UNIT : 8 MAINTENANCE MANAGEMENT:

UNIT STRUCTURE

8.1 Learning Objectives

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8.3.1 Objectives of Maintenance Management

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8.1 LEARNING OBJECTIVES

After going through this unit, you will be able to :

- define maintenance policy
- explain need for replacement
- identify replacement problems
- determine maintenance crew size

8.2 INTRODUCTION

Maintenance Management is the application of techniques of operations management to ensure breakdown free and smooth running of all plant and machinery within a facility and controlling the costs of maintenance. Maintenance management ensures improvement in efficiency of a facility by reducing possible loss that may occur by way of sudden faults in operation, frequent breakdowns inviting repairs leading to loss in man and machine hours thereby reducing profitability. Maintenance activities

in different machinery are different; which is again different for different equipments within machinery. The heterogeneity of the work adds to the heterogeneity in the type of work man required for attending maintenance jobs. The function is not only complex but also costly. However the necessity of ensuring error free operation necessitates the presence of it mandatorily in any facility.

8.3 OBJECTIVES AND TYPES OF MAINTENANCE

The major objectives of maintenance management are –

8.3.1 Objectives of Maintenance Management

a) Early detection and diagnosis of problems in machinery within a facility
b) Minimal wear and tear of machinery to ensure enhanced performance of the plant and machinery.
c) Minimise repair time and the cost so involved
d) Ensure error free operation of machinery to prevent accidents costing life of workmen.
e) Attain optimal performance of the plant and machinery thereby reducing non-productive time and attaining economies of scale in performance.
f) Attain goodwill of customers by way of adherence to delivery schedules free from production stops, equipment breakdowns, etc.
g) Achieve profitability with minimal loss in productive time within a facility
h) To pursue policies of replacement of machinery and its parts to have reliability and availability of the facility at minimal costs.

8.3.2 Types of Maintenance

a) Planned Maintenance
b) Preventive Maintenance
c) Breakdown maintenance

d) Predictive Maintenance

Planned Maintenance

Planned maintenance carries out maintenance activities of plant and machinery in a prescribed format to prevent possible occurrences of faults, breakdowns, etc. the practice follows inspection, servicing and overhauling of machinery prior to the alarm of danger (breakdown) rings. The objective is to ensure smooth operation within a facility with minimal stops. Planned maintenance follows the larger premise of a planned shutdown of a facility with conscious attempts of improving on the performance of all stages in an operation. Planned maintenance is religiously practised in continuous industries where a minor error could cause shut down of the entire operation. Planned maintenance is conducted in complete two phases viz., running maintenance and shut down maintenance. Running maintenance is performed in the normal operating condition of the machinery without any halts in production. Shut down maintenance is performed with a complete overhaul of the plant or its machinery. It is normally performed once in one or two years in continuous processes.

Preventive Maintenance

Under preventive maintenance, maintenance is carried prior to occurrences of its need. It performs maintenance of possible locations of failures through periodic servicing and inspection of machinery. Usual lubricating, cleaning, set-up adjustments and other activities performed at regular intervals and during equipment slowdowns are part of preventive maintenance programs. Preventive maintenance aims at reducing repetitive repairs through identification by inspection of machinery susceptible to breakdowns. It provides a safe working environment to workers through reduced repairs and better control of machinery.

Preventive maintenance maintains the reliable and optimal efficiency at nominal cost of maintenance. It ensures maximum availability of machinery for production.

Breakdown maintenance.

Breakdown maintenance is a rather a reactive program designed to activate on occurrence of breakdowns only. Whenever breakdown of machinery or its parts surfaces maintenance, which begins with repair works, is required to restore normalcy to the machinery and it's functioning. It is an emergency Breakdown maintenance is an expensive program since it is unpredictable in the costs of maintenance and the time involved. The facility may come to a sudden unpredictable halt for uncertain time in the process.

Breakdown maintenance performs necessary repairs at the point of breakdown to prevent replacement costs. Such maintenance is normally common in smaller factories where planned maintenance may be too expensive compared to the cost of a sudden halt or has been running under capacity. Common breakdowns handled by breakdown maintenance those which have occurred due to lack of lubrication, wear and tear of parts, etc.

Predictive Maintenance

Predictive maintenance is rather a new technique wherein equipment conditions are periodically observed to assess unusual operating behaviour like unusual sounds, vibrations, coolant failures, misalignment, abrasion, etc. Sensitive instruments like audio gauges, vibration analysers, amplitude meters, etc are employed for the purpose to asses and observe unusual behaviour in operating conditions of the machinery. Predictive maintenance is also known as condition monitoring and is conducted based on adequate study on the performance and behaviour of the machinery. Normally, mathematical analysis serves as a criterion in the decision of conducting predictive maintenance.

8.4 MAINTENANCE POLICY

Maintenance policy involves policy decisions in conducting maintenance of machinery, tools and equipment within a facility. It involves

planning and scheduling of maintenance activities for error free smooth operation. The following considerations are taken care of which designing the maintenance policy for a facility.

- **Type of process:**

  A job shop operation caters to diverse types of jobs at any instant. The volume of jobs handled for each sequence of operation is low. Such a process need not go for a planned maintenance program, through stoppage of all the activities within the process. Furthermore the process of planned maintenance would be expensive compared to expenses incurred owing to sudden breakdowns. A continuous process however cannot afford to face sudden breakdowns in any stage of the process leading to complete halt in the entire process. The set-up time, setup costs, the loss of profitability, and goodwill due to gaps in production are too costly for a continuous process. Such a process cannot afford to wait and watch for error to creep in the operation in order to diagnose them.

- **Type of machinery:**

  A stage in an operation will stop performing whenever machinery engaged in the stage stops performing. Some machinery works on simple techniques and are easily assembled and disassembled. Such machinery, if can be repaired without much of technical assistance and by the shop floor workmen, need not be maintained under planned or preventive maintenance programmes. There are however, equipments in operations which are installed and serviced by third party service providers. Repair and maintenance of such equipments require specialised know-how which cannot be easily sourced or cannot be performed by unauthorised staff and need to be maintained under supervision of competent maintenance personnel.

- **Costs involved**

  All said and done the choice of maintenance program is ultimately a result of the costs associated. The costs here refer to the costs involved in production stoppages due to maintenance in one hand

and the cost of running a maintenance program on the other. Another cost is the one occurring due to the necessity of replacement of machinery for non-performance of maintenance. It is the economics of maintenance cost, loss of production units and goodwill that decides which maintenance type is to be followed. Following a planned maintenance necessitates in taking prior decisions to ensure a smooth flow of production units during the period of planned maintenance. Enabling an uninterrupted flow of output in the market takes care of the goodwill and profitability of the organisation. However the cost of a planned maintenance program is high, it can be justified only with cost incurred due to sudden breakdowns requiring breakdown maintenance. Preventive maintenance leads to consistency in the quality of the products produced. In case of breakdown maintenance, need based repairs are performed which often cost the quality of the output products so produced. Such inconsistency can be inconsistency in quality, deteriorated products leading to frequent returns from customers and a tarnished brand image.

- **Safety at the work place**

  Workplace safety is a priority in any organisation. Maintenance programs are designed to prolong the productive life of any machinery and to reduce sudden breakdowns as far as possible. Maintenance ensures that operational parameters are set in safe limits to prevent accidental leakage of fluids, breakage of items, auto-ignition of vapour due to excessive heat generation, etc. Such operational limits ensure safety at the workplace. Cleaning being a part of maintenance prevents accidents that may be caused from spillage of fluids, scattered tools and equipments, etc.

8.5 NEED FOR REPLACEMENT

Replacement is a necessary requirement in any facility. Machinery and other equipments wear out in performance and gradually the cost of supporting them follows a cost curve. Replacement is done for machinery

and equipments whose productive life has elapsed. Additionally, it is done for machinery whose cost of maintenance is so high that it justifies replacing it with another. Sometimes the machinery stands no longer remains suitable to produce products demanded in the market. Under such circumstances it becomes imperative to substitute the functioning of the machinery with one of a higher specification or specifications that which may produce required products. In certain instances the technology of working of machinery can no more be serviceable necessitating the replacement of the same. Replacement has a cumulative effect in a facility. Replacing one equipment or machinery may necessitate modifications in the related machines or those immediately preceding or succeeding in the stages of operation. Efficiency or better performance obtained by way of replacement of certain machinery may not get revealed in the entire facility performance unless the performance of other machinery is also enhanced.

Replacement is imperative under the following conditions:

a) Wear and tear of machinery has lead to high costs of maintenance,
b) Loss in efficiency,
c) Deteriorated quality of the products produced, frequent and sudden break downs, etc
d) Obsolescence in the technology used in the machinery
e) Advanced technology being available which can produce better quality products, efficiency in power consumption, etc.
f) Servicing and maintenance cannot be arranged easily
g) Inability to produce products as per market demand.
h) Machinery creates unfit creating conditions hazardous or unsafe for the workmen.

8.6 CRITERIA FOR REPLACEMENT

Machinery can be replaced if it is technologically not suitable for use and if the costs of the replacement can be arranged by the organisation. Factors for deciding replacement of machinery can be discussed under two heads.

a) Technical aspects and

b) Financial aspects

Technical aspects

a) Functioning and deterioration of equipment

b) Technological life of the machinery

c) Adherence to safety and environmental regulations

d) Frequency of breakdowns and shut downs

e) Quality of products produced and demand in the market

f) Adherence to production deadlines

Financial aspects

a) Cost of maintenance and repairs

b) Cost of replacement of parts

c) Cost of power consumed

d) Salvage value towards end of service life

e) Cost of deteriorated quality products produced by the machinery

Problem 1.

A Super bakery produces variety of cakes and biscuits everyday in Gurgaon. It has a number of machines for the same. The bakery recently purchased a blender of capacity 5000ml at a cost of Rs. 9,000. The cost of installation of the blender has been Rs. 500. The scrap value of it is Rs. 1200. The blender needs oiling and servicing every year. The cost of oiling per year is given in the table below. Oiling has to be done by experts, service charges for each service is Rs. 200. The Board of Management is suggesting substitution of the existing blender with one from Germany of make Bl-1. The Finance department is however sceptical to purchasing the same immediately. The Board of Management wants to decide the year in which the blender should be replaced. Advise the Board of Management.

Year	1	2	3	4	5	6	7	8	9
Cost of oiling, etc. in Rs.	800	1300	1980	2800	3000	3300	4000	4300	4600

Cost of the blender = Rs. 9000

Cost of installation = Rs. 500

Scrap value of blender = Rs. 1200.

Service cost per service = Rs. 200

Solution:

The cost C of the blender includes the price P at which the blender is purchased and the cost of installation I.

P+I = C

9000 + 500 = 9500 = total cost of the blender

Since the salvage value S of the blender is Rs. 1200, the cost C_1 of the machine stands at

C_1= C- S

= Rs.(9500-1200)

= Rs. 8300

The annual cost incurred every year on the machine should hence include the cost of maintenance annually. The following table gives the annual cost incurred on the blender

Year	Cost of maintenance (oiling etc)	Cost of maintenance add service charge	cumulative maintenance charges	C-S (Fixed over all years)	Cost of blender and maintenance less scrap value	Amount spent on blender per year
1	800	1000	1000	8300	9300	9300.00
2	1300	1500	2500	8300	10800	5400.00
3	1980	2180	4680	8300	12980	4326.67
4	2800	3000	7680	8300	15980	3995.00
5	3000	3200	10880	8300	19180	3836.00
6	3300	3500	14380	8300	22680	3780.00
7	4000	4200	18580	8300	26880	3840.00
8	4300	4500	23080	8300	31380	3922.50
9	4600	4800	27880	8300	36180	4020.00

It has been observed from the table that year 6 onwards the annual cost incurred on the blender increases, hence the blender need to be replaced at the end of year 6.



CHECK YOUR PROGRESS

Q.1: Define maintenance management.

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Q.2: State two objectives of maintenance management.

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Q.3: State any two types of maintenance.

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8.7 RELIABILITY

The probability that a product provides uninterrupted service under normal operating conditions is a measure of its reliability. The duration during which a product is reliable is a measure of the time in which maintenance is not necessitated. The more reliable a product is, the less is its possibility of breakdown requiring maintenance. Knowledge of reliability of a product enables operations Managers to make approximate predictions of time of failure and the time for requirement of spares, and servicing. A measure of reliability enables managers to predict the life of a product and the possible time of replacement.

A washing machine with a reliability of 0.97 refers to 97 continuous working hours out of 100 available hours. The machine thus has a 0.03 chance of being faulty. Reliability is quality of a product over time since it is a measure of uninterrupted service from a product in a specified time. The higher the reliability the lesser is the need for maintainability.

A measure of reliability is obtained by the bath-tub curve popular in maintenance engineering.

The bathtub curve is a representation of failures that occur in the lifecycle of a product till its wear out. A product in its initial period of use is likely to fail more frequently. Normally such failures are a result of manufacturing flaws, design flaws, uneven stress developed in parts or

components, improper handling or operation of the products, etc. Such failures are handled through improvement in product design and manufacturing processes. This period of failure is termed as infant mortality since the product is more likely to fail in its infancy. Normally as the infancy period elapses for a product, the product performance becomes relatively stable; the product operates with minimal or without failure. Failure is however possible during this period due to accidental causes of failure. This period is termed a youth and forms the useful stage in the life of the product. With usage over time, the product gradually is subjected to wear and tear. Hence after a considerable period of use the products necessitates frequent maintenance as frequency of failures also rise. This is termed as the old age period. The failure rates during the entire life period of a product when plotted against time along the horizontal axis takes the shape of a bath tub and hence the name.

