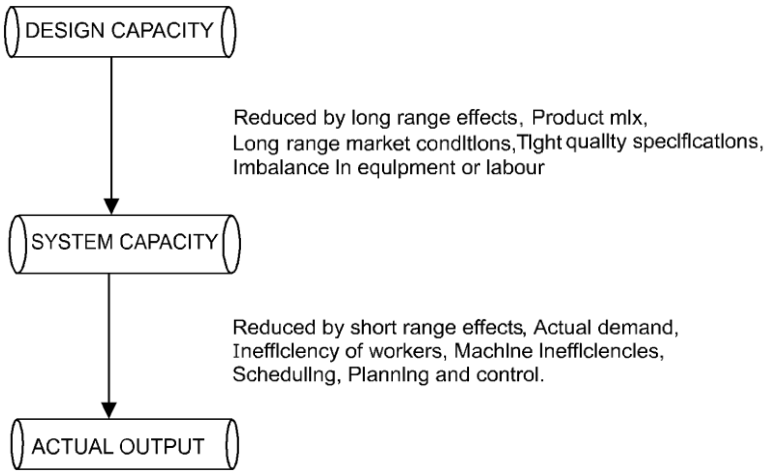


Fig. *Capacity and output relationship*

The system capacity is less than design capacity because of long range uncontrollable factors. The actual output is still reduced because of short-term effects such as, breakdown of equipment, inefficiency of labour. The system efficiency is expressed as ratio of actual measured output to the system capacity.

$$\text{System Efficiency (SE)} = \frac{\text{Actual output}}{\text{System capacity}}$$

3. **Licensed capacity:** Capacity licensed by the various regulatory agencies or government authorities. This is the limitation on the output exercised by the government.

4. **Installed capacity:** The capacity provided at the time of installation of the plant is called installed capacity.

5. **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.

1. **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 utilisation.

2. **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 capitalising on technological breakthrough.

3. **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 labour 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 labour 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:

1. **Inventories:** Stock of finished goods during slack periods to meet the demand during peak period.
2. **Backlog:** During peak periods, the willing customers are requested to wait and their orders are fulfilled after a peak demand period.
3. **Employment level (hiring or firing):** Hire additional employees during peak demand period and layoff employees as demand decreases.
4. **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.
5. **Subcontracting:** During peak periods, hire the capacity of other firms temporarily to make the component parts or products.
6. **Process design:** Change job contents by redesigning the job.

ROUTING

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:

(*a*) Type of work to be done on product or its parts.

(*b*) Operation required to do the work.

(*c*) Sequence of operation required.

(*d*) Where the work will be done.

(*e*) 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 work place of operation.

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. These 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.

(*f*) Rate at which job must be completed, determined from the operation sheet.

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.

SCHEDULING

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:

1. **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.
2. **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.
3. **Cumulative detailed:** Cumulative detailed combination is both feasible and practical approach. If master schedule has fixed and flexible portions.
4. **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 centres in the routing. The forward method generates in the process inventory that are needed at subsequent work centres 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 Figure.

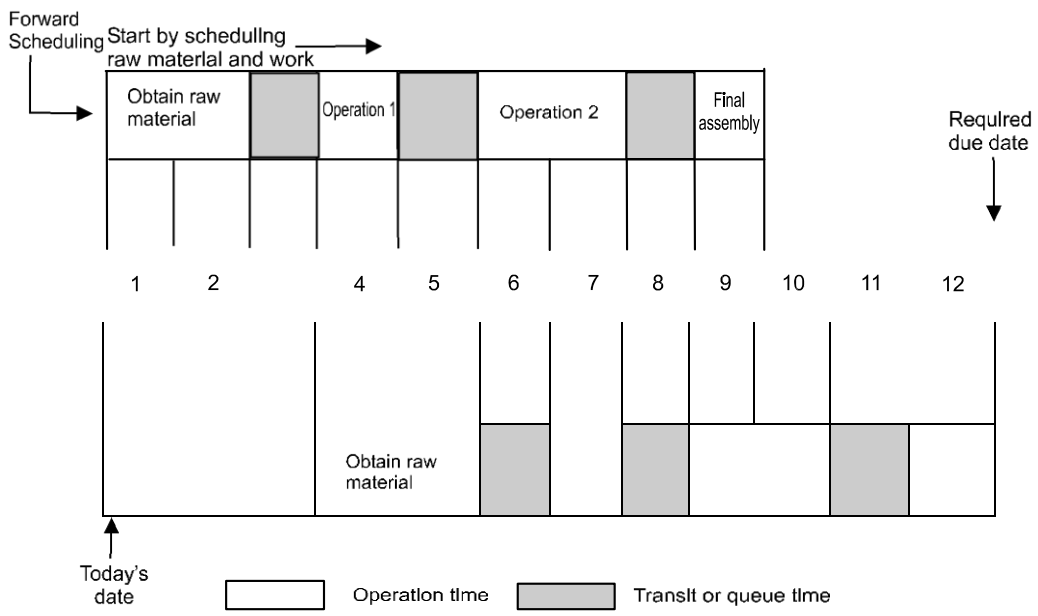


Fig. *Forward and backward scheduling*

SCHEDULING METHODOLOGY

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,

(*a*) Scheduling or progress charts, which depicts the sequential schedule;

(*b*) Load charts, which show the work assigned to a group of workers or machines; and

(*c*) 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. 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
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, labour 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.

(*a*) **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.

(*b*) **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.

SEQUENCING

The order in which jobs pass through the machines or work stations is called sequencing. The relative priorities are based on certain rules as discussed in the following:

1. First Come, First Served (FCFS) rule: This is a fair approach particularly applicable to people. In case of inventory management, it is First In First Out (FIFO). That means the 1st piece of inventory at a storage area is the 1st one to be used.
2. The shortest processing time (SPT) rule: SPT rule sequences jobs in increasing order of their processing times (including set up).
3. The Earliest Due Date (EDD) rule: Sequences jobs in order of their due dates, earliest first.
4. The critical ratio (CR) rule: Sequences jobs in increasing order of their critical ratio.

   $$CR = \frac{\text{Due date- Today'sdate}}{\text{Remaining processing time}}$$

   If CR>1 The job is ahead of schedule.

   If CR<1 The job is behind schedule.

   If CR=1 The job is exactly on schedule.
5. The Slack Time Remaining (STR) rule: It employs that the next job processed is the one that has the least amount of slack time.

   Slack = (Due date – Today's date) – Remaining processing time

Sequencing of n jobs through 2 machines (Johnson's rule)

Considering 2 machines and 'n' jobs as shown in Table 1.

Table 1 Job sequencing for n job

1	t_{11}	t_{12}
2	t_{21}	t_{22}
3	t_{31}	t_{32}
4	t_{11}	t_{42}
.	.	.
.	.	.
i	t_{i1}	t_{i2}
.	.	.
n	t_{n1}	t_{n2}

Step 1: Find the minimum among t_{i1} and t_{i2}.

Step 2(a): If the minimum processing time requires m/c-1, place the associated job in the 1st available position in sequence.

Step 2(b): If the minimum processing time requires machine-2, place the associated job in the last available position in sequence.

Step 3: Remove the assigned job from the table and return to Step 1 until all positions in sequence are filled. (Ties may be considered randomly)

The above algorithm is illustrated with the following example.

Ex.1 Consider two machines and six jobs flow shop scheduling problem. Using Johnson's algorithm, obtain the optimal sequence which will minimize the makespan.

Job	Time taken by machines	
	1	2
1	5	4
2	2	3
3	13	14
4	10	1
5	8	9
6	12	11
Sum	50	42

Solution: The working of the algorithm is summarized in the form of a table which is shown below.

Stage	Unscheduled job	Min	Assignment	Partial sequence/ Full sequence
1	1 2 3 4 5 6	t_{42}	Job 4-[6]	× × × × × 4
2	1 2 3 5 6	t_{21}	Job 2-[1]	2 × × × × 4
3	1 3 5 6	t_{12}	Job 1-[5]	2 × × × 1 4
4	3 5 6	t_{51}	Job 5-[2]	2 5 × × 1 4
5	3 6	t_{62}	Job 6-[4]	2 5 × 6 1 4
6	3	t_{31}	Job 3-[3]	2 5 3 6 1 4

Now the optimal sequence is 2-5-3-6-1-4.

The makespan is determined as shown below.

Job	M/C-1		M/C-1		Idle time on m/c-2
	Time in	Time out	Time in	Time out	
2	0	2	2	5	2
5	2	10	10	19	5
3	10	23	23	37	4
6	23	35	37	48	0
1	35	40	48	52	0
4	40	50	52	53	0

The makespan for this schedule is 53.

INVENTORY CONTROL OR MANAGEMENT

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 utilised. 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

1. **To stabilise 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.

2. **To take advantage of price discounts:** Usually the manufacturers offer discount for bulk buying and to gain this price advantage the materials are bought in bulk even though it is not required immediately. Thus, inventory is maintained to gain economy in purchasing.

3. **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.

4. **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.

5. **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.

6. 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: (*i*) When should an order be placed? (Order level), and (*ii*) 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 utilisation of working capital. Helps in minimising 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 categorised 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:

Table 1

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 (Fig. 1).