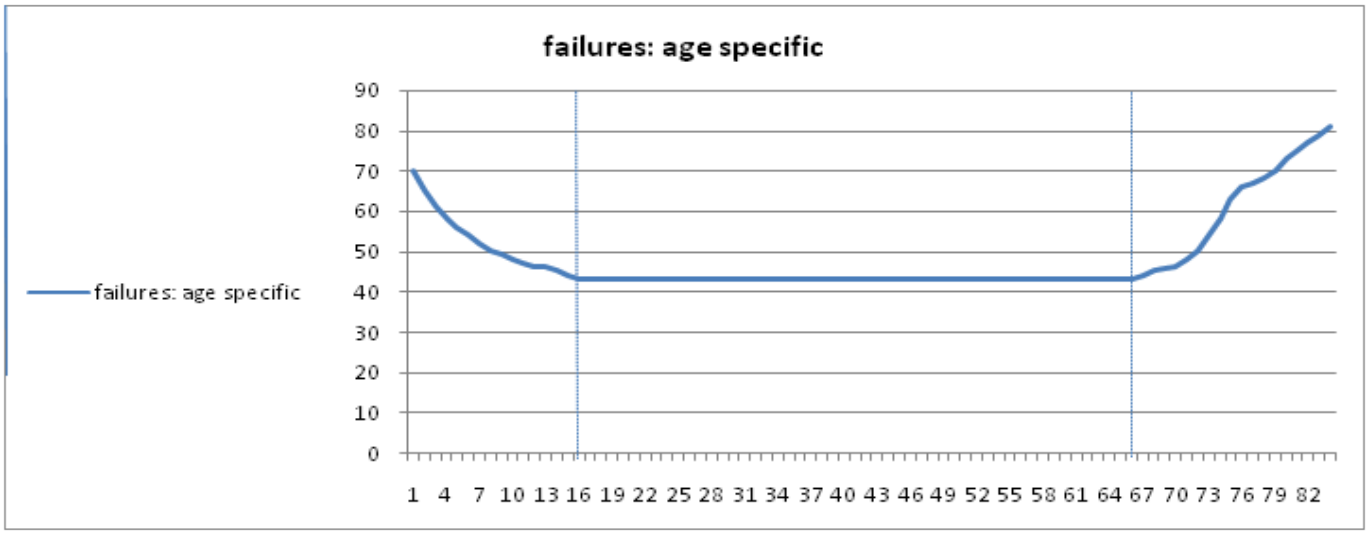


Figure 8.1

The bathtub curve is significant for the operations managers since it shows the length of each period in the life of the product. Ideally the infant mortality phase should be as short as possible and the youth period should be significantly long. Furthermore, the length and the frequency of failures during the infant mortality period enable managers to take significant decisions with regard to warranty of the products. Maintenance policies are to be adequately designed to minimise failures during the youth period. The

later part of the life faces frequent failures. The frequency and type of failure may help the managers to take steps on replacement of products.

8.8 DETERMINATION OF MAINTENANCE CREW SIZE

Crew size required for maintenance depends on average job load which includes scheduled maintenance and anticipated number failure or breakdown maintenance that might be required. Each type of maintenance has to be classified in terms of time required to attend the job. This in turn will help to assess the crew size. In case of breakdowns, the same needs immediate attention else it could prolong production stoppage. A larger crew size may render under utilisation of manpower whereas a smaller crew size may lead to backlog in the maintenance job. Non-occurrence of breakdown may lead to increased idle time of the crew. This in turn raises the cost of holding crew. Hence an estimated backlog of jobs is maintained. The optimal crew size is based on the backlogs and is given by:

Crew Size = Scheduled man hours per week/ (hours per week X backlog)

Where, Scheduled man hours per week= man hours required for attending scheduled maintenance and breakdowns based on prediction.

Information system for Maintenance Management

It is the detailed information of the operations that can help managers to decide and plan for performing maintenance function smoothly. For any machinery a record of the necessary maintenance required, with the tentative time for the same, may feed valuable input for decisions in future. It is imperative to have stored such information and to have ease of access to information pertinent to maintenance. Information necessary for the same may be of the following types:

a) The available or the possible bathtub curve to locate the infancy, useful life and wear out phase to locate the time of probable breakdowns.
b) Possible locations of breakdowns and the maintenance crew that might be required.
c) The detailed activities involved in the operation of the machinery to assess the costs.

d) The necessary mathematical models and /or record of readings to trace the presence or absence and the behaviour (if at all present) of unusual sounds, vibrations, etc. for predictive maintenance.

e) Schedules for proactive maintenance programmes.

f) A record of reliability of the machinery to assess for replacements.

Organisations are nowadays equipped with Maintenance Information System which is a robust package that tracks, and generates necessary information aiding operations managers for maintenance related decisions. Such a system is equipped with latest data on records of maintenance schedules, costs of maintenance, and the crew size requirement. The system simplifies and serves as an essential tool in helping maintenance mangers in conducting error free and efficient maintenance functions.



8.9 LET US SUM UP

In this unit, we have discussed the following:

- Maintenance management ensures improvement in efficiency of a facility by reducing possible loss that may occur by way of sudden faults in operation, frequent breakdowns inviting repairs leading to loss in man and machine hours thereby reducing profitability.
- Some of the Objectives of Maintenance Management are
  - Early detection and diagnosis of problems in machinery within a facility.
  - Minimal wear and tear of machinery to ensure enhanced performance of the plant and machinery.
  - Minimise repair time and the cost so involved
  - Ensure error free operation of machinery to prevent accidents
- Four popular types of Maintenance are
  - Planned Maintenance
  - Preventive Maintenance
  - Breakdown maintenance

- Predictive Maintenance

- Factors responsible for designing the maintenance policy for a facility are
  - Type of process
  - Type of machinery
  - Costs involved
  - Safety at the work place
- Sometimes when machinery no longer remains suitable to produce products it becomes imperative to replace the machinery with one of a higher specification or specifications that which may produce required products.
- Replacement becomes necessary under the following conditions:
  - Wear and tear of machinery causing high costs of maintenance,
  - Loss in efficiency,
  - Deteriorated quality of the products produced
  - Obsolescence in the technology used in the machinery
  - Availability of advanced technology being available.
- Replacement of machinery can be done in consideration technical aspects and financial aspects involved in the machinery.
- The probability that a product provides uninterrupted service under normal operating conditions is a measure of its reliability. The more reliable a product is, the less is its possibility of breakdown requiring maintenance.
- The bathtub curve is a representation of failures that occur in the lifecycle of a product till its wear out. The bathtub curve is significant for the operations managers since it shows the length of each period in the life of the product.
- Crew size required for maintenance depends on average job load which includes scheduled maintenance and anticipated number failure or breakdown maintenance that might be required.



8.10 FURTHER READING

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8.11 ANSWERS TO CHECK YOUR PROGRESS

Answer to Question No.1: Maintenance Management is the application of techniques of operations management to ensure breakdown free and smooth running of all plant and machinery within a facility and controlling the costs of maintenance.

Answer to Question No.2: Two objectives of Maintenance Management are:-

- To attain minimal wear and tear of machinery for enhanced performance of the plant and machinery.
- To minimise repair time and the cost involved in repairs.

Answer to Question No.3: The two types of Maintenance are:

- Planned Maintenance
- Preventive Maintenance



8.12 MODEL QUESTIONS

Q1: Why is Maintenance Management essential in any facility?

Q2: What are the objectives of Maintenance Management?

Q3: Under what conditions of machinery does its replacement become essential?

Q4: What is a bath-tub curve? How does it help in estimating maintenance programs?

Q5: Why is backlog an essential factor in determination of maintenance crew size?

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UNIT 9: CAPACITY PLANNING

UNIT STRUCTURE

9.1 Learning Objective

9.2 Introduction- Capacity Planning

9.3 Types of Capacity

9.4 Measures of Capacity

9.5 Capacity Planning Strategies

9.6 Flexibility in Capacity in a facility

9.7 Increasing the capacity of a plant

9.8 Estimating Capacity of a Facility

9.9 Capacity Planning: Evaluation of Alternatives

9.10 Let Us Sum Up

9.11 Further Reading

9.12 Answers to Check your progress

9.13 Model Questions

9.1 LEARNING OBJECTIVES

After going through this unit, you will be able to:

- state the meaning of Capacity and Capacity Planning
- describe the capacity requirement in a facility
- discuss various Capacity Planning strategies
- estimate the capacity of a plant
- make decisions related to replacement of machinery

9.2 INTRODUCTION -CAPACITY PLANNING

The maximum number of units of output or input that can be handled by a facility per unit of time is the capacity of the facility. A facility employs resources like man, materials, tools and equipments, etc for transformation of one form of input to another form of output. Capacity here represents the maximum possible units that can be generated by the use of the resources. The capacity of a tea factory can be the tonnes of green leaves processed by it; the capacity of vehicle manufacturer is the number of vehicles produced

by a plant, etc. A reprographic facility measures its capacity by the machine - hours of the photocopier machine. On the other hand a hospital measures its capacity by the number of patients that can be treated in a given period of time. For facilities that produce standard outputs of high volume output is used to measure the capacity. However for facilities that produce low volumes of customised types, input measures are used to describe the capacity of the facility.

Organisation type	**Measures of capacity**
Hospital	Availability of beds/ no. of patients that can be treated per day.
Retail shop	Floor area available
Automobile manufacturer	Vehicles rolled out per month/week
Consultancy firm	No. of consulting man-hours availability per month/week

Capacity Planning is an essential component for strategic growth of an organisation. It facilitates an organisation to determine the machinery, labour-size, and other capital intensive facilities. Capacity of a facility impacts the markets demands, cost structure, inventory policies, etc.

Proper Capacity Planning is essential because inaccurate capacity planning will either lead to under utilisation or overutilization of the facility which further leads to high initial investments and lesser profits. Over utilised capacity can cause higher breakdown of machinery, resentment amongst manpower, etc. It is therefore imperative to establish a judicious capacity in a facility to minimise possible occurrence of loss due to underutilisation or over-utilisation of capacity.

Capacity investments are fixed investments and are large in monetary terms. A judicious planning is needed in making such capacity decisions.

Capacity Planning enables managers to decide issues like:-

I. Number of customers a facility can handle

II. Buffer capacity essential to handle uncertainty in demands

III. Possible problems that may arise out of expansion of production system

9.3 TYPES OF CAPACITY

a) Design Capacity

The capacity of a facility as per design is its design capacity. In other words it is the capacity a facility designed to operate under normal or full scale operating conditions. It is measured by the maximum load of the facility that can be handled under ideal conditions of functioning. Design capacity is practically not attainable since it does not include occurrence of loss due to set-ups, adjustments, machine breakdowns, HR issues, etc. Ideal operating conditions can only ensure load as per design capacity.

b) Effective Capacity

Effective capacity is also known as system capacity. It is the capacity of a facility operating under the normal working conditions inclusive of machine adjustments, set up time loss, material replacements, etc. Effective capacity is the attainable level of capacity in a facility.

c) Actual Capacity

Actual capacity is the actual attainable output (or input) under limitations of machine breakdowns, absenteeism, defective products, etc. Actual capacity may be at times equal to effective capacity.

9.4 MEASURES OF CAPACITY

The criterion for deciding the capacity depends on a multitude of factors. As mentioned in the earlier sub units, variety in the output units and the volume against each variety produced decides whether the output gives measure of the capacity of the plant or the input. A refrigerator manufacturer measures the capacity by the units of refrigerators produced. Any facility

that produces high volume of a standardised product uses output as the measure of the capacity. A vehicle workshop handles a variety of repairing jobs. Each output for such a workshop is different from the other. In such cases there is low volume but high variety in the jobs. Such cases measure capacity by the volume of input vehicles it can handle. Similar measure applies to pure services like a doctor's consultancy.

An important feature in measuring capacity lies in the type of level in which it is measured. A heat treatment unit in a facility may measure its capacity by the hours available per unit of time. A painting shop may measure the capacity by the square meters of paint that can be applied per unit of time. However at the division level capacity may be measured by input or output measures as found appropriate.

Capacity helps to measure the performance of a system (or a facility). Generally two measures of capacity are commonly used to reflect the performance:-

a. $\text{Efficiency} = \dfrac{\text{Actual Out}}{\text{Effective Capacity}}$

b. Capacity Utilisation rate

$$= \frac{\text{Capacity used (or actual Output attained)}}{\text{Best Opertaing Level (or design capacity)}}$$

In the equations above, design capacity is a constant denominator; likewise, effective capacity can be at best increased up to design capacity. For enhancing capacity utilisation rate and efficiency, actual output must be increased. This calls for reduction in machine breakdowns, absenteeism etc. The variation between the effective capacity and the actual capacity is what is termed as 'waste'

Improving Actual Output

Actual output can be increased either by all or some of the following methods.

I. Production of uniform products and services reduce number of set-ups required for each production. A larger batch size entails lesser variations in the set-ups and hence reduced loss of set-up time.

II. Adequate quality control measures include maintenance planning to reduce machinery breakdowns, losses resulting from wear and tear, etc.