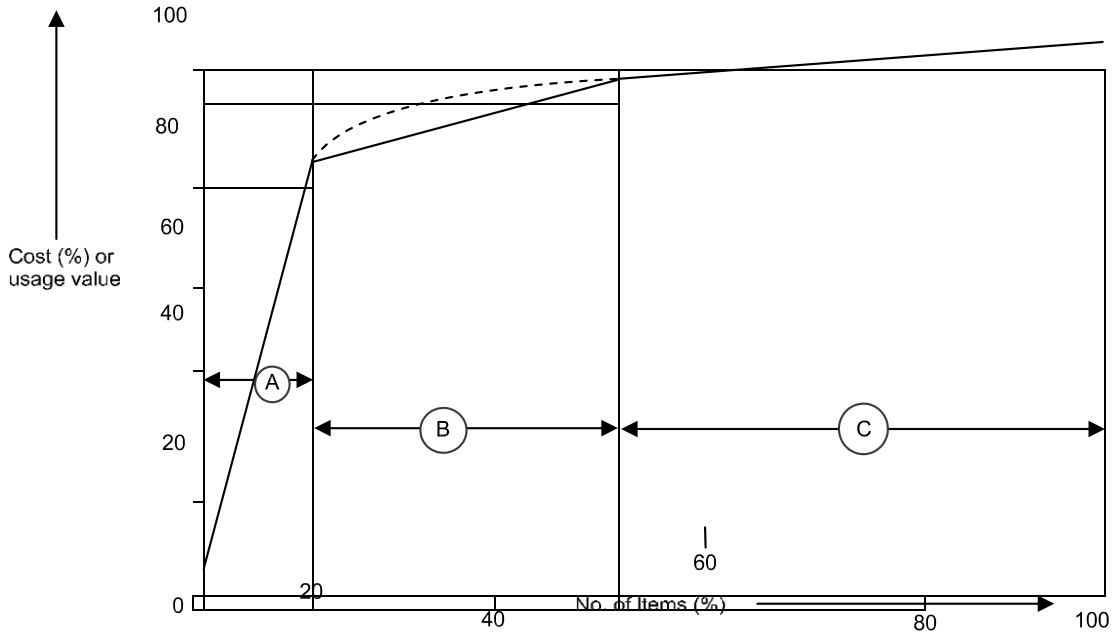


Fig. 1 *ABC classification*

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

A-Item: Very tight control, the items being of high value. The control need be exercised at higher level of authority.

B-Item: Moderate control, the items being of moderate value. The control need be exercised at middle level of authority.

C-Item: 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.

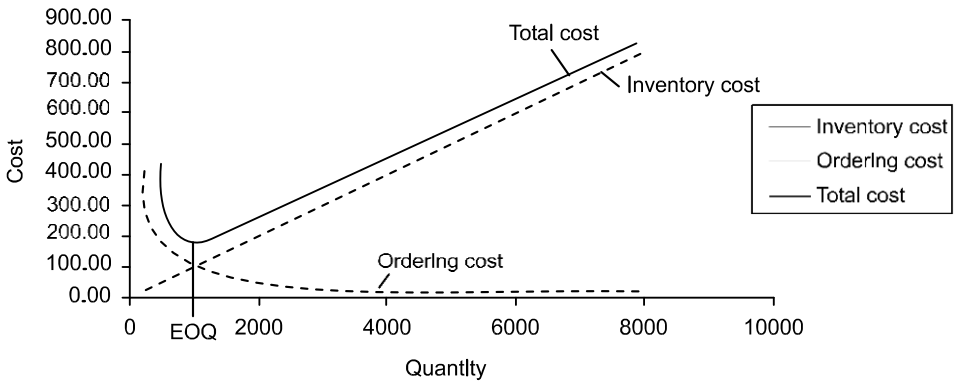


Fig. 2 *Inventory cost curve*

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

This method involves the following steps:

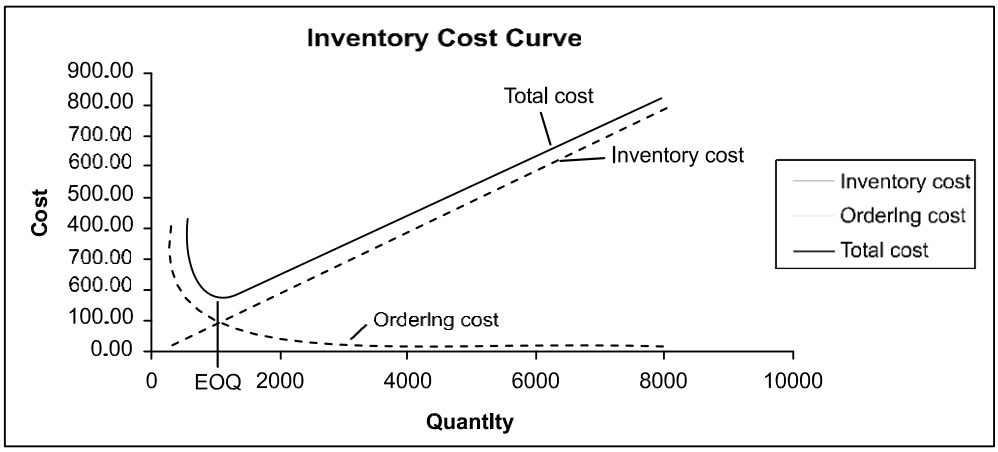
1. Select the number of possible lot sizes to purchase.
2. Determine average inventory carrying cost for the lot purchased.
3. Determine the total ordering cost for the orders placed.
4. Determine the total cost for each lot size chosen which is the summation of inventory carrying cost and ordering cost.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

ILLUSTRATION 1: *The XYZ Ltd. carries a wide assortment of items for its customers. One of its popular items has annual demand of 8000 units. Ordering cost per order is found to be Rs. 12.5. The carrying cost of average inventory is 20% per year and the cost per unit is Re. 1.00. Determine the optimal economic quantity and make your recommendations.*

SOLUTION:

No. of orders/ year (1)	*Lot size (2)*	*Average inventory (3)*	*Carrying cost (4)*	*Ordering cost (5)*	*Total cost/ year (6) =(4) + (5)*
1	8000	4000	800.00	12.5	812.50
2	4000	2000	400.00	25	425.00
4	2000	1000	200.00	50	250.00
8	1000	500	100.00	100	200.00
12	666.667	333.333	66.67	150	216.67
16	500	250	50.00	200	250.00



The table and the graph indicates that an order size of 1000 units will gives the lowest total cost among the different alternatives. It also shows that minimum total cost occurs when carrying cost is equal to ordering cost.

2. Determination of EOQ by Analytical Method

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

1. Demand is known and uniform.
2. Let D denotes the total number of units purchase/produced and Q denotes the lot size in each production run.
3. Shortages are not permitted, *i.e.*, as soon as the level of the inventory reaches zero, the inventory is replenished.
4. Production or supply of commodity is instantaneous.
5. Lead-time is zero.
6. Set-up cost per production run or procurement cost is C_3.
7. Inventory carrying cost is C_1 = 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.

This fundamental situation can be shown on an inventory-time diagram, (Fig. 3) with Q on the vertical axis and the time on the horizontal axis. The total time period (one year) is divided into *n* parts.

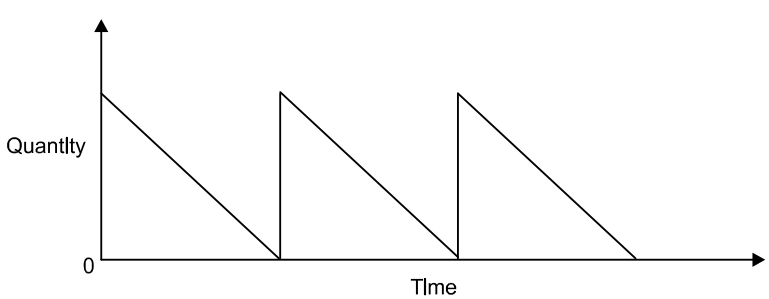


Fig. 3

The most economic point in terms of total inventory cost exists where,

Inventory carrying cost = Annual ordering cost (set-up cost)

Average inventory = 1/2 (maximum level + minimum level)

$= (Q + 0)/2 = Q/2$

Total inventory carrying cost = Average inventory × Inventory carrying cost per unit

i.e., Total inventory carrying cost $= Q/2 \times C_1 = QC_1/2$ …(1)

Total annual ordering costs = Number of orders per year × Ordering cost per order

i.e., Total annual ordering costs $= (D/Q) \times C_3 = (D/Q)C_3$ …(2)

Now, summing up the total inventory cost and the total ordering cost, we get the total inventory cost C(Q).

i.e., Total cost of production run = Total inventory carrying cost + Total annual ordering costs

$C(Q) = QC_1/2 + (D/Q)C_3$ (cost equation) …(3)

But, the total cost is minimum when the inventory carrying costs becomes equal to the total annual ordering costs. Therefore,

$$QC_1/2 = (D/Q)C_3$$

or $$QC_1 = (2D/Q)C_3 \quad \text{or} \quad Q^2 = 2C_3D/C_1$$

or $$Q = \sqrt{\frac{2C_3D}{C_1}}$$

i.e., Optimal quantity (EOQ), $$Q_0 = \sqrt{\frac{2C_3D}{C_1}} \quad ...(4)$$

Optimum number of orders, $$(N_0) = \frac{D}{Q_0} \quad ...(5)$$

Optimum order interval, $$(t_0) = \frac{365}{N_0} \text{ in days} = \frac{1}{N_0} \text{ in years or } (t_0) = \frac{Q_0}{D} \quad ...(6)$$