III. High employee morale to eliminate absenteeism, lock outs, etc., and good coordination with suppliers for on time deliveries.

IV. Adequately devised production planning and control measures to ascertain on-time delivery of products from vendors.

Capacity involves intensive capital investment. This calls for a judicious planning for optimum and not maximum utilisation of the capacity. In this context of optimal utilisation, economies of scale delineate the relationship of capacity and cost. As the volume of output increases, the fixed cost is shared by more number of units. In other words, the fixed cost per unit decreases with increase in the number of units produced. A higher volume warrants economies of scale. This also improves on the utilisation of resources in the facility. Additional to this, bulk discounts on account of larger input units, etc. are also possible in such cases. Further as the number of units continue to increase capacity gets over-utilised, breakdowns and machinery failures surface more and hence the plant now face diseconomies of scale.



CHECK YOUR PROGRESS

Q1: Define Capacity.

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Q2: What is Capacity utilisation rate?

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Q3: Write two methods of improving actual output of a facility.

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Fill in the blanks

a) Commodities are the goods produced in the ……sector

b) Service sector is a part of ……. sector

c) Commercial banks and developmental banks are examples of …….. services

9.5 CAPACITY PLANNING STRATEGIES

Capacity Planning strategies vary with the time frame in which decisions are to be considered for planning. Some issues of capacity planning addresses long term investment decisions while others address medium and short term decisions. Hence capacity planning strategies may be of long term, medium term or short term types.

Long term capacity expansion decisions involve expansions of facility, purchase of newer technology, etc. the emphasis is laid on making the proper amount of capacity available to meet the projected growth.

Medium term strategies involve accommodating capacity to seasonal variations of demand and short term sudden increase in growth which do not justify expansion of capacity through capital investments. The priority now is laid on strategies such as overtime, outsourcing and sub-contracting. Shifting demands from peak periods to non-peak periods is a generally followed strategy.

Short term capacity decisions are directed towards ensuring effective usage of plant and machinery ensuring smooth performance. The objective is to prevent all possible breakdowns and to check idle capacity. Such strategies include scheduling for effective resource deployment strategies and maintenance routines.

9.6 FLEXIBILITY IN CAPACITY IN A FACILITY

Making optimum utilisation of a facility though is the religious objective for any facility yet capacity of a facility is approximated through forecast only. The general rule hence becomes accommodating variations in actual

capacity requirements over the forecast values. A facility must be robust enough to absorb the variations over the predicted facility requirements. A cushion in capacity is maintained to accommodate such additional demands. Popular nowadays is the concept of Flexible Manufacturing System better known as FMS in Operations Management. Such systems are more adaptable, simple to change over from one type of product line to another and normally have minimal set up costs. Flexibility in capacity is a medium term capacity decision requiring handling of seasonality in demands of products, offsetting impact of peak periods, etc. Such systems enable to attain economies of scope.

9.7 INCREASING THE CAPACITY OF A PLANT

The process of conversion of inputs to outputs in any facility constitutes (normally) of a number of sequential operations (such processes are called multi-stage processes). Each operation is unique in its functions and the value addition it contributes to the input. The output from one activity forms the input to the immediately succeeding operation in the process. The handling capacity of each operation may not necessarily be same. The amount of input that can be fed to one operation can differ from the input that can be handled by another. In such a case sometimes the entire output from one operation cannot fed to the succeeding operations and this makes a part of the output from first process to wait to be fed into operation 2.

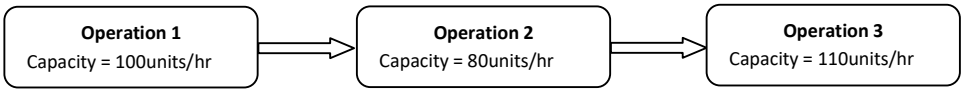


Fig 9.1 Operations in a multi-stage process with varying capacity of each operation

The above multistage operation shows that out of the 100 units from operation 1, 20 units cannot be immediately fed into operation 2. These 20 units need to wait till the operation 2 has completed its processing of the other 80 units. The entire multistage process is hence limited by the capacity of operation 2. Since operation 2 here limits the capacity of the entire process

it is called bottleneck in the system. Hence for capacity expansion in any facility the focus needs to be made at the bottleneck operation. This is however true only in case of fixed processes like that of mass production processes flow.

In case of a job shop, the problem of bottleneck normally surfaces in a slightly different form. An operation may at one instant be a bottleneck while at another instant another operation becomes the bottleneck. This is because each job demands a different sequence in operation.

9.8 ESTIMATING CAPACITY OF A FACILITY

Market conditions are continuously changing. Changing markets place demands for increased varied products and services from a facility. The existing facility may not however be able to produce products and services in demand. In the event that the market demands show a rising trend stop-gap arrangements may not serve. Hence capacity expansion may be required. Management might feel the need for capacity expansion, in anticipation of future market demands. A capacity planning exercise can be detailed with the following steps.

Step I : Estimation of total capacity requirement

Estimation of the total capacity is a resultant of external market environment and the internal organisational environment. The external market environment provides information about social, political, economic environment. The same provides clues about future direction of growth of an industry. In this context Porter's Five Forces model may be assessed to analyse the possible directions in growth in the near and later future. A futuristic market assessment along with a TOWS matrix analysis of the internal environment shows the necessary future capacity requirements.

Step II : Estimating Resource requirements

Once the total capacity required is assessed, the necessary resource estimations attain priority. Of the resources, necessary

capital intensive investments and manpower requirements are to be made. Capacity estimations are made on man-hour and /or machine hour basis for service and manufacturing facilities respectively.

Step 3 : Capacity availability calculations

As has been pointed out in the section, **Measures of Capacity,** the estimations of capacity done so far constitute the theoretical calculations and the most optimistic figures. However the actual capacity figure would be lesser than the same. This is because actual figures also accommodate sudden and planned stops in capacity utilisation. Planned stops may be preventive maintenance schedules, whereas sudden stops include absenteeism of labour, trade union strikes, machine failures, etc. though possible loss in resource-hours (man/machine) may be estimated and planning be made accordingly, unplanned and sudden stops cost a fortune, at times, to an organisation. Concern of any organisation should continuously be targeted towards reduced sudden stops in the capacity. This call for an exclusive employee friendly work-culture as is said, “Happy workers are productive workers’; and schedules of machinery maintenances to prevent possible lapses in working schedules.



CHECK YOUR PROGRESS

Q4: Define a multistage process.

……

……

Q5: What is a bottleneck in an operation?

……

……

9.9 CAPACITY PLANNING: EVALUATION OF ALTERNATIVES

A fool proof method of Capacity Planning involves evaluation and choice of alternatives. Commonly two methods are in use for evaluation of alternatives: Costs based method and the Performance based method.

1. Cost based methods

Cost based method involves assessment of all costs in each alternative to decide on the lowest cost alternative.

Capacity Planning decisions incorporate decisions related to purchase of plant and machinery. Sometimes plants need to be upgraded and at times plants need replacement to counter the effects of technological obsolescence. Sometimes capital investments are so high that managers are tempted to continue with the same set of available assets. Such a policy entails huge loss in profitability of the organisation.

Assessment of profitability arising out of investments in capacity expansion normally does not reveal benefits immediately or in the near future. Such investments are apparently costly. With time comes in the benefits from such investments. Sometimes larger benefits are preferred over smaller ones, *ceteris paribus*[1] *and* early benefits are preferred over later ones, *ceteris paribus.*

For the purpose of assessing the benefits from capacity investments popularly used methods are as below:

2. Payback method

Payback method calculates the time over which an investment made pays back. In other words, it calculates the time in which the investment made can be recovered. Any investment in capacity reflects as flow of cash back by way of implementation/utilisation of the asset/plant and machinery in the facility every year post installation.

Assuming the Initial investment as $C_{o,}$ and the cash flow as $C_{i,}$ in the i^{th}, the payback period is calculated as below:

$$\sum_{t=1}^{n}(Ct - Co) = 0$$

In case of availability of two or more available options of investment, the one with least payback period flows back the investment at the earliest and is the one chosen for implementation.

Exercise 9.1

Honda is planning to upgrade the painting assembly in its motor cycle plant. This would require installation of a newer assembly at its facility. The investment required is Rs. 60,000. The expected cash flow in five years is given

Year	1	2	3	4	5	6
Cash flow	30000	24000	24000	20000	28000	33000

If the acceptable payback period is $2\,1/2$ years, should Honda go ahead with the new assembly?

Solution

Year	1	2	3	4	5
Cash flow	30000	24000	24000	20000	28000
Cumulative flow back	30000 ((60000-30000)>0)	54000 ((60000-54000)>0	82000 ((60000-78000)<0		

Payback occurs after year 2.

Payback period = 2 + (60000-54000)/ 24000

= 2 + 6000/24000

= 2.25 years or 2 years 3 months which is less than years and hence Honda can go ahead with the new assembly.

3. Net Present Value Method (NPV)

More popular method in choice of investment proposals is the NPV method. The method looks into the cash flows from an investment from the perspective of present value. In other words the investment option is decided by calculating the cash inflows to the present at a given rate of return. In case the NPV is positive the option is accepted. In fact a higher NPV value guarantees better returns from an investment.

$$NPV=\sum_{t=0}^{n}\frac{C_t}{(1+i)^t}$$

Exercise 9.1

Honda is looking into purchasing a steering assembling unit as a technological upgradation to the present unit. Quotations were obtained from two vendors V1 and V2. Each of the machines involves an investment of Rs. 500000. The incremental cash flows are given. If the capital cost involved is 10 %. Advise Honda for the unit to be chosen.

Year	Cash flow as per quotation of V1	Cash flow as per quotation of V2
1	155000	142000
2	124000	153000
3	152000	135000
4	142000	154000
5	111000	100000

Solution :

PV factor refers to the present value of an amount with an interest rate of 10 %. The value is calculated as $1/(1.10)^n$, n referring to the payment period from now(i.e. n=0).

Present value is a product of the PV factor and cash flow against each year for the respective vendors.

Net Present Value is the sum total of the Present values for the respective vendors.

year	PV factor	Cash Flow V1	Present value V1	Cash Flow V2	Present value V2
0	1	-500000	-500000.00	-500000	-500000.00
1	0.909091	155000	140909.09	142000	129090.91
2	0.826446	124000	102479.34	153000	126446.28
3	0.751315	152000	114199.85	135000	101427.50
4	0.683013	142000	96987.91	154000	105184.07
5	0.620921	111000	68922.27	100000	62092.13
		NPV	23498.46	NPV	24240.89

NPV values in both cases are positive hence having considered each individually both investments could be made. However given an option to choose one of the two, Honda should go for Vendor 2 since NPV with V2 is higher than that of V1.

4. Performance based alternatives

Performance based alternatives assess performance of the process in the terms of resources utilised and loss due to waiting time. Employing methods of resource planning can help to improve the capacity of a facility. Waste elimination and de-bottlenecking are effective measures in this connection. Performance based alternative compares alternative while multiple resources are employed. The method uses tools like decision trees, simulation, and waiting lines.

5. Decision Trees

A decision tree is a representation of the various alternatives with the outcomes. It is used for decisions of sequential nature. The points of decisions are represented with rectangles called nodes. The branches from this node represent the options for the decision. Circles represent point of outcomes. Probabilities are assigned to the outcomes based on learning experience and expert judgements.

Exercise 9.2

Mr. Nair owns an omni-van with seating capacity of 8 which he uses for transporting children to and from school. He is presently facing

pressure from parents to accommodate more children in his van. He is therefore thinking of replacing his existing van with a winger to accommodate more children. Replacing the omni with a winger will require an investment of 5 lacs. He is also thinking of another option of purchasing an additional vehicle. Purchasing another vehicle (omni) will cost him Rs. 6 lacs.

Mr Nair is running under financial crisis. Hence replacing the omni with the winger and purchasing an additional omni can be made together. At best he can choose one option only. However while choosing one option, if he observes further demand from parents, he may move with the other option as well. The probability of strong demand is 0.7 on replacing the existing omni with a winger and this would lead to a profit of Rs 10 lac. After the purchase of an additional omni there is a probability of 0.75 of a strong demand and a profit of 6 lacs.

Decide the best course of action Mr. Nair should take.

Solution:

Options available to Mr. Nair:

1. Continue with the present vehicle ignoring the demand
2. Replace the omni with a winger
3. Purchase a new omni

Option 1 needs Rs. 0 investment and leads to Rs. 0 profit

Option 2 will lead to a profit of Rs. 10 lac if demand is high with probability of 0.7 or it would cause a loss of 5 lacs with a probability of 0.3, if demand is low.