Average yearly cost (TC) $$= \sqrt{2C_3DC_1} \quad ...(7)$$

ILLUSTRATION 2: *An oil engine manufacturer purchases lubricants at the rate of Rs. 42 per piece from a vendor. The requirements of these lubricants are 1800 per year. What should be the ordering quantity per order, if the cost per placement of an order is Rs. 16 and inventory carrying charges per rupee per year is 20 paise.*

SOLUTION: Given data are:

Number of lubricants to be purchased, D = 1800 per year

Procurement cost, C_3 = Rs. 16 per order

Inventory carrying cost, CI = C_1 = Rs. 42 × Re. 0.20 = Rs. 8.40 per year

Then, optimal quantity (EOQ), $$Q_0 = \sqrt{\frac{2C_3D}{C_1}}$$

$$Q_0 = \sqrt{\frac{2 \times 16 \times 1800}{8.4}} = 82.8 \text{ or } 83 \text{ lubricants (approx).}$$

ILLUSTRATION 3: *A manufacturing company purchase 9000 parts of a machine for its annual requirements ordering for month usage at a time, each part costs Rs. 20. The ordering cost per order is Rs. 15 and carrying charges are 15% of the average inventory per year. You have been assigned to suggest a more economical purchase policy for the company. What advice you offer and how much would it save the company per year?*

SOLUTION: Given data are:

Number of lubricants to be purchased, D = 9000 parts per year

Cost of part, C_s = Rs. 20

Procurement cost, C_3 = Rs. 15 per order

Inventory carrying cost, CI = C_1 = 15% of average inventory per year

= Rs. 20 × 0.15 = Rs. 3 per each part per year

Then, optimal quantity (EOQ), $Q_0 = \sqrt{\frac{2C_3D}{C_1}}$

$$Q_0 = \sqrt{\frac{2\ 15\ 9000}{3}} = 300 \text{ units}$$

and Optimum order interval, $(t_0) = \frac{Q_0}{D}$ in years $= \frac{300}{9000} = \frac{1}{30}$ years

$$= \frac{1}{30} 365 \text{ days} = 122 \text{ Days}$$

Minimum average cost $= \sqrt{2C_3DC_1}$ $\sqrt{2\ 3\ 15\ 9000}$ = Rs. 900

If the company follows the policy of ordering every month, then the annual ordering cost is

= Rs 12 × 15 = Rs. 180

Lot size of inventory each month = 9000/12 = 750

Average inventory at any time $= \frac{Q}{2}$ = 750/2 = 375

Therefore,storage cost at any time = 375 × C_1 = 375 × 3 = Rs. 1125

Total annual cost = 1125 + 180 = Rs. 1305

Hence, the company should purchase 300 parts at time interval of 1/30 year instead of ordering 750 parts each month. The net saving of the company will be

= Rs. 1305 – Rs. 900 = Rs. 405 per year.

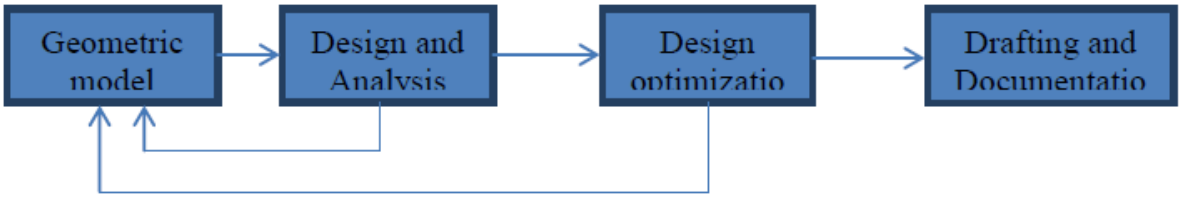
9.Modern Trends in Mabufacturing

Basic concepts of CAD

Computer Aided Design (CAD) involves the use of computer in

- Creating
- Analyzing
- Modifying
- Optimizing
- Drafting/ Documenting

A product data so as to achieve its design goal efficiently and effectively. The various phases of CAD section are presented in the following form:



As per the above figure, there are four phases of CAD process. A geometric model is generated first. It is analyzed for the desired design conditions and is optimized before finally getting documented and drafted.

CAD tool includes the following three elements.

(i) Computer modelling and computer graphics

Geometric modelling and computer graphics help to generate and visualize models on which the analysis is done subsequently. Modelling and designing are being used as synonyms now a day's. The kind of analysis which can be done on a model is controlled by the type of model used. Hence the computer aided model must be made only after confirming the kind of analysis which is to be performed on the model. Eg. Some model may not work for fluid dynamics and vibration analysis.

(ii) Analysis and optimization tools

These are the algorithms and programs for exclusive application which are applied on to the virtual product already modeled. This section can predict the behavior of the model under the loading condition when all constraints are simulated using boundary conditions. The analysis process is iterated number of times with varying attributes to optimize the results. The results so obtained from the model can be anticipated from the behavior of actual model in real situation.

(iii) Drafting and documentation

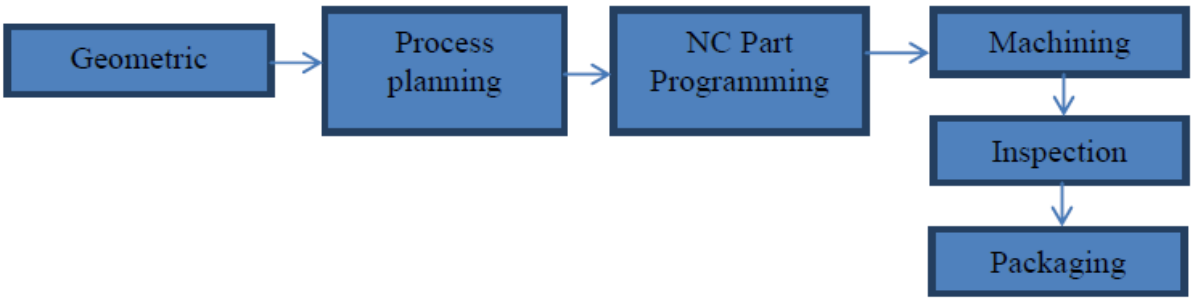
The model already created, analysed and optimized guarantees a safe model under the real conditions. This safe model drawing is to be communicated to production floor with technical illustrations. The tool used for this application is called Computer Aided Drafting orcalled Computer Aided Design and Drafting (CADD). Computer Aided Modelling/Designing and Computer Aided Drafting represent two different concepts. Their differences are presented in the following:

Sl.No.	Computer Aided Modelling/Designing	Computer Aided Drafting
1.	This is done before analysis is performed on the geometric model.	This is done after analysis is performed on the geometric model.
2.	This provides dimension which may/maynot be safe.	The dimensions are safe since these are obtained after the analysis.
3.	This is 2D drawing/3D model	This is generally 2D drawing.
4.	This model is used for design analysis	These are made basically for conveying the production design.

Basic concepts of CAM (Computer Aided Manufacturing)

CAM is defined as a process of use of computers in planning, manufacturing, inspecting and controlling the manufacturing operation directly or indirectly. CAM includes those activities which manufacture the product with the product drawing and technical illustration as a input

from the CAD and then make the product ready for shipment after inspection and packaging. The various phases of CAM section are shown below.



CAM Processes

In CAM, the basic information required is actually geometrical information which is supplied to the CAM processes through the CAD model already generated and analyzed. Interface algorithm extract that necessary geometrical information from the CAD model and feed it for process planning, part programming, machining, inspection and packaging.

CAM tool includes the following three elements:

(i) CAD Tool: The basic geometric information of the model is extracted from the geometric model created in the CAD phase of the product cycle. From the model necessary information regarding the shape, contour and sizes is extracted so as to implement in the manufacturing tool.

(ii) Manufacturing tool: The fundamental of manufacturing process which are used defines the manufacturing tool. It describes the method in which the product can be manufactured. This includes generation of part programming and manufacturing and computer aided process planning (CAPP) and tool and cutter design, etc.