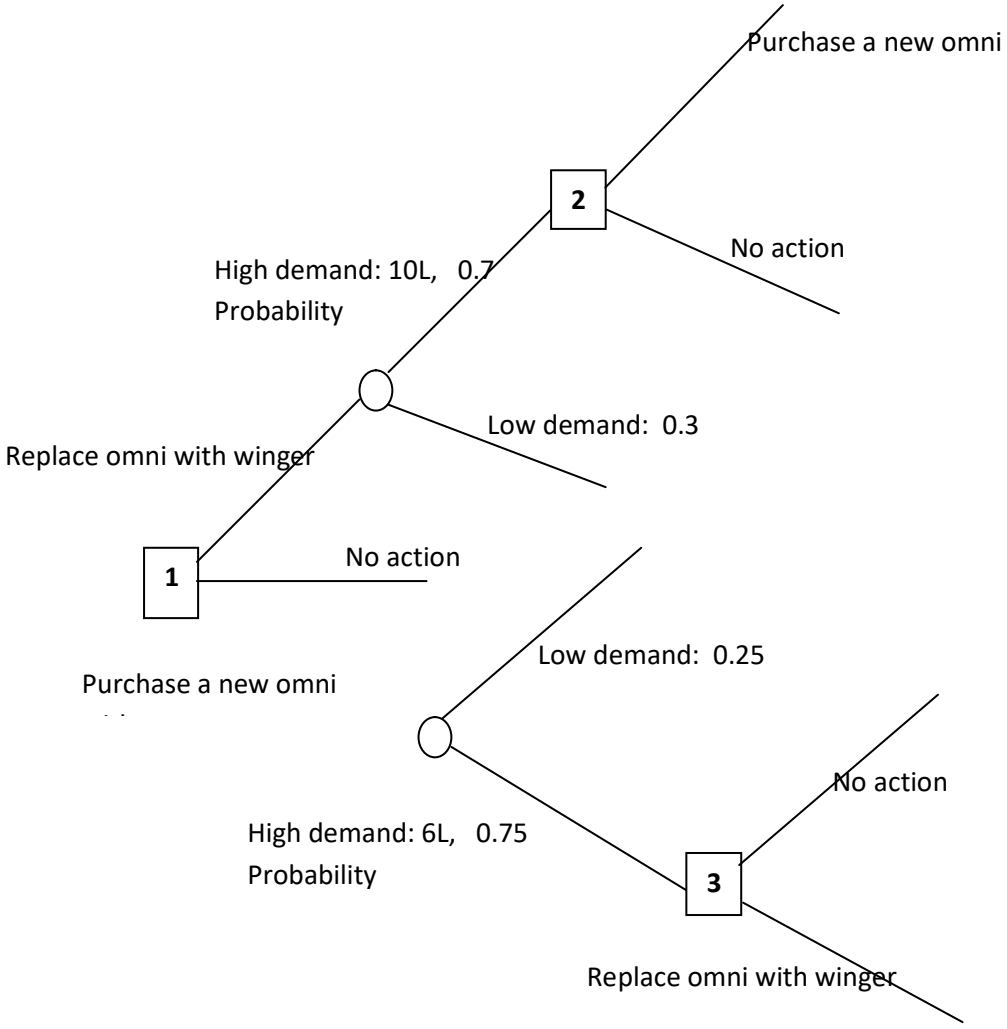
Option 3 may bring a profit of Rs.6 lacs with a probability of 0.75 for strong demand while it might also have a weak demand of probability of 0.25 leading to a loss of 6 lacs.

Additional to the above if Mr. Nair chooses option 2 he may further continue option 3 in case he observes demand from the market.

Similarly if he chooses option 3, he may afterwards take up option 2 following demand in the market.

Options	Outcome	Probability	Conditional value
No action		1	0
New Omni purchase	weak	0.25	-0.6
	Strong	0.75	0.6
Replace existing Omni by a winger	weak	0.3	-0.5
	Strong	0.7	1

The expected value at each node is obtained by multiplying the conditional value with the corresponding probability assigned.
Hence for Node 2 and 3, the total expected value is the sum total of expected values associated at the alternatives in the node.



Alternatives	**Outcome**	**Probability**	**Conditional value in 10 Lacs**	Expected value **in 10 Lacs**
Node 2				
New Omni purchase	weak	0.25	-0.6	-0.15
	Strong	0.75	0.6	0.45
			Total	0.3
No action		1	0	0
Node 3				
Replace existing Omni by a	weak	0.3	-0.5	-0.15
Winger	Strong	0.7	1	0.7
			total	0.55
No action		1	0	0
Node 1				
Replace existing Omni by a	weak	0.3	-0.5	-0.15
Winger	Strong	0.7	1.3	0.91
			total	0.76
No action		1	0	0
New	weak	0.25	-0.6	-0.15
Omni purchase				
	Strong	0.75	1.15	0.8625
			total	0.7125

Calculation for the best choice of alternative.

For Node 1, the total expected value would be determined considering outcomes at nodes 2 and 3 individually. Therefore after replacement of the Omni with a winger, if the demand is high, Mr. Nair may further opt for purchase of an additional Omni. Hence under the row against high demand the conditional value is obtained by a sum of the total

expected value for purchase of new Omni in node 2 and the conditional value for high demand for replacement (Omni with winger) in node 3. This gives a value of 1.3 or 13 lacs. In the similar manner for purchasing of a new Omni followed by replacement of the existing Omni with a winger, in node 1, the conditional value is 1.15, i.e., 11.5 lacs.

The net expected value considering the options under node 1 is as below having calculated values at nodes 2 and 3 is obtained:

1. Replace existing Omni by a Winger:	7.6 Lacs
2. New Omni purchase:	7.125 Lacs.

Mr. Nair would be at better profit status if he replaces his Omni by a winger



9.10 LET US SUM UP

In this unit, we have discussed the following :

- Capacity of the facility is the maximum number of units of output or input that can be handled by a facility per unit of time.
- It facilitates an organisation to determine the machinery, labour-size, and other capital intensive facilities.
- Capacity of a facility impacts the markets demands, cost structure, inventory policies, etc.
- Inaccurate capacity planning may lead to under utilisation or overutilization of the facility which further leads to high initial investments and lesser profits.
- Design Capacity is measured by the maximum load of the facility that can be handled under ideal conditions.
- Effective capacity is the capacity of a facility operating under the normal working conditions inclusive of machine adjustments, set up time loss, material replacements, etc.
- Actual capacity may be at times equal to effective capacity.

- Generally two measures of capacity are commonly used to reflect the performance viz., efficiency and capacity utilisation rate
- Capacity estimations are made on man-hour and /or machine hour basis for service and manufacturing facilities respectively.
- Commonly two methods are in use for evaluation of alternatives for investment decisions relating to capacity investments are costs based method and the performance based method.



9.11 ANSWERS TO CHECK YOUR PROGRESS

Answer to Question No.1: Capacity of a facility is the maximum number of units of output or input that can be handled by a facility per unit of time is the capacity of the facility. Capacity refers to the maximum possible units that can be generated by the use of the resources.

Answer to Question No.2: Capacity Utilisation rate is the ratio of actual output attained and the design capacity of the facility. For enhancing capacity utilisation rate and efficiency, actual output must be increased.

Answer to Question No.3: Actual output can be increased by any one of the two methods.

- Production of uniform products and services leading to reduced number of set-ups and further reducing set-up time.
- Adequate quality control measures include maintenance planning to reduce machinery breakdowns, losses resulting from wear and tear, etc.

Answer to Question No.4: A multi-stage process is a one where conversion of inputs to outputs in any facility constitutes of a number of sequential operations. The output from one activity forms the input to the immediately succeeding operation in the process.

Answer to Question No.5: In a multi-stage process, the operation that limits the operation of the entire process by capacity of processing is the bottleneck in the process.



9.12 FURTHER READING

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9.13 MODEL QUESTIONS

Q1: What would be the measures of capacity for a coaching centre and bicycle repair shop?

Q2: Define efficiency. Why is efficiency important in capacity utilisation of a facility?

Q3: What are the considerations to be made in estimating capacity of a facility?

Q4: Why does the bottleneck keep on changing for different jobs in a job shop facility?

Q5: How is flexibility of capacity obtained in a facility?

Q6: What are Flexible Manufacturing Systems?

Q7: How do cost based method differ from performance based method in evaluation of alternatives for of capacity planning decisions?

Q8: Of the cost based methods in evaluation of alternatives discussed in the unit, why is the NPV method a better one than the Payback method?

(Footnotes)

[1] Latin phrase meaning other things remaining constant

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UNIT 10: PRODUCTION PLANNING AND CONTROL

UNIT STRUCTURE

10.1 Learning Objectives

10.2 Introduction

10.3 Meaning and definition of Production Planning and Control

10.4 Elements of Production Planning and Control

- 10.4.1 Routing
- 10.4.2 Scheduling
- 10.4.3 Dispatching
- 10.4.4 Follow Up or Expediting

10.5 Techniques of Control

10.6 Advantages of Production Planning and Control

10.7 Let Us Sum Up

10.8 Further Readings

10.9 Answers To Check Your Progress

10.10 Model Questions

10.1 LEARNING OBJECTIVES

After going through this unit, you will be able to :

- define Production planning and control
- explain the elements of Production planning and control
- outline the techniques of Production planning and control
- explain the advantages of Production planning and control

10.2 INTRODUCTION

This unit will introduce you to the concept of Production planning and control. Production planning and control (PPC) is most essential for any organisation. Planning process within an organisation is dynamic and continuous. In this unit we are going to discuss how production

process is planned and scheduled and ultimately implemented in a production unit. For production purpose, all the facilities should be arranged and the factory itself has to be properly set up. PPC involves the planning of production, a decision on the sequence of operations to achieve what has been planned , the setting of starting and finishing time for production, proper dispatching of the material, and follow up action to check the progress of operations.

10.3 MEANING AND DEFINITION OF PRODUCTION PLANNING AND CONTROL

Planning and control generally involve the planning of manufacturing process. Especially it consists of the planning of routing, scheduling, dispatching, inspection, and coordination, control of materials, methods, machines, tools and operating times etc. The ultimate objective of PPC is to organize the supply and movement of materials and labour, machines utilization and related activities, in order to bring about the desired manufacturing results in terms of quality, quantity, time and place.

Production control regulates and stimulates the orderly show of materials in the manufacturing process from the beginning to the end.

Production planning may be defined as the technique of foreseeing every step in a long series of separate operations, each step to be taken at the right time and in the right place and each operation to be performed in maximum efficiency.

Planning and control are the two most important and dynamic process of management. Managers plan for different activities in their organisation and through control mechanism they take corrective actions where ever required.

Production planning consists of the evaluation and determination of production inputs such as labour, machinery and equipment, materials and utilities to achieve the desired goal. The productivity of an organisation can be improved by better planning efforts.

Production planning and control can be defined as “the process of planning or deciding on the resources the firm will require for its

future manufacturing operations and of allocating and time scheduling these resources to produce the desired products on time at the least total cost."

Generally PPC is used in manufacturing organisations. But it can also be used in different non manufacturing units also. For example, we can use PPC in any restaurant to provide customer service more efficiently.

10.4 ELEMENTS OF PRODUCTION PLANNING AND CONTROL

There are basically four elements in PPC, which are stared as below:

- Routing
- Scheduling
- Dispatching
- Follow up

10.4.1 Routing

Routing is the planning process, which is undertaken to find the best possible path for manufacturing a certain product. It determines what work will be done on a product and how it will be done. It establishes the operations, their path and sequence, and the proper class of machines that require performing specific operations. Routing prescribes the flow of work in the plant and it is related to the considerations of layout, temporary location for raw materials and components and material handling system.

The main aim of routing is to determine the best and cheapest Production Planning and control

Routing procedure involves the following different activities:

(1) An analysis of the article to determine what to make and what to buy.

(2) To determine the quality and type of material

(3) Determining the manufacturing operations and their sequence.

(4) A determination of lot sizes

(5) Determination of scrap factors

(6) An analysis of cost of the article

10.4.2 Scheduling

The next step after routing is scheduling. Scheduling is the allocation of resources applying the limiting factors of time and cost to perform a collection of tasks. It involves the assignment of starting and completion times for the various operations to be performed. Therefore scheduling can bring productivity in shop floor by providing a schedule/ routine for processing a set of jobs. Scheduling finds the total time needed for manufacturing of a product. It also finds the time required in each machines to perform each task. The purpose of scheduling is to execute a customer's order well in time. For example, if we order for a car, the manufacturer will estimate the time required for its production and then will give us the delivery date. Scheduling is that phase of production and control, which rates the work in order of its priority and then provide for its release to the plant at the proper time and in correct sequence. Thus, scheduling is concerned with when the work shall be performed on a product. Routing and scheduling activities are complementary to each other. One cannot route properly without having previously designed schedule and scheduling is impossible without the knowledge of required routing.

The essence of scheduling is to make allocation decisions pertaining to the starting and finishing times for tasks. Scheduling can be classified into Single machine scheduling, Flow shop scheduling and Job shop scheduling.

Scheduling is mainly concerns with time element and priorities of a job. The pattern of scheduling differs from one job to another which is explained as below:

Production schedule: The main aim is to schedule that amount of work which can easily be handled by plant and equipment without interference. Its not independent decision as it takes into

account the following factors.

(1) Physical plant facilities of the type required to process the material being scheduled.

(2) Personnel who possess the desired skills and experience to operate the equipment and perform the type of work involved.

(3) Necessary materials and purchased parts.

Master Schedule: Scheduling usually starts with the preparation of the master schedule which is weekly or monthly break-down of the production requirement for each product for a definite time period. This would enable the production manager to shift the production from one product to another as per the changed production requirements. This forms a base for all subsequent scheduling acclivities. A master schedule is followed by operator schedule which fixes total time required to do a piece of work with a given machine or which shows the time required to do each detailed operation of a given job with a given machine or process.

Best scheduling is not always possible because of the following conditions:

- Physical plant facilities of the type required to process the material being scheduled.
- Personnel who possess the desired skill and experience to operate the equipment and perform the type of work involved and,
- Necessary materials and purchased parts.