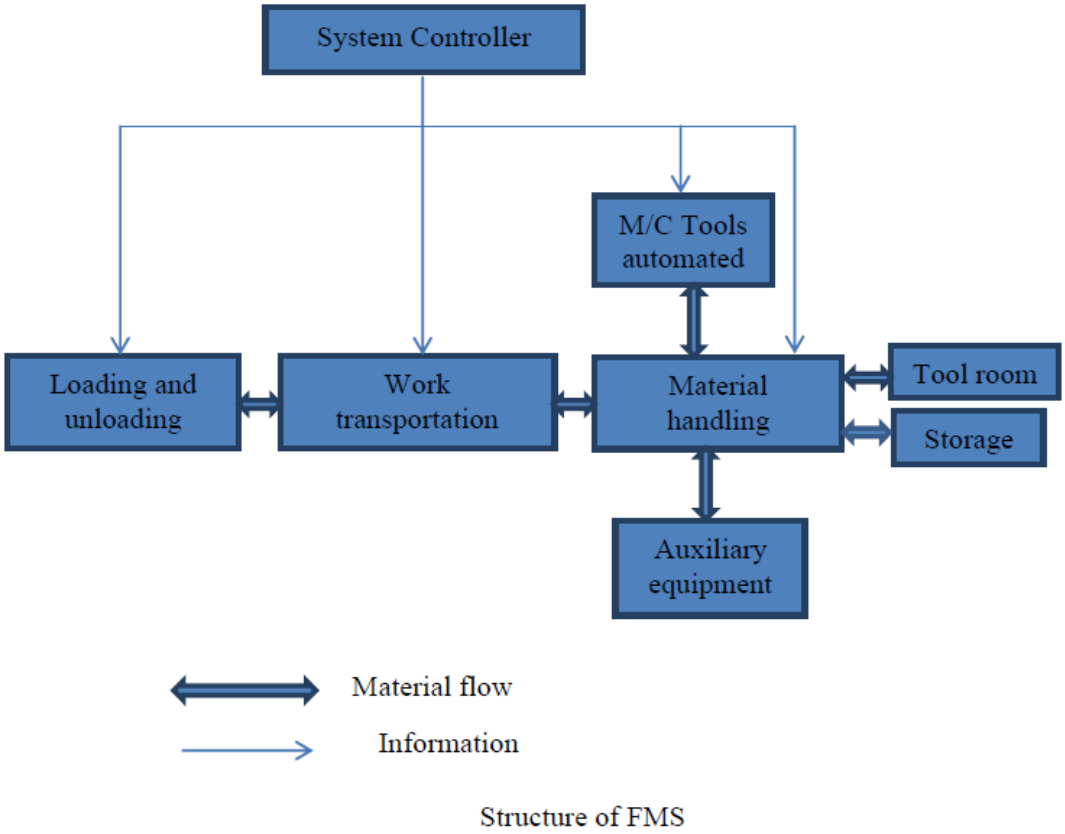
(iii) Networking tools: The knowledge of networking and interfaces is required for communication capability between various machines and computers. e.g. transferring a part program from one computer to 04 different machines, controlling a robot from a computer etc. a communication or networking tool is a must for CAM to be operational effectively.

CAM employs computers for 02 basic purposes:

(a) Computer monitoring and control: Where computers are used to control and monitor the applications. The major applications include in this category are: controlling machines and robots.

(b) Manufacturing support application: It includes those applications which are not controlled directly by computer but are used to support the primary and direct operation. Such applications include numeric part programming, CAPP, generating computer aided schedules and all other kinds of planning.

(c) Flexible Manufacturing System (FMS): A FMA integrates all major elements of manufacturing into a highly automated system. FMS has born in the latter half of 1960's as a means to improve productivity of small and medium volume production.



Structure of FMS

The major components are:

(a) **Automated m/c tools**: In order to achieve the system flexibility, NC/Computer controlled general purpose m/c tools are normally used.

(b) **Work transportation device**: These devices are used to carry parts between loading area and machining station. Individual conveyors are used for high degree of flexibility.

(c) **Material handling device**: These devices transport work in process or tolls to assigned positions.

(d) **Loading and unloading station**: The raw materials and/or finished parts are loaded/unloaded in this area by robot.

(e) **Tool room and storage**: All the tools used in this system are stored in the tool room and transported to machining centers when required.

(f) **Auxiliary equipments**: Besides m/c tools, an FMS can also include cleaning online inspection, automated measurement and gauging equipments.

(g) **System controller**: The system controller oversees the operation of entire FMS. It coordinates the operation of variety of equipments in the system.

Advantages of FMS

1. There is a greater potential to make changes in terms of product, technology.
2. It reduces both direct and indirect labour cost because of automatic handling, gauging and inspection facilities.
3. It provides reduced manufacturing lead time, reduced inventory of parts (both stock and work in progress).
4. It improves the utilization of equipments. In this case, utilization is 85% compared to 50% in conventional method.
5. It provides a better management control by integration of computers.
6. It provides better and more consistent products.

Computer Integrated Manufacturing (CIM)

- CIM is defined as a process of integration of CAD, CAM and business aspects of a factory and it attempts to describe complete automation with all processes functioning under computer control.
- CIM includes Management Information System (MIS), sales marketing, finance, database management system, design, manufacturing, monitor and control and bar code software etc., which helps to manage and control the overall factory environment. CAD, CAM and CIM basically involve fundamental principles of these underlying branches with hardware and software to operate and utilize them effectively.

Just In Time (JIT)

The Just-in-time production concept was first implemented in Japan around 1970's to eliminate waste of

- Materials
- M/C
- Capital
- Manpower
- Inventory

Throughout the manufacturing system. The JIT concept has the following objectives:

- Receive supplies just in time to be used.
- Produce parts just in time to be made into subassembly.
- Produce subassemblies just in time to be assembled into finished products.
- Produce and deliver finished products just in time to be sold.

In order to achieve these objectives, every point in the organization where buffer stocks normally occur is identified. Then, critical examinations of reasons for such stocks are made. A set of possible reasons for maintaining high stock is listed below:

- Unreliable/unpredictable deliveries
- Poor qualities from supplier
- Increased variety of materials
- Machine break down
- Labour absenteeism
- Frequent machine setting
- Variations in operators capabilities

- Schedule charges
- Changing product priorities
- Product modification

In traditional manufacturing, the parts are made in batches, placed in inventory and used whenever necessary. This approach is known as 'Push system' which means that parts is produced in accordance with the order. That means the rate at which the products come out at the end of final assembly matches with the order quantity for that product. There are no stockpiles within the production process. It is also called zero inventory, stockless production, demand scheduling. Moreover, parts are inspected by the workers as they are manufactured. This process of inspection takes a very short period. As a result of which workers can maintain continuous production control immediately identifying defective parts and reducing process variation. This JIT system ensures quality products. Extra work involved in stockpiling parts is eliminated.

Advantages of JIT

1. Exact delivery schedule is possible with JIT practices.
2. Quality of product is improved.
3. Lower defect rates i.e. lower inspection cost.
4. Lower raw material inventory, in process inventory and finished product inventory resulting lower product cost.
5. Satisfying market demand without delay in delivery.
6. Flexibility in utilizing manpower as workers is trained to do many jobs.
7. JIT helps in effective communication and reduces waste.
8. Less shop floor space is required.
9. Employee morale is high in an efficient working environment.
10. JIT reduces scrap and need for rework.

ISO 9000

ISO stands for International organization for standardization. It is an international body consists of representatives from more than 90 countries. The national standard bodies of these countries are the member of this organization. These are non-governmental organizations and can provide common standards of goods and services on international trades.

ISO9000 series has 5 numbers of international standards on quality management which are listed below with different objectives.

ISO 9000: Provides guide lines on selection and use of quality management and quality assurance standards.

ISO 9001: This is applicable for industries doing their own design and development, production, installation and servicing. It has 20 elements.

ISO 9002: It has 18 elements. It is same as ISO 9001 without the 1sttwo tasks i.e. design and development.

ISO 9003: It has 12 elements covering final inspection and testing for laboratories and warehouses.

ISO 9004: This provides guidelines to interpret the quality management and quality assurance. It also has suggestions which are not mandatory.

Benefits of ISO 9000 Series

1. This gives competitive advantage in the global market.
2. Consistency in quality, as ISO helps in detecting non-conforming early which makes it possible to rectify.
3. Documentation of quality procedure adds clarity to quality system.
4. It ensures adequate and regular quality training for all members of the organization.
5. It helps in customers to have cost effective purchase procedure.
6. The customers during purchase from firm holding ISO certificate need not spend much on inspection and testing. This will reduce quality cost and lead time.
7. This will aid to improved morale and involvement of workers.
8. The level of job satisfaction will be more.
9. This will help in increasing productivity.

Steps in ISO 9000 Registration

1. Selection of appropriate standard from ISO 9001/9002/9003 using guidelines given in ISO 9000.
2. Preparation of quality manual to cover all the elements in the selected model.
3. Preparation of procedure and shop floor instruction which are used at the time of implementing the system. Also document these items.
4. Self-auditing to check compliance of the selected module.
5. Selection of a registrar (an independent body with knowledge and experience to evaluate any one of the three quality systems i.e. ISO 9001/ 9002/ 9003) and the application is to be submitted to obtain certificate for the selected quality system/ model.

Sl.No.	System requirement	ISO 9001	ISO 9002
1	Management responsibility	✓	✓
2	Quality system	✓	✓
3	Product identification & traceability	✓	✓
4	Inspection status	✓	✓
5	Inspection & Testing	✓	✓
6	Inspection, measuring & test equipment	✓	✓
7	Control of non-conforming products	✓	✓
8	Handling, storage, packaging & delivery	✓ ✓	✓ ✓
9	Document control	✓	✓
10	Quality record	✓	✓
11	Training	✓	✓
12	Statistical technique	✓	✓
13	Internal auditing	✓	✓
14	Contract review	✓	✓
15	Purchasing	✓	✓
16	Process control	✓	✓
17	Purchaser's supplied product	✓	✓
18	Corrective action		✗
19	Design control	✓	✗
20	Servicing	✓	

✓ Present

✗ Not Present

Quality circle (QC)

Quality circle may be defined as a small group of workers (5 to 10) who do the same work voluntarily meeting together regularly during their normal working time usually under the leadership of their own supervisor to identify, analyze and solve work related problems.

This group presents the solution to the management and wherever possible implement the solution themselves. The QC concept was first originated in Japan in 1960. The basic cycle of a quality circle starts from identification of problem.

Philosophical basis of QC

1. A belief that people will take pride and interest in their work if they get autonomy and take part in decision making.