While preparing schedules, the types of orders and their promised delivery dates must be taken into consideration. Some orders may call for overtime work because they have to be delivered soon. Such rush orders should receive priority over repeat orders, which can be scheduled for completion in the normal course.

10.4.3 Dispatching

Dispatching is the transition from planning phase to action phase.

In this phase, the worker is ordered to start manufacturing the product. Dispatching involves the actual granting of permission to proceed according to plans already laid down. In dispatching, orders are issued in terms of their priority.

The dispatch section of the PPC is responsible for the following task:

- Checking the availability of material and then taking appropriate action to have it transferred from the main stores to the point at which it is needed.
- Ensuring that all production aid is ready when needed and then having them issued to manufacturing departments.
- Obtaining specific drawings from the drawing office.
- Informing the process section that production is commencing.
- At the conclusion of the manufacturing, ensure that all the drawings, layout and tools are withdrawn and returned to their correct location.

Dispatching is an important step as it translates production plans into actual production.

10.4.4 Follow up or expediting

Once production has been set in motion, it is necessary to check that it is proceeding according to the plan. Every production programme involves determination of the progress of work, removing bottlenecks in the flow of work and ensuring that the productive operations are taking place in accordance with the plans. It spots delays or deviations from the production plans. It helps to reveal detects in routing and scheduling, misunderstanding of orders and instruction, under loading or overloading of work etc. All problems or deviations are investigated and remedial measurers are undertaken to ensure the completion of work by the planned date.

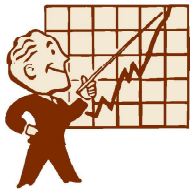
Generally production is assumed to progress as expected. But there may be differences which may arise due to the following

reasons:

- Materials may be delivered late or may not be delivered at all.
- Associated departments may have fallen behind in their own production.
- There may be excessive absenteeism on the part of the worker.
- The customer may insist on changing the specification or delivery date.
- Machines may break down.
- There may be errors in drawings.
- There may be too many rejections due to poor material quality.

Other things related to production are inspection and corrective actions. Inspection: This is mainly to ensure the quality of goods. It can be required as effective agency of production control.

Corrective measures: Corrective action may involve any of those activities of adjusting the route, rescheduling of work, changing the workloads, repairs and maintenance of machinery or equipment, control over inventories, poor performance of the employees. Certain personnel decisions like training, transfer, demotion etc. may have to be taken. Alternative methods may be suggested to handle peak loads.



CHECK YOUR PROGRESS

Q.1: Fill in the blanks with appropriate words:

(i) There are ———————————— elements in Production Planning and Control process.

(ii) Routing is the ---------- activity which determines the best rout for manufacturing.

(iii) Scheduling involves starting and completion ---------- for various operations to be performed.

(iv) ---------- involves actual permission to proceed as per the plan.

(v) Follow up is the process of ---------- the activities , whether it is going as per the plan or not.

10.5 TECHNIQUES OF CONTROL

Production control is the process of planning production in advance of operations, establishing the exact route of each individual item part or assembly, setting, starting and finishing for each important item, assembly or the finishing production and releasing the necessary orders as well as initiating the necessary follow-up to have the smooth function of the enterprise. The production control is of complicated nature in small industries. The production planning and control department can function at its best in small scale unit only when the work manager, the purchase manager, the personnel manager and the financial controller assist in planning production activities. The production controller directly reports to the works manager but in small scale unit, all the three functions namely material control, planning and control are often performed by the entrepreneur himself. Production control starts with dispatching and ends up with corrective actions.

Production technique is an updating and revising procedure, through which the requirements of implementation, the labour assignments, the machine assignments, the job priorities, the production routes etc may be revised. It is a correcting mechanism which goes on through out the implementation process of the already drawn out production plan and schedule. In order to perform the function of PPC properly, managers require some techniques to control any deviations.

Following are the some of the technical tools used by the managers:

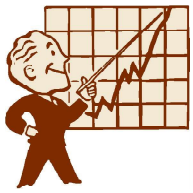
1. Control Charts and Graphs: Gantt chart is an effective control chart used to gauge the planned and actual progress. Again a simple graph will be highly useful to compare actual progress with the scheduled progress.
2. Control Boards: A control board is a device for automatically indicating the progress of the work. Control boards are generally used for repetitive productions.

3. Communication systems: Quick exchange of information and instructions is highly useful for controlling productions.
4. Quantitative techniques: With the help of quantitative techniques like, PERT, CPM or linear programming, managers can control production.

10.6 ADVANTAGES OF PRODUCTION, PLANNING AND CONTROL

Following are the advantages of using PPC in any plant:

- PPC forecasts sales orders and makes sales order more economical in production.
- It co-ordinates the operations of several departments.
- It ensures better service to customers by delivering quality goods within the specified time period.
- Reduces production costs through orderly scheduling of work activities and reducing wastages.
- Reduces employee idle time.
- Ensures a better control of material and contributes to efficient buying.



CHECK YOUR PROGRESS

Q.2: What are the techniques used by managers in production control?

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Q.3: Write any two advantages of PPC.

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10.7 LET US SUM UP

In this unit we have discussed how production process is planned and scheduled and ultimately implemented in a production unit. Production planning and control (PPC) is most essential for any organisation. PPC involves the planning of production, a decision on the sequence of operations to achieve what has been planned , the setting of starting and finishing time for production, proper dispatching of the material, and follow up action to check the progress of operations.

Generally PPC is used in manufacturing organisations. Elements of PPC are Routing, Scheduling, Dispatching and Follow up. There are different Techniques of production control are used such as Control Charts and Graphs, Control Boards, Communication systems, Quantitative techniques etc. Managers can avail lots of benefits by using PPC. PPC forecasts sales orders and makes sales order more economical in production. It reduces production costs through orderly scheduling of work activities. PPC also reduces an employee's idle time and ensures a better control of material and contributes to efficient buying.



10.8 FURTHER READING

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- Production and Operations Management, by R. Panneerselvam, PHI publications.
- Production and Operations Management, by S.N. Chary, Tata Mc Graw Hill.



10.9 ANSWERS TO CHECK YOUR PROGRESS

Ans. to Q. No. 1:

1. (i) Four, (ii) Planning, (iii) Time, (iv) Dispatching, (v) Checking.

Ans. to Q. No. 2: Control Charts and Graphs, Control Boards, Communication systems, Quantitative techniques.

Ans. to Q. No. 3: (a) PPC forecasts sales orders and makes sales order more economical in production,(b) It co-ordinates the operations of several departments.



10.10 MODEL QUESTIONS

Q.1: What do you mean by Production planning and control?

Q.2: Explain the different elements of PPC.

Q.3: Explain the different techniques used in control process.

Q.4: Do you think the follow up stage is important in any production plan? If yes, explain your comment.

Q.5: Discuss few advantages of PPC.

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UNIT 11: INTRODUCTION TO PURCHASING

UNIT STRUCTURE

11.1 Learning Objectives

11.2 Introduction

11.3 Overview of Purchasing Function

11.4 Activities Under Purchasing Function

11.5 The Transition of Purchase To Supply Management

11.6 Types of Calls For Bids

11.7 Locating Tenders

11.8 Selection of Bidders

11.9 Bidding Process

11.10 Technical Evaluation

11.11 Commercial Evaluation

11.12 Negotiating

11.13 Selection And Award

11.14 Post-Award Administration

11.15 Let Us Sum Up

11.16 Further Reading

11.17 Answers To Check Your Progress

11.18 Model Questions

11.1 LEARNING OBJECTIVES

After going through this unit, you will be able to :

- explain the basic concept of Purchasing system followed in organization
- know the objective and importance of following a professional purchasing system
- explain the standard purchasing methods and procedure.

11.2 INTRODUCTION

In the earlier unit we have discussed about product design. Now we are going to discuss on purchasing management. Purchasing refers

to a business or organization attempting to acquire goods or services to accomplish the goals of the enterprise. Though there are several organizations that attempt to set standards in the purchasing process, processes can vary greatly between organizations. Typically the word “purchasing” is not used interchangeably with the word “procurement”, since procurement typically includes Expediting, Supplier Quality, and Traffic and Logistics (T&L) in addition to Purchasing. Purchasing function is one of the most important business functions in an organization. All business organizations follow a well defined, documented and systematic process of purchasing. In government organization the activities related to purchasing process is stricter to prevent any discrepancy and malpractices.

11.3 OVERVIEW OF PURCHASING FUNCTION

Purchasing managers/directors, and procurement managers/ directors guide the organization’s acquisition procedures and standards. Most organizations use a three-way check as the foundation of their purchasing program. This involves three departments in the organization completing separate parts of the acquisition process. The three departments do not all report to the same senior manager to prevent unethical practices and lend credibility to the process. These departments can be purchasing, receiving; and accounts payable or engineering, purchasing and accounts payable; or a plant manager, purchasing and accounts payable. Combinations can vary significantly, but a purchasing department and accounts payable are usually two of the three departments involved.

Historically, the purchasing department issued Purchase Orders for supplies, services, equipment, and raw materials. Then, in an effort to decrease the administrative costs associated with the repetitive ordering of basic consumable items, "Blanket" or "Master" Agreements were put into place. These types of agreements typically have a longer duration and increased scope to maximize the Quantities of Scale concept. When additional supplies are required, a simple release would

be issued to the supplier to provide the goods or services.

This trend away from the daily procurement function (tactical purchasing) resulted in several changes in the industry. The first was the reduction of personnel. Purchasing departments are now smaller. There was no need of group of clerks processing orders for individual parts as in the past. Another change was the focus on negotiating contracts and procurement of large capital equipment. Both of these functions permitted purchasing departments to make the biggest financial contribution to the organization.

Objectives of Purchasing

Following are the objectives of purchasing

- To ensure smooth flow of raw material in the production process
- To get the best quality of raw material for production
- To minimize the raw material cost
- To identify the best source / supplier of raw material
- To strengthen the relationship between the supplier and the company
- To ensure the delivery of the right material to the right customer at the right time

11.4 ACTIVITIES UNDER PURCHASING FUNCTION

The purchasing function comprises the essential activities associated with the acquisition of the materials, services, and equipment used in the operation of an organization. The major types of activities are:

- Coordination with user departments to identify purchase needs
- Discussion with sales representative
- Identification of potential suppliers
- The conduct of market studies for important materials
- Negotiation with potential suppliers
- Analysis of proposals
- Selection of suppliers
- Issuance of purchase order
- Administration of contracts and resolution of related problems

- Maintenance of a variety of purchasing records

During the early years, purchasing function tended to be handled in a reactive, "staff support" manner. Subsequently, it was conducted more professionally with a managerial emphasis. But it was still viewed largely as a group of tactical activities. In those firms that have not moved toward the development of the procurement or supply management concepts, the importance of purchasing function has not diminished, but often it is not being fully realized because it still has a tactical, operations oriented focus.

The firms that have seen the strategic potential inherent in this function have tended to enhance its basic activities by expanding them and developing procurement or supply management operations.

11.5 THE TRANSITION OF PURCHASE TO SUPPLY MANAGEMENT

The progression from purchasing to supply management involves two major paradigm shifts. (1) From a focus on internal processes to value added benefits and (2) from tactical to a strategic focus.

Value adding benefits:

Historically the performance of many purchasing managers and their organizations was measured and evaluated on changes in the purchase price of the materials, their ability to keep the production line running, and the cost of their department's operation. Today many world class organizations expect their purchasing and supply management function focus on the following five value-adding outputs of proactive procurement or supply management.

1. **Quality**: The quality of purchased materials and services should be virtually defect free.
2. **Cost**: The purchasing and supply management function must focus on strategic cost management. Strategic cost management is the process of reducing the total cost of acquiring, moving, holding, converting, and supporting products containing purchased materials and services throughout the supply chain.

3. **Time:** The purchasing and supply management function and its outside suppliers must play active roles in reducing the time required to bring new products to the market.
4. **Technology:** The purchasing and supply management function has two key responsibilities in the area of technology: (1) It must ensure that the firm's supply base provides appropriate technology in a timely manner (2) It must ensure that is the technology which affects the firm's core competencies is carefully controlled when dealing with the outside suppliers.
5. **Continuity of supply:** The purchasing and supply management function must monitor the supply trends, develop appropriate similar supply alliances, and take such other actions as are required to reduce the risk of supply disruptions.

Strategic Focus:

As has been discussed, purchasing's historical focus has been on purchase price and continuity of supply. Supply management adds the following strategic activities:

1. **Integration**: The firm's supply strategy must be integrated with the organization's marketing, conversion and finance strategies and that of the corporation or strategic business unit.
2. **Business Environment**: Supply management must address the identification of threats and opportunities of the firm's supply environment.
3. **Technology**: As discussed in the previous section, supply management must address the issues of technology access and control. The firm wants to gain access to technology in its supply base while being careful not to create competitors through outsourcing activities.
4. **Component and commodity strategies**: Supply management must develop formalized market driven supply plans for critical purchase materials and services.
5. **Management Information System**: Supply management must ensure that a timely, cost effective and comprehensive information

system is in place to provide data required as and when required to make optimal supply decisions.

6. **Centralization of development and management**: The development and management of organization's supply strategy will be centralized, while the low value adding supply activities will be decentralized.
7. **Use of senior procurement professionals**: The typical manufacturer will assign to the senior procurement professionals the responsibilities of managing five to ten key supply relationships or alliances.
8. **Use of professional personnel**: More professional personnel must be assigned to purchasing/procurement/ supply management.

11.6 TYPES OF CALLS FOR BIDS

There are different types of tenders, which are discussed as follows–

- "Open tenders", in other words open calls for tenders, also called advertised tenders, are open to all vendors or contractors who can guarantee performance.
- "Restricted tenders", in other words restricted calls for tenders, also called invited tenders, prequalified, short-listed, or selective tenders, are only open to selected prequalified vendors or contractors. Example: ad and results.

There are 3 main procedures when tendering for contracts that are above a certain level cost:

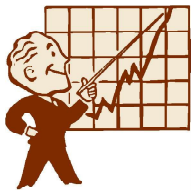
- Open procedure
- Restricted procedure
- Negotiated procedure

Each of them works in different ways.

11.7 LOCATING TENDERS

In India Notice Inviting Tenders (NIT) are published in notional dailies. Tender invitations are also published in the websites of respective

organizations. Now a days many Government and private organizartions have gone for e-tendering processes. There are many websites available where one may get the information of Notice Inviting Tenders (NIT) Because of the special language and sometimes the difficult to grasp the procedures, some organisations also offer companies with Tender writing training or do the writing for them. Workshops are run either for half a day or 1 day and one can get much idea there to have a good understanding of what is expected of one when tendering.



CHECK YOUR PROGRESS

Q1: List down the major types of activities under purchasing function

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Q.2: Make a list of value-adding outputs of proactive procurement or supply management.

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Q.3: Make a list of the strategic activities of purchase and supply management

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Q.4: The three main procedures when tendering for contracts that are above a certain level cost are :

(i) .....

(ii) .....

(iii).....

11.8 SELECTION OF BIDDERS

This is the process where the organization identifies potential suppliers for specified supplies, services or equipment. These suppliers' credentials (qualifications) and their history are analyzed, together with the products or services they offer. The bidder selection process varies from organization to organization, but can include running credit reports, interviewing management, testing products, and touring facilities. Often purchasing managers research the potential bidders obtaining information on the organizations and products from media sources and their own industry contacts. Engineering would also inspect sample products to determine if the company can produce products they need. Engineering management must make this decision based on the cost of the products they are likely to procure, the importance of the bidders' product to production, and other factors. Other organizations might have minority procurement goals to consider in selection of bidders. Significant utilizing of minority suppliers may qualify the firm as a potential bidder for a contract with a company or governmental entity looking to increase their minority supplier programs.

Organizational goals will dictate the criteria for the selection process of bidders. If only one firm can meet the specifications for the product then the purchasing managers must consider utilizing a "Sole Source" option or work with engineering to broaden the specifications if the project will permit alteration in the specifications.

11.9 BIDDING PROCESS

This is the process an organization utilizes to procure goods, services or equipment. The processes vary significantly from the stringent to the very informal. Responses are usually very detailed. Bidders not responding exactly as specified and following the published procedures can be disqualified. Smaller private businesses are more likely to have less formal procedures. Bids can be in the form of an email or general mail to all of the bidders specifying products or services. Responses by

bidders can be detailed or just by sending the proposed Rupee amount.

Most of the bid processes are multi-tiered. Purchasing departments watch for abuses of the user discretion privilege. Acquisitions in a mid range can be processed with a slightly more formal process. This process may involve the user providing quotes from three separate suppliers. The formal bid process starts as low as Rs. 10,000 or as high as Rs.1,00,000,000 depending on the organization. Depending of the commodity being purchased and the organization the bid may specify a weighted evaluation criterion. Other bids would be evaluated at the discretion of purchasing or the end users. Some bids could be evaluated by a cross-functional committee. Other bids may be evaluated by the end user or the buyer in Purchasing.

11.10 TECHNICAL EVALUATION

Technical Evaluations, that is, evaluations of the technical suitability of the quoted goods or services, if required, are normally performed prior to the Commercial Evaluation. During this phase of the procurement process, a technical representative of the company (usually an engineer) will review the proposal and designate each bidder as either technically acceptable or technically unacceptable.

11.11 COMMERCIAL EVALUATION

Payment Terms - The terms and conditions of payment quoted by each bidder are compared and stated in the comparative statement.

Cost of Money - Cost of Money is calculated by multiplying the applicable currency interest rate multiplied by the amount of money paid prior to the receipt of goods. If the money were to have remained in the Buyer's account, interest would be drawn. That interest is essentially an additional cost associated with such Progress or Milestone payments.

Manufacturing Location - The manufacturing location is taken into consideration during the evaluation stage primarily to calculate the freight costs and regional issues which may be considered.

Manufacturing Lead-Time - the manufacturing lead-time is the time from the placement of the order (or time final drawings are submitted by the Buyer to the Seller) until the goods are manufactured and prepared for delivery. Lead-times vary by commodity and can range from several days to years.

Transportation Time - Transportation time is evaluated while comparing the delivery of goods to the Buyer's required use-date. If Goods are shipped from a remote port, with infrequent vessel transportation, the transportation time could exceed the schedule an adjustments would need to be made.

Delivery Charges - the charge for the Goods to be delivered to a stated point. Bid Validity Packing Bid Adjustments Terms and Conditions Seller's Services Standards

Organizations Financial Review Payment Currency Risk Analysis - market volatility, financial stress within the bidders Testing.

11.12 NEGOTIATING

Negotiating is a key skill set in the Purchasing field. One of the goals of the Purchasing Agents is to acquire goods as per the most advantageous terms of the buying entity (or simply, the "Buyer"). Purchasing Agents typically attempt to decrease costs while meeting the Buyer's other requirements such as an on-time delivery, compliance to the commercial terms and conditions (including the warranty, the transfer of risk, assignment, auditing rights, confidentiality, remedies, etc).

Good negotiators, those with high levels of documented "cost savings", receive a premium within the industry relative to their compensation. Depending on the employment agreement between the Purchasing Agent (Buyer) and the employer, Buyer's cost savings can result in the creation of value to the business, and may result in a flat-rate bonus, or a percentage payout to the Purchasing Agent of the documented cost savings.

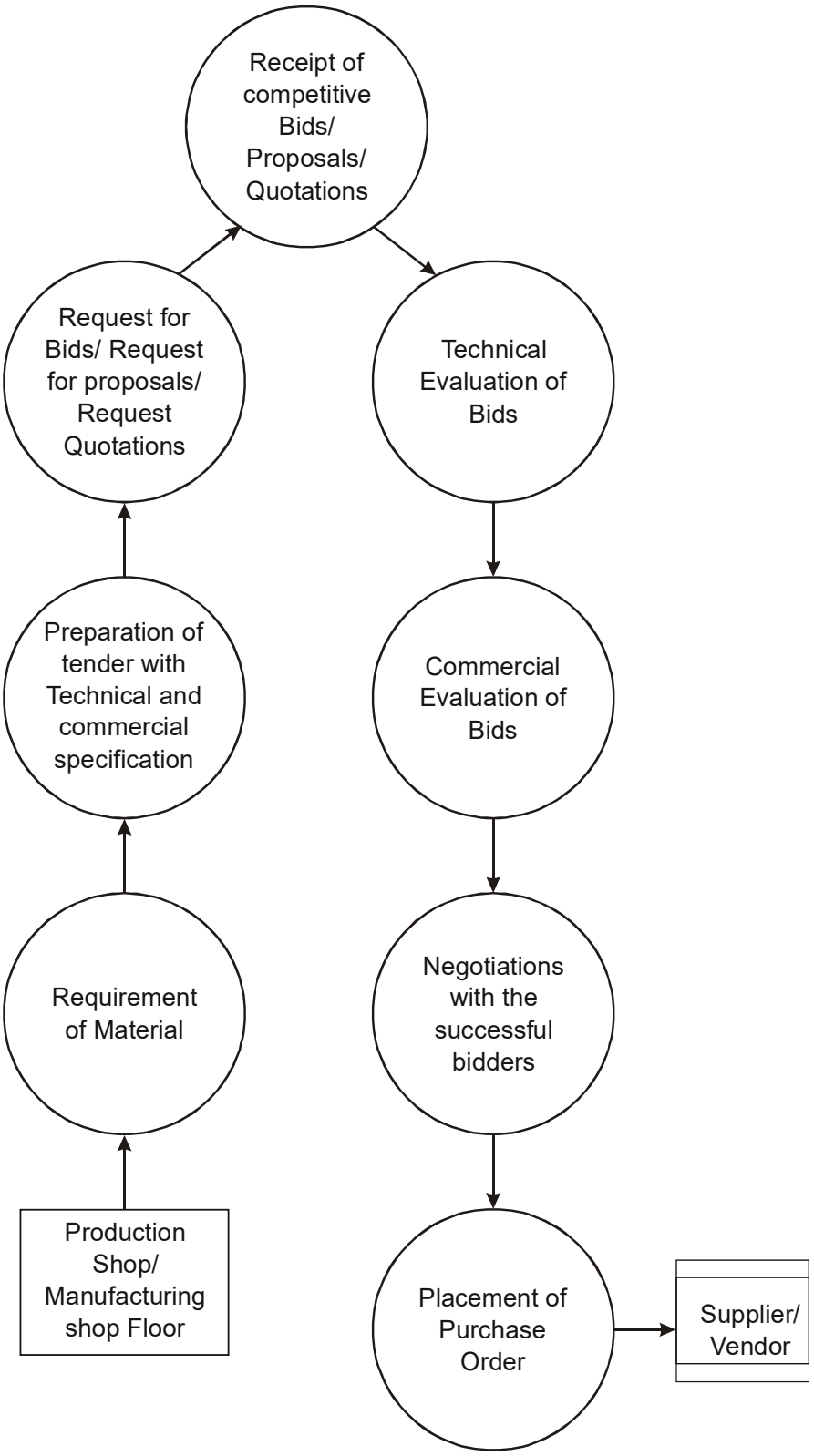
11.13 SELECTION AND AWARD

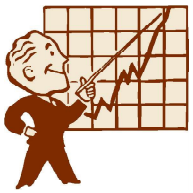
This is the process an organization utilizes to procure goods, services or equipment. Processes vary significantly from the stringent to the very informal. Large corporations and governmental entities are most likely to have stringent and formal processes. These processes can utilize specialized bid forms that require specific procedures and detail. The very stringent procedures require bids to be opened by several staff from various departments to ensure fairness and impartiality. Responses are usually very detailed. Bidders not responding exactly as specified and following the published procedures can be disqualified. Smaller private businesses are more likely to have less formal procedures. Small private firms are more likely to have informal procedures. Bids can be in the form of an email to all of the bidders specifying products or services. Responses by bidders can be detailed or just the proposed Rupee amount.

11.14 POST-AWARD ADMINISTRATION

Post-award administration typically consists of making minor changes, additions or subtractions, that in some way change the terms of the agreement or the Seller's Scope of Supply. Such changes are often minor, but for auditing purposes ,must be documented into the existing agreement. Examples include increasing the quantity of a Line Item or changing the metallurgy of a particular component.

Following figure summarizes the purchasing process in brief:





CHECK YOUR PROGRESS

Q.5: List the Issues to be considered under commercial evaluation of bids.

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11.15 LET US SUM UP

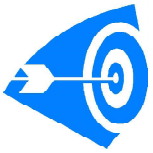
In this unit we have discussed different aspects related to purchasing management. Major business changes have occurred in business and industry in the past few years. World class competition, criticality of product marketing timing, environmental objectives, priced based costing, escalating customer demand, and tremendous emphasis on quality are a few of the key challenges exist in business now. These developments, in turn, have had direct impact on purchasing function in most organizations.

Clearly purchasing is a professional activity, now in transition. In most leading organizations today, the function, that used to be called as purchasing or procurement, is termed as supply chain management today. Often included in this expanded responsibility, is the integration of long term strategic material planning with the corporate strategic planning process. Now the approach is close supplier tie up. In order to implement Just in Time, the pull method of material control is to be followed. Unitill and unless the firms go for a strategic tie up with the suppliers it becomes very difficult to operate in such a system. Therefore the purchasing policies of the organization must conform to the organizations' business policy. A healthy relationship of the purchasing function with other functions of the organization and the suppliers is the need of the hour.



11.16 FURTHER READING

- Production and Operations Management by S. Anil Kumar & N. Suresh, New Age International (2008)
- Production Management, by K. Aswathappa, Himalaya Publishing House
- Production and Operations Management, by R. Panneerselvam, PHI publications.
- Production and Operations Management, by S.N. Chary, Tata Mc Graw Hill.



11.17 ANSWERS TO CHECK YOUR PROGRESS

Ans. to Q. No. 1:

a. Coordination with user departments to identify purchase needs
b. Discussion with sales representative
c. Identification of potential suppliers
d. The conduct of market studies for important materials
e. Negotiation with potential suppliers
f. Analysis of proposals
g. Selection of suppliers
h. Issuance of purchase order
i. Administration of contracts and resolution of related problems
j. Maintenance of a variety of purchasing records

Ans. to Q. No. 2:

a. Quality improvement
b. Cost optimization
c. Time optimization
d. Technology up gradation
e. Ensuring continuity of supply with trends

Ans. to Q. No. 3:

a. Integration of other business functions with purchase
b. Evaluation of Business environment
c. Adaptation of upgraded technology
d. Formulation of market driven supply plans
e. Implementation of Management Information System
f. Formulation of supply base strategy
g. Centralization of development and management
h. Use of senior procurement personnel
i. Use of professionals in procurement and supply management

Ans. to Q. No. 4:

I. Open procedure
II. Restricted procedure
III. Negotiated procedure

Ans. to Q. No. 5:

a. Payment terms
b. Cost of Money
c. Manufacturing location
d. Manufacturing lead time
e. Transportation time
f. Delivery changes



11.18 MODEL QUESTIONS

Q.1: Describe the purchasing function in detail.