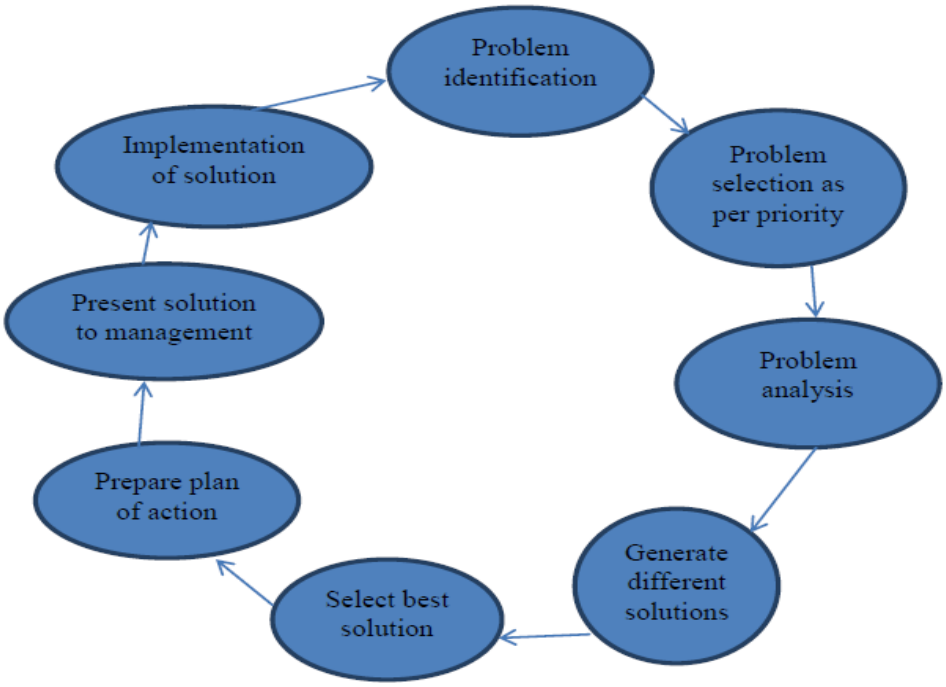
2. It develops a sense of belongingness in the employees towards a particular organization.

3. A belief that each employee desires to participate in making the organization a better place.

4. It is a mean/method for the development of human resources through the process of training, work experience and participation in problem solving.

5. A willingness to allow people to volunteer their time and effort for improvement of performance of organization.

6. The importance of each member's role in meeting organizational goal.



Quality Circle

Characteristics of quality circle

Characteristics of quality circle

1. QCs are small primary groups of employees/workers whose lower limit is 3 and upper limit is 12.

2. Membership is voluntary. The interested employees in some areas may come together to form a quality circle.

3. Each quality circle is led by area supervisor.

4. The members meet regularly every week/ as per agreeable schedule.

5. The QC members are specially trained in technique of analysis and problem solving in order to play their role efficiently.

6. The basic role of quality circle is to identify work related problems for improving quality and productivity.

7. QC enables the members to exercise their hidden talents, creative skills, etc.

8. It promotes the mutual development of their member through cooperative participation.

9. It gives job satisfaction because of identifying and solving challenging problems while performing the job.

10. It provides their member with opportunities for receiving public recognition from the company's management.

11. The members also receive recognition in the form of memento, certificate and privileges.

12. It also contributes to their self-esteem and self-confidence through acceptance of their recommendation by the management

Objectives of QC

1. To improve the quality and productivity.
2. To reduce the cost of products/ services by waste reduction, effective utilization of resources eliminating error/ defects.
3. To utilize the hidden creative intelligence of the employees.
4. To identify and solve work related problems.

5. To motivate people for solving challenging tasks.
6. To improve communication within the organization.
7. To increase employee's loyalty and commitment to organizational goals.
8. To enrich human capability, confidence, morale, attitude and relationship.
9. To pay respect to humanity and create a happy bright workplace.
10. To satisfy the human needs of recognition and self-development.

Total Quality Management

Total Quality Management (TQM) is a concept created by W. Edwards Deming. It was originally introduced in Japan after World War II to assist the Japanese in re-building their economy. The main focus of TQM was and is continuous quality improvement in the areas of product or service, employer-employee relations and consumer-business relations. Total Quality Management is a management approach that originated in the 1950s and has steadily become more popular since the early 1980s. Total Quality is a description of the culture, attitude and organization of a company that strives to provide customers with products and services that satisfy their needs. The culture requires quality in all aspects of the company's operations, with processes being done right for the first time to eradicate defects waste from operations.

Total Quality Management is a method by which management and employees can become involved in the continuous improvement of the production of goods and services. It is a combination of quality and management tools aimed at increasing the business and reducing losses due to wasteful practices. The quality of a library is defined and assessed from a perspective of different groups of people. Moreover, the quality of library services decides on the perception of the library within its parent organization (Gilbert, 1992).

The practice of Quality Management in Library and Information Science existed since the evolution of the subject itself, but the terminology used for these varies widely. Performance indicators; performance evaluation; evaluation of reference sources using precision and recall rations; cost benefit and cost effectiveness studies; user surveys electing opinions on library services all these make a part and parcel of quality studies using different mechanisms of assessment and methodologies **(Shewhart, 1986**).

Quality assurance studies were mostly restricted to technical libraries and academic libraries. Although quality assurance studies based on ISO 9001:2000 and 2 other accreditation schemes were conducted in other countries, such studies are rarely reported in Indian Libraries and Information system.

1.1 Definitions of Total Quality Management

1.1.1 Definition of Quality

Defining quality is far from easy. Just try to find why one finds that a product is not of quality. Quality refers to grade of service, product, reliability, safety, consistency and consumer's perception. The notion of quality often subsumes a comparison between products. Product A is better than B and therefore has a higher quality (Lorente, 1998). However, the word "better" is vague and different definitions can be used. Quality: means "degree of excellence"; implies "comparison", is not absolute. Quality – is to satisfy customers' requirement continually, whereas Total Quality is to achieve quality at low cost. Broadly quality includes fitness for use, grade, degree of preference, degree of excellence and conformity to requirements.

According to British Standard BS 7850, quality is defined as "Quality is concerned with meeting the wants and need of customers" (**Sivankalai and Yadav, 2012**).

The dictionary has many definitions of "quality". A short definition that has achieved acceptance is: "Quality is Customer Satisfaction". "Fitness for use" is an alternative short definition (Walton, 1990). Here, customer means anyone who is impacted by the product or process. **Deming (1986)** defines "Quality is a predictable degree of uniformity and dependability, at low cost and suited to the market".

According to ISO 8402, quality is "the totality of features and characteristics of a product or service that bear on its ability to satisfy stated or implied needs".

1.1.2 Dimensions of Quality

The following are the components given by Juran (2005) reveal the dimensions of quality.

1. Manufacturing Industries Service Industries
2. Product Features Accuracy

3. Performance Timeliness
4. Reliability Completeness
5. Durability, Friendliness and Courtesy
6. Ease of use Anticipating Customer needs
7. Serviceability Knowledge of Server
8. Esthetics
9. Availability reputation
10. Reputation

1.1.3 Quality Planning

Quality planning is the pre-determined activities in order to achieve conformation to the requirements. Many organizations are finding that strategic quality plans and business plans are inseparable. The quality planning procedure given by (Juran, 2005) has the following steps:

• Identify the customers

• Determine their needs

• Translate those needs into our language

• Develop a product that can respond to those needs

• Optimize the product features to meet our and customer needs

1.1.4 Quality Costs

All organizations make use of the concept of identifying the costs needed to carry out the various functions – product development, marketing, personnel, production etc., Until the 1950's this cost concept had not been extended to quality function, except for the departmental activities of inspection and testing. During the 1950's the concept of "Quality Cost" emerged. Different people assigned different meanings to the term. Some people equated quality cost with the cost of attaining quality; some people equated the term with the extra incurred due to poor quality. But, 4 the widely accepted thing is "Quality cost is the extra cost incurred due to poor or bad quality of the product or service" (Juran, 2005).

1.1.5 Categories of Quality Cost

Many companies summarize quality costs into four broad categories. They are;

a) Internal failure costs - The cost associated with defects that are found prior to transfer of the product to the customer.

b) External failure costs - The cost associated with defects that are found after product is shipped to the customer.

c) Appraisal costs - The cost incurred in determining the degree of conformance to quality requirement.

d) Prevention costs - The cost incurred in keeping failure and appraisal costs to a minimum. Sometimes we can also include the hidden costs i.e. implicit costs (**Juran, 2005**).

1.1.6 Emerging Quality Cost Model

It is been argued that higher quality doesn't mean higher costs. The companies estimate quality costs for the following reasons:

a) To quantifying size of the quality problem in the language of money improves communication between middle managers and upper managers.

b) To identify major opportunities for cost reduction.

c) To identify the opportunities for reducing customer dissatisfaction and associated threats to product salability.

The main focus of TQM was and is continuous quality improvement in the areas of product or service, employer-employee relations, and consumer-business relations using the following **14 Deming's Principles.**

1. Create constancy of purpose for improvement of product and service;

2. Adopt the new philosophy;

3. Cease dependence on mass inspection to achieve quality;

4. End the practice of awarding business on the basis of a price tag-instead, minimize the total cost;

5. Improve constantly and forever the system of production and service;

6. Institute training for all employees;

7. Adopt and institute leadership;

8. Drive out fear;

9. Break down barriers between staff areas;

10. Eliminate slogans, exhortations, and targets for the work force;

11. Eliminate numerical quotas for the work force and eliminate numerical goals for people in management;

12. Remove barriers that rob people of pride in their work;

13. Encourage education and self-improvement for everyone;

14. Take action to accomplish the transformation"

1.2 Total Quality Management

ISO defined TQM as “A management approach of an organization centered on quality, based on participation of all its members and aiming at long term benefits to all members of the organization and society.”

TQM is "a system of continuous improvement employing participative management and centered on the needs of customers" (**Jurow and Barnard, 1993**).

There are a broad range of definitions of TQM, some examples are as follows:

• TQM is an integrated, corporately led programme of organizational change designed to engender and sustain a culture of continuous improvement based on customer oriented definitions of quality (**Kanaji, 1990**).

• TQM is defined as fitness for use or purpose. TQM is a way of managing the effectiveness, flexibility and competitiveness of business as a whole TQM represents the management of quality as a strategic issue rather than an operational issue for lower levels of the hierarchy (**Engelkemeyer, 1993**).

- TQM is a systematic approach to the practice of management, requiring changes in organizational processes, strategic priorities, individual beliefs, individual attitudes and individual behaviors **(Oakland, 1990**).
- **Brockman, J. R. (1992)** has defined that "TQM is a management philosophy, embracing all activities through which the need of customer, the community and the objectives of the organization are satisfied in the most effective and potential of all employees in continuing drive for improvement."

According to **Moghaddam and Moballeghi (2007)**, TQM is the application of a number of activities with perfect synergy. The various important elements of TQM are:

- Customer-driven quality;
- Top management leadership and commitment;
- Continuous improvement;
- Fast response;
- Actions based on facts
- Employee participation; and
- A TQM culture

Libraries can benefit from TQM in three ways: breaking down interdepartmental barriers; redefining the beneficiaries of library services as internal customers (staff) and external customers (patrons); and reaching a state of continuous improvement (**Jurow and Barnard, 1993**).

1.3 Four-level model in TQM

In his study of total quality management in managing quality, Dale et al., (1990), outline a four-level model of the evolution of quality management. In addition to the framework it proposes, clear definitions of quality terms are also provided.

Level 1. Inspection: measure the characteristics of a product and compare them with its specifications; the goal here is the fitness of standards. This is the passive "Inspecting" attitude. 7 **Level 2. Quality Control**: inspection performed by the workers themselves with a feedback loop to the production line; here we avoid the "inspector" effect and allow some learning to take place.

Level 3. Quality Assurance: set of (implemented) predefined and systematic activities necessary to give confidence in the process quality; one step further. Quality procedures are designed and planned as a whole to ensure that no bad products be delivered. We do not just rely on everybody's work and control. This introduces the notion of a coherent set of quality procedures/tests. The given confidence (in the definition of QA) is important both for the producer and for the customer.

Level 4. Total Quality Management: centered on quality and based on the participation of everybody which aims at the customer satisfaction and at the improvement of the company's personnel, of the company and of the society.

The ultimate step in TQM is a quality assurance plan is operational but the management; the workers and the customers continuously interact to review/improve this plan. Quality is concerned with meeting the wants and needs of customers. One of the key and enduring definitions is that “Quality is fitness for purpose”. According to the British Standards, quality is defined as “the totality of features and characteristics of a product of service that bear on its ability to satisfy the stated or implied needs”.

1.4 Components of TQM

The primary focus of this study was to understand the impact of TQM principles on library management. Hence, seven components of TQM were identified after extensive review of literature. The seven identified components were: Leadership, policy and strategy, training and development, staff management, teamwork, resources and processes. These components of TQM are fundamental to the basic principles of TQM, propounded by the quality gurus and available in all established TQM literature.

1.4.1 Leadership

According to Deming's 14 points, 7th point says "Adopt and institute leadership". On this basis, first component is considered as Leadership. The presence 8 of leadership quality in the librarian would go long way to drive out the fear of change that the employers may perceive in Total Quality Management effort. The challenge is to build a management team that possesses such characteristics. The two intellectual capabilities that is essential to the leader is ability to perform abstract thinking; to move from concrete experience to a set of generalized ideas; and back to concrete experience again in ways that change the way the people think about the problem or an opportunity. The leadership of an organization must be committed to continuous improvement. This commitment must be visible throughout all layers of management. Management must "walk the talk" (**Heinbuch, 1993**).

The leaders must possess a vision and share the vision with everyone. Since the success of library depends upon the leadership ability of librarian to lead the team and take into confidence and work in team support in achieving customers satisfaction in the light of the objectives of the college. Efforts have been made to identify the leadership quality of the librarian in achieving Total Quality Management in management college libraries. Leadership is a work-in-progress and is a practical step in a journey to change organizational culture and build individual and organizational leadership capacity (**Williamson, 2009**)

1.4.2 Policy and Strategy

All the services provided by the library should come under the scrutiny of Total Quality Management. The coupling of policy and Total Quality Management services as a measure in assuring the entire library will be involved in strategic quality management programmes. Libraries and information services are not static entities impervious to outside influences but are dynamic and may be affected by one, or a number of factors. The total commitment to the strategic quality management has to be embedded in the management college libraries vision statement and policy and strategy of the libraries will re-enforce the commitment and clear goals before the library personnel, for which they exist.

The policy and strategy designed by the library should be made aware to the library users about the library objectives and services. The customer services and satisfaction lie at the heart of the

service quality and therefore the library managers should focus upon the problem definitions. Policy and strategy of the management college library reflects the libraries vision statement, mission, goals and objectives 9 and also services. Total quality management as a tool that can help in achieving the objectives of educational institutes in such a competitive modern global economy (**Ahmed, 2012**).

1.4.3Training and Development

One of the essential ingredients of quality program is an extensive amount of training to the library staff. By training and development, the full potentials of library personnel can be achieved to improve the efficiency and development of the library. By creating an awareness of training opportunities, the organization demonstrates its commitment to a continuous improvement of employee's skills.

The training programme will enable the staff to become familiar with the techniques such as latest development in their field. Thus, the training and development will eliminate waste and effecting continuous improvement. The training, development and education of employees at all levels within organizations is now considered a vital component in maintaining competitiveness in the international arena. It is also of some significance within the human resource management (HRM) and development (HRD) literature (**Garavan, 1997**).

1.4.4 Staff Management

Deming's model of profound knowledge emphasizes need to understand the human psychology, which is not an easy task. The library staff are the primary resource of the library, whatever the quality of collection, databases, services and building may be, but the effective organization, maintenance, motivation and empowerment of the library staff are the most crucial factors that can make the name of the institution. It is certainly true that, as long as there is an understandable human desire for development exists between the library managers and its staff achieving total quality management in library is not an impediment rather it is a simple task. The managers needs to develop an attitude of awarding their staff for better performance, which will boost the morale of staff in achieving Total Quality Management in Libraries (**Stuart, 2007**).

1.4.5 Team Work

Working in teams is one of the current popular management techniques and it is becoming increasingly common for academic librarians to work with others on campus to solve problems, deliver services, develop information resources, create facilities and formulate policies. Collaborative teams of librarians and computing professionals have created campus websites, offered workshops for staff and users, planned labs and instructional technology centers and developed joint service desks. Teams of faculty, librarians, instructional technologists and others have created network-based learning experiences incorporating electronic information resources as an integral aspect of the curriculum. Faculty, student, librarian, and technologist teams have developed publishing projects such as electronic journals, electronic dissertations and databases. Teams of librarians, technologists and assessment experts are working to establish measures of the use and value of technology and electronic information resources on campuses. Graham (2003) says "it was tough he says the teams are very good about giving new workers safety guidelines and saying, look, if you are ever in doubt, make sure that you come and ask.

1.4.6 Resources

An approach to re-thinking the functions and objectives of the management college library is to start from a zero-base, this approach will identify what the college library aims to do and how to do then calculate, what information resources are needed to serve the institution, objectives effectively. The budget projects the amount of financial support required for personnel, equipment and suppliers needed to carry out the show of the library. The facilities like library books, building, furniture, equipment should be properly maintained in good condition (Schmiedel, 2007).

1.4.7 Processes

he pursuit of quality must become the primary motivation in the organizational process. The wide range of library activities and services aimed at collecting, organizing, maintaining and delivering information services and products. As a leader of the library, the library manager must identify the key processes of the 11 library activities by breaking the processes in small activities. Each key processes of the library are assigned with library staff based upon type of work involved and competencies and skill required for the work. If however, the work process

by which service was delivered is examined, there is an opportunity to say confidently that services was delivered is examined, there is an opportunity to say confidently that services were improved. With the emergence of computers and communication technology on one hand and complex needs of user community, there is a need to improve the work processes of the library on the basis of principle that nothing is constant and change for betterment is the ultimate. The library manager should authorize their library staff to identify the key processes of the library and assist for improvement in the execution of the work processes Cordes (2007).

1.5 Benefits of TQM

Customer satisfaction oriented benefits (Hackman and Wageman, 1995) of TQM are;

1. Improvement in product quality
2. Improvement in product design
3. Improvement in production flow
4. Improvement in employee morale and quality consciousness
5. Improvement in product service
6. Improvement in market place acceptance

Economic improvement oriented benefits of TQM are,

1. Reduction in operating costs
2. Reduction in operating losses
1. 3Reduction in field service costs
3. Reduction in liability exposure

Total Productive Maintenance (TPM)

What is Total Productive Maintenance (TPM)?