Q.2: Explain the transition of purchase to supply management .

Q.3: What is a tender? How many types of bids are there? Explain.

Q.4: What is commercial evaluation of quotations? Explain.

Q.5: What is Technical evaluation of quotations? Explain.

Q.6: Explain how the selection of bidders is done.

Q.7: Explain the Negotiation process in the purchasing function.

Q.8: Describe the whole purchasing process in brief.

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UNIT 12: MATERIAL REQUIREMENT PLANNING

UNIT STRUCTURE

12.1 Learning Objectives

12.2 Introduction

12.3 Product Structure

12.4 Bill of Material

12.5 Introduction to Material Requirements Planning (MRP)

12.6 Using the MRP System

12.7 Manufacturing Resources Planning (MRP–II)

12.8 Let us Sum up

12.9 Further Reading

12.10 Answers to Check Your Progress

12.11 Model Questions

12.1 LEARNING OBJECTIVES

After going through this unit, you will be able to :

- explain the basic concepts of product structure and Bill of material
- explain the basic building blocks of MRP
- describe the logic and steps involved in the MRP methodology
- discuss implications of safety stock and lead time in MRP

12.2 INTRODUCTION

In this unit we will discuss about the planning techniques used to ensure a smooth flow of material within the factory / organization. We need to do material requirements planning (MRP) to manufacturing the specified number of final products as per the Master Production Schedule (MPS). MRP is a technique for determining the quantity and timing for the acquisition of dependent items needed to satisfy master schedule requirement.

The basic structure for MRP are–

(1) Product structure or Bill of Material

(2) MPS

(3) EOQ (discussed in unit 10)

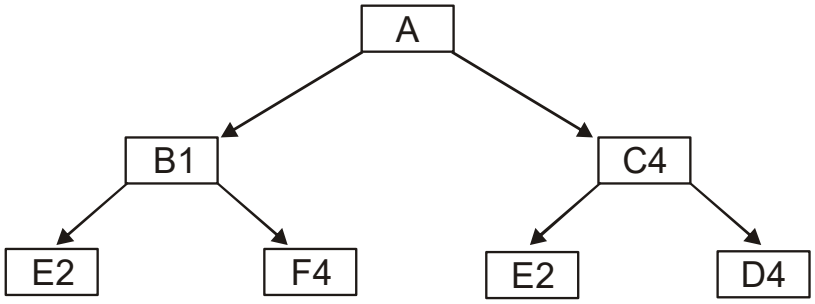
(4) Beginning inventory.

The unit further discusses how Prodution Planning and Control is carried out along with Scheduling. PPC involves the planning of prodcution, scheduling and the sequence of operations to achieve what has been planned for, upto the despatch of the materials.

12.3 PRODUCT STRUCTURE

To understand concept of MRP the knowledge of product structure is essential. The product structure graphically depicts the dependency relationships (assemblies and sub assemblies) among various items and make up the final product. Entry level in the product structure has a parent relationship with those below it. The number in parentheses show the number of items at a particular level needed to assemble one unit of its parents.

Example:



To assemble one A

- Number of B required is 1
- Number of C required is 4

To assemble one B

- Number of E required is 2
- Number of F required is 4

To assemble one C

- Number of E required is 2
- Number of D required is 4

12.4 BILL OF MATERIAL

A bill of material is a list of parts, ingredients or materials needed to assemble one unit of a product. BOM essentially consists of the complete list of each part in the product structure, the components that are indirectly used in a part, and the quality of each component needed to make one unit of that particular part. Clearly BOM is an alternative representation of product structure.

12.5 INTRODUCTION TO MATERIAL REQUIREMENTS PLANNING (MRP)

Material Requirements Planning (MRP) is a structured approach that develops schedules for launching orders for materials in any manufacturing system and ensuring the availability of these at the right time and at the right place. It uses the basic building blocks of resources planning to develop these schedules. The following figure shows the core logic of the MRP process, the inputs and outputs of the process.

As shown in the figure, four key processes drive the MRP procedure. These processes occur in a cyclic fashion. The first process is the "net" process. The MPS for the end product provides information on the gross requirements for the end product. By utilising the information available in the inventory records, the "net" process computes the net requirements for the end product. The second process is the "lot"

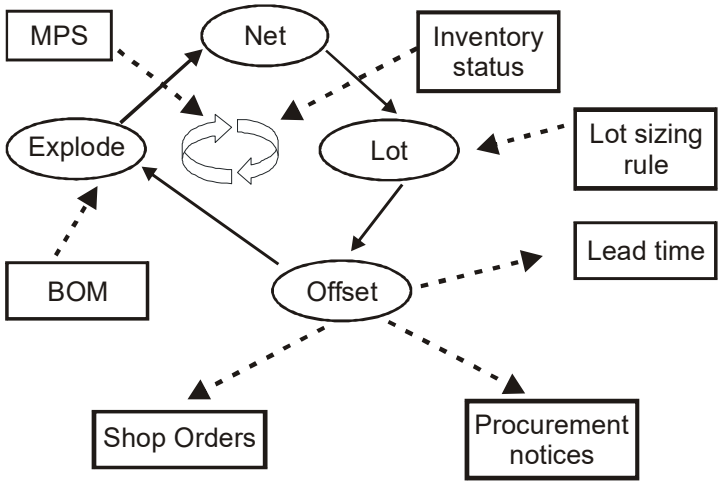


Figure 12.1

process. Once the net requirements are computed, the lot sizing rule is used to schedule planned receipts of the product. The third process is the" offset" process. Once the planned receipts are identified, lead time information is used to offset and obtain the planned order releases for the product. The planned order releases are either work orders for a manufacturing shop to assemble as many components as per the schedule or a purchase order to obtain sub-assemblies from outside. Once the three processes are completed, the requirements for the end products are estimated and orders are scheduled. Then the next step is to cascade the process down the product structure and repeat the procedure with all the components at the next level in the product structure. This process is the last in the cycle denoted as “explode”. In order to perform the explosion process, BOM (Bill of material) data is required. The planned order releases of a parent creates dependent demand for the offsprings as specified in the BOM. This becomes the gross requirements for the offsprings. The procedure continues iteratively, level-by-level, until the lowest level is reached and all component schedules are determined.

Therefore, the key inputs for the MRP processes are MPS (Master Production schedule), BOM (Bill of material) , inventory status, lead time data and lot sizing rule. As we proceed through the lower level components, two types of outputs are generated from the MRP system. The first output is a work order. Work orders are generated for items that are manufactured in house. The second output is a procurement notice. Procurement notices are generated for items that are bought from outside and directly used in the assembly. It triggers the purchase ordering process in an organisation.

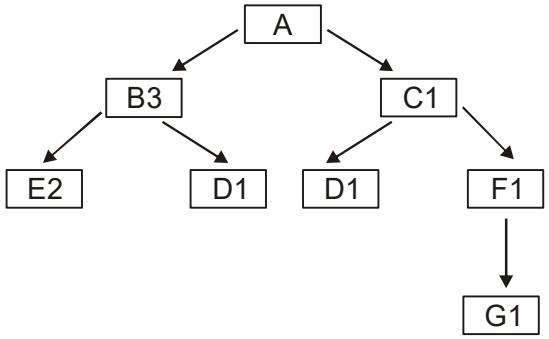
Example : 1

A manufacturing organisation needs to plan the materials required for the next 6 weeks for the manufacture of its end product A, as per a master production schedule. In addition to the end product, there is an independent requirement of component C, as it is sold as a spare in the market. The master production schedule for both the end product and

the spares are given below. In order to assemble one unit of product A components B to G are required. The figure below shows the product structure. In the figure, the number alongside each component denotes the number of each component required to assemble its immediate parent. An extract of inventory status reveals the inventory on hand. There are no pending orders for delivery. Different lot sizing rules are used for the components of product A. Moreover, the components have different lead times. All this information is available in the accompanying table. Perform an MRP exercise to estimate the quantity and timing of the components required for the manufacture of product A as per MPS.

Master production schedule for the next six periods						
	1	2	3	4	5	6
Product A	100	150	200	100	0	200
Component C		50	60			70

Inventory status, lead time and lot sizing rule			
Component	On hand	Lead Time	Lot Size
A	150	1	LFL
B	1000	2	LFL
C	300	1	LFL
D	750	2	3 Periods
E	700	6	3 Periods
F	200	1	400
G	500	3	500



Product Structure

Solution

We perform the MRP exercise by using the four step process. We begin with product A. The table below shows the net requirements calculations. Since the lot sizing rule is lot-for-lot, the net requirements and the planned receipts are the same, We offset the planned receipt by lead time to obtain the planned order releases. The table below has all the workings.

Product A					Lot Size : LFL Lead Time : 1		
	0	1	2	3	4	5	6
Gross Requirement		100	150	200	100		200
On hand Inventory	150	50	0	0	0	0	0
Net requirement		0	100	200	100	0	200
Planned receipts		0	100	200	100	0	200
Planned order releases		100	200	100	0	200	0

Now we continue the process by exploding the product structure and moving to the next level. There are two components at this level: components B and C. In our example, if an order needs to be released for assembling 100 units of product A in week 1, then we need 300 units of component B and 100 units of component C at the beginning of the week itself so that we can launch the work order. Therefore, the planned order releases of a parent determine the gross requirements for the offsprings. We repeat the process once for B and then for C before we explode to the next level. The next two tables show the workings for components B and C.

Component : B					Lot Size :	LFL	
BOM Quantity: 3					Lead Time : 2		
	0	1	2	3	4	5	6
Gross Requirement		300	600	300	0	600	0
On hand Inventory	1000	700	100	0	0	0	0
Net requirement		0	0	0	0	0	0
Planned receipts		0	0	200	0	600	0
Planned order releases		200	0	600	0	0	0

Component : CLot Size : LFL							
BOM Quantity: 1Lead Time : 1							
	0	1	2	3	4	5	6
Gross Requirement		100	250	160	0	200	70
On hand Inventory	300	200	0	0	0	0	0
Net requirement		0	50	160	0	200	70
Planned receipts		0	50	160	0	200	70
Planned order releases		50	160	0	200	70	0.

While computing the gross requirements for C we take into consideration, both the dependent demand of C (as indicated in the product structure) as well as the independent demand (as indicated in the MPS). Consider period 2. The planned order releases for product A during this period is 200. Therefore, there is a gross requirement of 200 units of C. There is also an independent demand of 50 units of C during period 2. Therefore, the gross requirement for component C is 250 (200 + 50 = 250). Similar computations have been made for all other periods also.

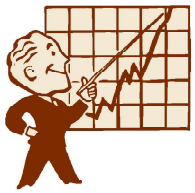
Component D is used by both B and C. Therefore, while arriving at the gross requirements of D, we take into consideration the planned order releases of both the parents. For example, during period 1, the planned order releases of components B and C are 200 and 50, respectively. Since they both require one component of D, the gross requirement for D during period 1 is 250. Since the first instance of planned receipt is week 3, we add up the requirements of three weeks

(weeks 3-5) in order to implement the POQ policy and schedule a planned order release during the beginning of week 1.

Component : D					Lot Size : POQ 3		
BOM Quantity: 1 for B, 1 for C					Lead Time : 2		
	0	1	2	3	4	5	6
Gross Requirement		250	160	600	200	70	0
On hand Inventory	750	500	340	0	0	0	0
Net requirement		0	0	260	200	70	0
Planned receipts				530			
Planned order releases		530		0	0	0	0

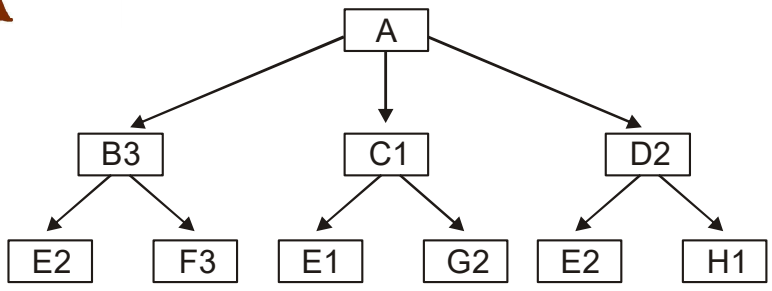
We perform similar computations for the remaining items in the product structure. The tables below have detailed workings for components E, F and G.

Component : E					Lot Size : POQ 3		
BOM Quantity: 2 for B					Lead Time : 6		
	0	1	2	3	4	5	6
Gross Requirement		400	0	1200	0	0	0
On hand Inventory	1700	1300	1300	100	100	100	100
Net requirement		0	0	0	0	0	0
Planned receipts		0	0	0	0	0	0
Planned order releases		0	0	0	0	0	0



CHECK YOUR PROGRESS

Q.1: Explain the following product structure.