It can be considered as the medical science of machines. Total Productive Maintenance (TPM) is a maintenance program which involves a newly defined concept for maintaining plants and equipment. The goal of the TPM program is to markedly increase production while, at the same time, increasing employee morale and job satisfaction.

TPM brings maintenance into focus as a necessary and vitally important part of the business. It is no longer regarded as a non-profit activity. Down time for maintenance is scheduled as a part of the manufacturing day and, in some cases, as an integral part of the manufacturing process. The goal is to hold emergency and unscheduled maintenance to a minimum.

Why TPM?

TPM was introduced to achieve the following objectives. The important ones are listed below.

- Avoid wastage in a quickly changing economic environment.
- Producing goods without reducing product quality.
- Reduce cost.
- Produce a low batch quantity at the earliest possible time.
- Goods send to the customers must be non-defective.

Similarities and differences between TQM and TPM:

The TPM program closely resembles the popular Total Quality Management (TQM) program. Many of the tools such as employee empowerment, benchmarking, documentation, etc. used in TQM are used to implement and optimize TPM. Following are the similarities between the two.

1. Total commitment to the program by upper level management is required in both programs
2. Employees must be empowered to initiate corrective action, and
3. A long range outlook must be accepted as TPM may take a year or more to implement and is an on-going process. Changes in employee mind-set toward their job responsibilities must take place as well.

The differences between TQM and TPM is summarized below.

Category	TQM	TPM
Object	Quality (Output and effects)	Equipment (Input and cause)
Mains of attaining goal	Systematize the management. It is software oriented	Employees participation and it is hardware oriented
Target	Quality for PPM	Elimination of losses and wastes.

Types of maintenance :

1. Breakdown maintenance : It means that people waits until equipment fails and repair it. Such a thing could be used when the equipment failure does not significantly affect the operation or production or generate any significant loss other than repair cost.

2. Preventive maintenance (1951): It is a daily maintenance (cleaning, inspection, oiling and re-tightening), design to retain the healthy condition of equipment and prevent failure through the prevention of deterioration, periodic inspection or equipment condition diagnosis, to measure deterioration. It is further divided into periodic maintenance and predictive maintenance. Just like human life is extended by preventive medicine, the equipment service life can be prolonged by doing preventive maintenance.

2a. Periodic maintenance (Time based maintenance - TBM): Time based maintenance consists of periodically inspecting, servicing and cleaning equipment and replacing parts to prevent sudden failure and process problems.

2b. Predictive maintenance: This is a method in which the service life of important part is predicted based on inspection or diagnosis, in order to use the parts to the limit of their service life. Compared to periodic maintenance, predictive maintenance is condition based maintenance. It manages trend values, by measuring and analyzing data about deterioration and employs a surveillance system, designed to monitor conditions through an on-line system.

3. Corrective maintenance (1957): It improves equipment and its components so that preventive maintenance can be carried out reliably. Equipment with design weakness must be redesigned to improve reliability or improving maintainability

4. Maintenance prevention (1960): It indicates the design of new equipment. Weakness of current machines are sufficiently studied (on site information leading to failure prevention, easier maintenance and prevents of defects, safety and ease of manufacturing) and are incorporated before commissioning a new equipment.

TPM - History:

TPM is an innovative Japanese concept. The origin of TPM can be traced back to 1951 when preventive maintenance was introduced in Japan. However the concept of preventive maintenance was taken from USA. Nippondenso was the first company to introduce plant wide preventive maintenance in 1960. Preventive maintenance is the concept wherein, operators produced goods using machines and the maintenance group was dedicated with work of

maintaining those machines, however with the automation of Nippondenso, maintenance became a problem as more maintenance personnel were required. So the management decided that the routine maintenance of equipment would be carried out by the operators. (This is Autonomous maintenance, one of the features of TPM). Maintenance group took up only essential maintenance works.

Thus Nippondenso which already followed preventive maintenance also added Autonomous maintenance done by production operators. The maintenance crew went in the equipment modification for improving reliability. The modifications were made or incorporated in new equipment. This lead to maintenance prevention. Thus preventive maintenance along with Maintenance prevention and Maintainability Improvement gave birth to Productive maintenance. The aim of productive maintenance was to maximize plant and equipment effectiveness to achieve optimum life cycle cost of production equipment.

By then Nippon Denso had made quality circles, involving the employees participation. Thus all employees took part in implementing Productive maintenance. Based on these developments Nippondenso was awarded the distinguished plant prize for developing and implementing TPM, by the Japanese Institute of Plant Engineers (JIPE). Thus Nippondenso of the Toyota group became the first company to obtain the TPM certification.

Motives of TPM	1. Adoption of life cycle approach for improving the overall performance of production equipment. 2. Improving productivity by highly motivated workers which is achieved by job enlargement. 3. The use of voluntary small group activities for identifying the cause of failure, possible plant and equipment modifications.
Uniqueness of TPM	The major difference between TPM and other concepts is that the operators are also made to involve in the maintenance process. The concept of *"I (Production operators) Operate, You (Maintenance department) fix"* is not followed.
TPM Objectives	1. Achieve Zero Defects, Zero Breakdown and Zero accidents in all functional areas of the organization. 2. Involve people in all levels of organization. 3. Form different teams to reduce defects and Self Maintenance.
Direct benefits of TPM	1. Increase productivity and OPE (Overall Plant Efficiency) by 1.5 or 2 times. 2. Rectify customer complaints. 3. Reducethe manufacturing cost by 30%. 4. Satisfy the customers needs by 100 % (Delivering the right quantity at the right time, in the required quality.) 5. Reduce accidents. 6. Follow pollution control measures.
Indirect benefits of TPM	1. Higher confidence level among the employees. 2. Keep the work place clean, neat and attractive. 3. Favorablechange in the attitude of the operators. 4. Achieve goals by working as team. 5. Horizontaldeployment of a new concept in all areas of the organization. 6. Share knowledge and experience. 7. The workers get a feeling of owning the machine.

Kaizan

Kaizen means change (Kai) to become good (Zen). In other words, it means continuous improvement. In fact, continuous improvement is required in all activities of the organization such as:

- Productivity improvement
- New product development
- Labor management relation

- Total productive maintenance
- Just in time production & delivery system
- Customer orientation etc.

The various activities of an organization where continuous improvement is required is presented under the kaizen umbrells. This continuous improvement in all areas are taken through small step by step process. Because various behavioural, cultural and philosophical changes are better brought about through small step by step improvement than through radical changes.

Poka-yoke

Poka-yoke is a Japanese term that means "mistake-proofing" or "inadvertent error prevention". A poka-yoke is any mechanism in any process that helps an equipment operator avoids (yokeru) mistakes (poka). Its purpose is to eliminate product defects by preventing, correcting, or drawing attention to human errors as they occur. The concept was formalized, and the term adopted, by Shigeo Shingo as part of the Toyota Production System. It was originally described as baka-yoke, but as this means "fool-proofing" (or "idiot-proofing") the name was changed to the milder poka-yoke.

Implementation in manufacturing

Poka-yoke can be implemented at any step of a manufacturing process where something can go wrong or an error can be made. For example, a fixture that holds pieces for processing might be modified to only allow pieces to be held in the correct orientation, or a digital counter might track the number of spot welds on each piece to ensure that the worker executes the correct number of welds.

Shigeo Shingo recognized three types of poka-yoke for detecting and preventing errors in a mass production system:

1. The contact method identifies product defects by testing the product's shape, size, color, or other physical attributes.
2. The fixed-value (or constant number) method alerts the operator if a certain number of movements are not made.

3. The motion-step (or sequence) method determines whether the prescribed steps of the process have been followed.

Either the operator is alerted when a mistake is about to be made, or the poka-yoke device actually prevents the mistake from being made. In Shingo's lexicon, the former implementation would be called a warning poka-yoke, while the latter would be referred to as a control poka-yoke.

Shingo argued that errors are inevitable in any manufacturing process, but that if appropriate poka-yokes are implemented, then mistakes can be caught quickly and prevented from resulting in defects. By eliminating defects at the source, the cost of mistakes within a company is reduced.

A methodic approach to build up poka-yoke countermeasures has been proposed by the Applied Problem Solving (APS) methodology, which consists of a three-step analysis of the risks to be managed:

1. Identification of the need
2. Identification of possible mistakes
3. Management of mistakes before satisfying the need

This approach can be used to emphasize the technical aspect of finding effective solutions during brainstorming sessions.

Benefits of poka-yoke implementation

A typical feature of poka-yoke solutions is that they don't let an error in a process happen. Other advantages include:

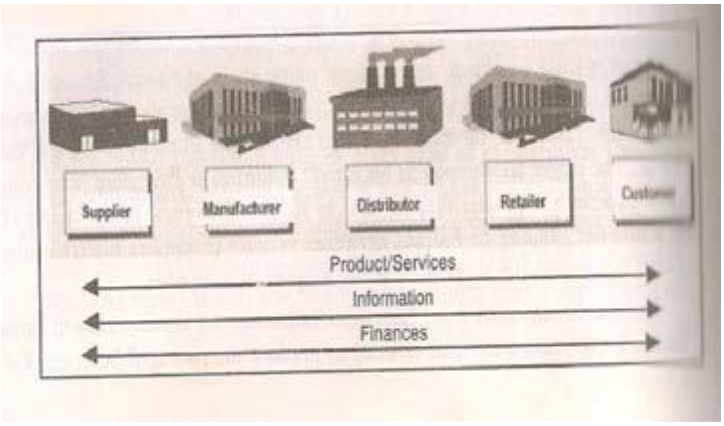
- Less time spent on training workers;
- Elimination of many operations related to quality control;
- Unburdening of operators from repetitive operations;
- Promotion of the work improvement-oriented approach and actions;
- A reduced number of rejects;
- Immediate action when a problem occurs;
- 100% built-in quality control;

- Preventing bad products from reaching customers;
- Detecting mistakes as they occur;
- Eliminating defects before they occur.

Supply Chain Management

'Supply Chain Management' is defined as the integration-oriented skills required for providing competitive advantage to the organization that are basis for successful supply chains. A typical supply chain may involve a variety to stage. These supply chain stages include:

- Customers
- Retailers
- Wholesaler/ Distributors
- Manufacturers
- Component/Raw material suppliers



The concept of a supply chain is shown in Figure. Though many stages are shown in the figure, each stage need not be present in a supply chain. The number of stages included should meet that the organization generates profits for itself.

'Supply Chain Management' is the integration-oriented skills required for providing competitive advantage to the organization that are basis for successful supply chains. 'Supply Chain Management' can be defined as the active management of supply chain activities to maximize customer value and achieve a sustainable competitive advantage. It represents a conscious effort by the supply chain firms to develop and run supply chains in the most effective and efficient ways possible.

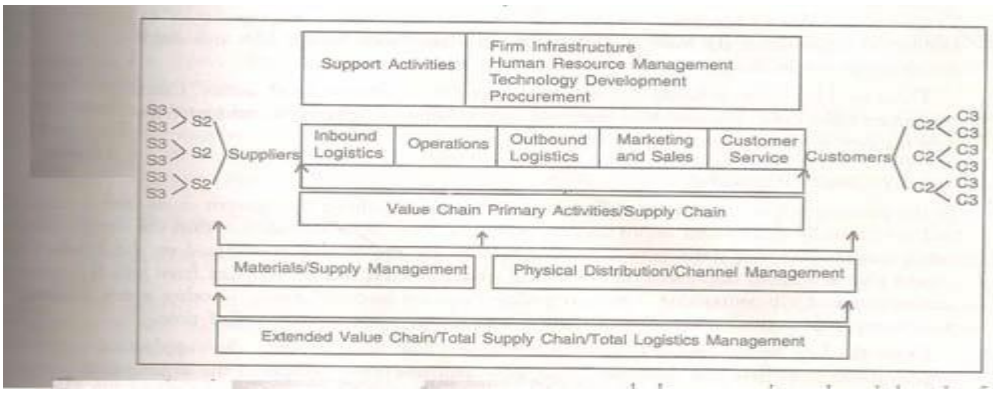
Within each organization, such as a manufacturer, the supply chain includes all functions involved in receiving in receiving and filling a customer request. The functions that are chain includes all functions involved in receiving and filling a customer request, operations, distribution, finance, and customer service. The decision is tradeoff between price, inventory, and responsiveness.

Its activities begin with a customer order and ends when a satisfied customer has paid for his or her purchase. Generally, more than one player is involved at each stage. A manufacturer may receive materials from several suppliers and then supply several distributors. Thus, most supply chains are actually networks.

Supply chain is an integral part of the value chain. According to Michael Porter, who first articulated the value chain concept in the 1980s, the value chain is comprised of both the primary and support activities. The supply chain consists only of the primary activities or the operational part of the value chain. The supply chain, therefore, can be thought of as a subset of the value chain. In other words, while everyone in the same organization works in the value chain, not everyone within the organization works in the supply chain.

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. The supply chain profitability is based on the effort involved in the appropriate management of the flows between and among stages in a supply chain. Unlike the traditional measure of organizational success in terms of the profits at an individual stage, supply chain success is measured in terms of supply chain profitability.

The objective of every supply chain is to maximize the overall value generated so that the final price of the good covers all of the costs involved plus a profit for each participant in the chain. Figure shows the supply chain as a network and also as a part of the value chain.



The appropriate design of the supply chain will depend on both the customer's needs and the role of the stages involved. In some cases, a manufacturer may fill customer orders directly. For example, Dell has been one of the most successful examples of effective supply chain management. Dell builds-to-order, that is, a customer order initiates manufacturing at Dell.

Dell does not have a retailer, wholesaler, or distributor in its supply chain. While other computer companies must stock a month of inventory. Dell carries only a few days' worth. In fact, many of the components are delivered within hours of being assembled and shipped to the customer. It plans orders and signals suppliers every two hours, which enables it to manufacture and deliver exactly what its customers want.

In other cases, such as in a mail order business like Amazon.com, the company maintains an inventory of product from which they fill customer orders. In the case of retail stores, the supply chain may also contain a wholesaler or distributor between the store and the manufacturer.

Decisions in a Supply Chain: Supply chain management involves proactively managing the two-way movement and coordination (that is, the flows) of goods, services, information, and funds from raw material through end user. A company with a "supply chain orientation" is one that recognizes the strategic value of managing operational activities and flows across a supply chain. Its decision fall into three categories of phases:

Supply Chain Design: Supply Chain Design is a strategic decision. If reflects the structure of the supply chain over the next several years. It decides what the chain's configuration will be, how resources will be allocated, and what processes each stage will perform.

Successful design requires a high degree of functional and organizational integration. In order to do so, it is essential to develop supply chain process maps (flow charts) for major supply chains and their related processes helps establish an understanding of the supply chain. There should be a clearly understood mapping convention to be utilized, along with other information requirements. The objective of this exercise is to develop supply chain maps that present all supply chain entities along with key processes.

From this exercise will flow such decisions as the location and capacities of production and warehousing facilities, the products to be manufactured or stored at various locations, the modes of transportation, and the type of information system to be utilized. The organization must also identify key and critical supply chains components. It must be knowledgeable regarding its part of the supply chain and also must understand how the part interfaces with the other parts of the supply chain.

The supply chain configuration should support the organization's strategic objectives. In the case of TI Cycles regarding the location and capacity of its manufacturing facilities at Aurangabad, the joint manufacturing agreement with Avon Cycle and distribution network are all supply chain design or strategic decisions.

These are long-term decision and are very expensive to alter on short notice. Consequently, when companies make these decisions, they must take into account uncertainty in anticipated market conditions over the next few years.

Supply Chain Planning: In the planning phase, companies define a set of operating policies that govern short-term operations and are normally determined on an annual basis. These decisions are made within the supply chain's configuration. Planning starts with a demand forecast for the coming year. Based on the demand, an annual plan is worked out. Decisions regarding which markets will be supplied from which locations, outsourcing and subcontracting, inventory policies, etc. are made. Planning, in other words, establishes parameters within which a supply chain will function over a specified period of time.

One the key supply chains have been identified, one must identify the supply chain member organizations (suppliers and customers) that are considered most critical to the organization's

supply chain management efforts. In selecting external members, several issues should be addressed.

SCM endeavors are likely to be more productive if participating organization are not direct competitors. There may be limits to collaborative supply chain efforts when both buyer-supplier and competitor relationships exist between participating organizations.

All organizations and their representatives must be pursuing similar goals. This does not mean that each organization should have identical goals, but that their respective goals must be compatible with the overall SCM initiative.

SCM initiative is unlikely to be successful unless all members from each organization involved feel they are benefiting from participation. SCM efforts have to be focused where the involvement is beneficial to all the members.

In well managed organizations, in the planning phase uncertainty in demand, exchange rates, and competition over this time horizon are included in the decisions. Given a shorter time horizon and better forecasts than the design phase, the planning phase tries to exploit the supply chain design to optimize performance.

Supply Chain Operation: This has a short-term time horizon, monthly, weekly or daily. The focus, during this phase, it on individual customer orders. At the operational level, within planning policies, the goal is to handle incoming customer orders in the best possible manner. Firms allocate inventory or production to individual orders, set a date that an order is to be filled, generate pick lists at a warehouse, allocate an order to a particular shipping mode and shipment, set delivery schedules of trucks, and place replenishment orders.

Aggregate planning is the basis for decisions at this stage. The aggregate plan serves as a broad blueprint for operations and establishes the parameters within which short-term production and distribution decisions are made. It allows the supply chain to alter capacity allocations and change supply contracts. In addition, man constraints that must be considered in aggregate planning come from supply chain partners outside the enterprise, particularly upstream supply chain partners. Without these inputs from both up and down the supply chain, aggregate planning cannot realize its full potential to create value.

The output from aggregate planning is also of value to both upstream and downstream partners. Production plans for an organization define demand from suppliers and establish supply constraint for customers. If a manufacturer has planned an increase in production over a given time period, the supplier, the transporter, and warehousing partner must be aware of this plan and incorporate the increase in their own plans.

Because operation decisions are being made in the short term, there is less uncertainty about demand information. Given the constraints established by the configuration and planning policies, the goal during the operation phase is to exploit the reduction of uncertainty and optimize performance.

Ideally, all stages of the supply chain should work together to optimize supply chain performance. An important supply chain issue is collaboration with downstream supply chain. Therefore, it is important to perform aggregate plans over as wide a scope of the supply chain as is reasonably possible.