12.6 USING THE MRP SYSTEM

Perhaps the most significant impact that a well-designed MRP system could provide to an organisation is the reduction in inventory. MRP systems were first developed in the early 60's and organisations using MRP systems reported dramatic reduction in their inventory. The reasons are obviously related to the logic of exploiting peculiar characteristics of dependent demand items. Using traditional EOQ baased inventory control systems will often result in having the inventory when not required. The other advantage of the MRP system is the increased visibility of items and their dependencies through a BOM representation of products being manufactured. Further, it could potentially inculcate a certain discipline in the planning process. .

Despite the simplicity and initial success, MRP installations faced several problems after implementation. In several cases, MRP systems suffer from three major problems:

- The data integrity is low. The quality of the solution is only as good as the data used for the computation. If the lead time data is wrong, organisations may either have too much inventory or frequent shortages. Similarly, if the inventory status is wrong it could jeopardise the entire computation.
- Users did not have the discipline of updating the required databases as and when changes were taking place elsewhere in the organisation. If the R&D department creates new designs and revisions in existing product design, this data needs to be incorporated in the BOM file. Failure to do so will mean introducing errors in the process, resulting in inappropriate planning.
- There are uncertainties associated with several issues that lie outside the control of the people and the system (for instance, bad supply management resulting in many uncertainties in lead time and quantity delivered and so on).

The net result of these problems is that MRP systems predictions may often turn out to be more or less wrong and the system may have

to be rerun often. This could also result in several production schedule changes and consequent delays in the downstream supply chain.

Moreover, there are other limitations in using the MRP system. The amount of computation involved in generating component-wise schedules for the planning horizon is large. Real life examples require thousands of iterations that consume time. In some cases, it is not uncommon to have a single run of MRP extending for about 12-16 hours. Although, speed and availability of computing power keep increasing continuously, this issue still merits some attention and puts realistic limits to the frequency of generation of MRP schedules.

Therefore, an organisation needs to incorporate certain aspects into the MRP planning framework to minimise problems arising out of these issues. Alternative methods are available to re-run an MRP system and they have implications on the accuracy, cost and time pertaining to the exercise. However, there are methods available to handle some of the uncertainties in the system and thereby reduce the risk of shortage, but such alternatives have cost implications as well.

12.7 MANUFACTURING RESOURCES PLANNING (MRP-II)

The previous sections show the applicability of MRP logic to other domains of the business. Further, the availability of computing power and software for storage and manipulation of large chunks of data have increased ever since organisations began to use MRP systems. Therefore, it was logical that newer systems were developed to expand the application of MRP into other domains of business where dependency relationships exist. In the 1980's, organisations began to incorporate several modules in the MRP systems. This enlarged version is known as Manufacturing Resources Planning (MRP-II).

A typical MRP-II system will consist of the following modules:

- Business Planning
- Purchasing
- Forecasting/Demand Management

- Inventory Control
- Order Entry and Management
- Shop Floor Control
- Master Production Scheduling (MPS)
- Distribution Requirements Planning (DRP)
- Material Requirements Planning (MRP)
- Service Requirements Planning (SRP)
- Capacity Requirements Planning (CRP)
- Accounting

As we see from the above list, MRP-II covers all activities, from business planning to servicing the customer. In reality, the business planning exercise triggers dependency relationships for all-resources in an organisation. The forecasting/ demand management module and the order entry system essentially interface with the outside world and bring recent information into the planning system. Based on these, production planning, MPS and other requirements planning can be done. Since the outcome of these exercises is to procure items and services from outside and perform in-house activities as per plan, the relevant modules have also been included to close the gap. Essentially, the focus is on planning for all the resources that an operations system requires.

The advantage of MRP-II lies in its ability to provide numerous feedback loops between different modules and minimise re-planning on a piece-meal basis. As more and more gaps are closed, it promotes a centralised approach to planning and promises to bring additional benefits arising out of integration.



12.8 LET US SUM UP

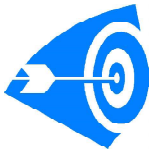
- In this unit, we have discussed about MRP. In case of manufacturing a product, the firm has to plan materials so that the right quantity of material is available at the right time as per the master production schedule.

- Bill of material and product structure depicts the dependency relationships among various components in a manufacturing setup.
- MRP logic involves a four step logic: Net-Lot- Offset –Explode. Through an iterative process, the material requirements of all components in an organization during a planning horizon are arrived.



12.9 FURTHER READING

- Kanishka Bedi (2013). *Production and Operations Management*, Oxford University Press, India
- B Mahadevan (2010), *Operations Management-Theory and Practice,* Pearson India, India
- Lee Krajewski and Larry Ritzman (2011). *Operations Management-Processes and Supply Chains*, Pearson India, India
- K Aswathappa and K Shridhara Bhat (2013). *Production and Operations Management*, Himalaya Publishing House, India



12.10 ANSWERS TO CHECK YOUR PROGRESS

Ans to Q. No. 1:

To assemble one A

- Number of B required is 3
- Number of C required is 1
- Number of D required is 2

To assemble one B

- Number of E required is 2
- Number of F required is 3

To assemble one C

- Number of E required is 1
- Number of G required is 2

To assemble one D

- Number of E required is 2
- Number of H required is 1



12.11 MODEL QUESTIONS

Q1: Describe the basic concept of Product structure

Q2: Explain Bill of material

Q3: Write a short note on MRP-II.

*** ***** ***

UNIT 13: QUALITY MANAGEMENT

UNIT STRUCTURE

13.1 Learning Objectives

13.2 Introduction

13.3 Quality Management Evolution

13.4 Definitions of Quality

13.5 Benefits of Quality Management

13.6 Dimensions of Quality

13.7 Determinants of Quality

13.8 Causes of Quality Failure

13.9 Quality Control

13.10 Inspection

13.11 Quality Assurance

13.12 Quality in Services

13.13 Quality Costs

13.14 Control Surplus and Waste Disposal

13.15 Let Us Sum Up

13.16 Further Reading

13.17 Answers To Check Your Progress

13.18 Model Questions

13.1 LEARNING OBJECTIVES

After going through this unit, you will be able to :

- explain the basic concept of Quality Management
- describe the benefits of quality management
- outline the dimensions of Quality
- explain the basic concepts of quality control, quality assurance, quality cost and quality in service

13.2 INTRODUCTION

In this unit, we are going to discuss on quality management. Quality management is a method for ensuring that all the activites to design, develop

and implement a product or service effectively and efficiently with respect to the system and its performance. Quality management can be considered to have three main components: quality control, quality assurance and quality improvement. Quality management is focused not only on product quality, but also on the means to achieve it. Quality management, therefore, uses quality assurance and control of processes as well as products to achieve more consistent quality. Quality Management comprises all activities of the overall management function that determine the quality policy, objectives and responsibilities and implement them by such means as quality control and quality improvements within a quality system.

13.3 QUALITY MANAGEMENT EVOLUTION

Quality management is not a recent phenomenon. Advanced civilizations that supported the arts and crafts allowed clients to choose goods meeting higher quality standards than the normal goods. This craft based approach to quality and the practices used were the major inputs when quality management was created as a management science.



Henry Ford :
A prominent American industralist and founder of the Ford Motor Company.

Henry Ford has a major role in bringing process and quality management practices into operation in his assembly lines. Walter A. Shewhart made a major step ‘in the evolution towards quality management by creating a method for quality control for production, using statistical methods, first proposed in 1924. This became the foundation for his ongoing work on statistical quality control.

Customers recognize that quality is an important attribute in products and services. Suppliers recognize that quality can be an important differentiator between their own offerings and those of the competitors. (quality differentiation is also called the “quality gap”). The ISO 9000 series of standards are probably the best known International standards for quality management.

13.4 DEFINITIONS OF QUALITY

Quality can be defined in the following ways

- Quality is meeting or exceeding customer's expectations.
- Quality is the totality of features and characteristics of a product or service that bears on its ability to satisfy stated or implied needs.
- Quality is meeting or exceeding customer requirements now and in future.
- Quality is the sum of the attributes that can describe a project.
- Quality refers to meeting specifications and performance standards Most of the definitions are made by recent authors and all these lead to customer satisfaction and customer delight.

13.5 BENEFITS OF QUALITY MANAGEMENT

There are many benefits of quality management. Some of them are listed below :

- Image of the organization will be high and the improved reputation can lead it to be a major player in the competition.
- For the consistency in quality, market share will increase and consequently sales and profits will be higher.
- Due to improved quality, the re-work and delays are avoided or reduced. This reduces the manufacturing costs.
- Cost of manufacturing will come down owing to better utilization of operator time, reduced wastage and reduction in scrap.
- Sales activity will be on strong footing as sales personnel will have high problem due to consistency in quality.
- Employee morale at all level will be high. This will improve work atmosphere and lead to better team work.
- New jobs, challenging jobs will be normally given to a company, which has high reputation for quality.

13.6 DIMENSIONS OF QUALITY

Dimensions of quality are the attributes or factors of quality, which are commonly called as evaluation factors. These are the factors regularly talked about by common people, who doubt the goods they have bought

and used. One or more of the following factors describe the quality aspects relevant to a product.



Longevity : Duration of service.

1. **Reliability-** Free from breakdown and manufacturing probalities. This means performance and consistency of performance is ensured.
2. **Durability-** This means the normal **longevity** of a product getting longer life without much repairs and inconveniences and necessity to replace.
3. **Performance-** Performance refers to doing the job as per specifications. The product should give the performance service it is intended for.
4. **Innovative-**This refers to extra features, additions to existing facilities.
5. **Service Aspect**-The product should be easy to handle and easy to operate for maintenance and service activities.



Clientele : Customers collectively.

6. **Aesthetics-**This include looks, feel, colouring, packing, odour, sound etc. Such attributes for different products should suit the product and **clientele** tastes.
7. **Safety-** Any product consumed or used by the customers should be safe in using, handling and repairing work. Necessary instructions should be given in catalogue and packing wherever essential.

Above factors are more suiting for production-oriented units. For service and service cum production units following factors will be more applicable. They are :

(a) **Prompt Response–** Positive responses to attend service problems and keeping up schedule.

(b) **Courtesy–** Good and dignified behaviour towards customers and to their calls.



Infuse : Teach and impress by frequent repetitions.

(c) **Accessibility–** Always at least one representative is to be available to attend calls and visitors.

(d) **Credibility–** Developing a good trust worthy association and winning customer confidence which helps to grow business.

(e) **Proactive–** Trying to find out if service is attended and quality of services etc are maintained. This will **infuse** confidence in customer

and also enables the companies to know the areas of improvements, if needed.

13.7 DETERMINANTS OF QUALITY

Many direct and indirect activities contribute to the quality and consistency of quality. The perfection in these activities determines the quality aspects. The activities start from design stage to packing and forwarding stage. These are narrated as under.

(i) **Design Stage:** The quality care starts at the design stage itself. A design is made and revised based on (a) Customer expectations, (b) Competitor product, (c) Easy Maintenance and replacement of spares and (d) Innovation to be taken care.

Even though the design job is of engineering and design office is the contributions of R&D, marketing, production and quality control departments are also very important. The design developed should be easily possible to manufacture at competitive costs. It should not be a fancy design but a good workable, good design with requisite aesthetics suiting the product.

(ii) **Materials Stage:** The raw materials, components, bought outs (like motors, bearings, joints etc) play most important role in this respect. These are to be arranged as per the specifications. Deviation in specialization is likely to have adverse effect on quality.

(iii) **Process stage:** Next important stage is processing of materials to be converted into product. This involves manufacturing, subcontracting, assembly, trial-run, testing, stage inspection and corrective actions, if any. Layout for the process, machinery and tools, measuring instruments, trained personnel to take efficient care of process contribute to quality and consistency of quality.

(iv) **Quality to specifications:** The common words like 'Good quality'. 'Best quality' have no place in industrial quality management. What is important is quality as per specifications. Conforming to specification is quality acceptance and non-conformance leads to rejection on quality grounds. Specification is a camrrw language

in industry and everyone understands this and hence the confusion is avoided.

(v) **Organization Focus:** All employees of an organization and specially the top management must be committed towards quality concepts at every level and stage of production. This is total quality management concept and this alone helps to achieve an enduring quality culture.

(vi) **Training and Re-training of Human Resource:** It is human resource which will utilize machinery and tools. They only can discuss and negotiate new contracts, design aspects, trial run etc. Hence, training and development towards changes in technology, processing, standards and operation of new types of machines is essential. Sometime re-training is required to fine tune the skills and knowledge. Dr. Deming in his theory of TQM **opines** that management responsibility towards quality is 85% and that of workers is 15%. This means management must provide machinery, tools, training and work environment to obtain a prescribed quality. Workers will give quality output as per the facilities provided.



Opines- Expect, believe or suppose.

13.8 CAUSES OF QUALITY FAILURE

Following are some of the causes of quality failure :

(i) **Man power Related:** Human error can happen due to fatigue, poor eye sight, hearing and movement, inadequate training and re-training, poor knowledge of the process.Lack of supervision, frequent changes, transfers, absentees and also management's lesser attention to quality etc often lead to quality failure.

(ii) **Facilities Related:** To get a particular standard of quality the machineries, tools and fixtures, measuring instrument should have the accuracies. The machineries should be good enough to give consistency of quality in all the batches. **Worn** out tools, deteriorating machines are to be re-conditioned periodically or replaced. Preventive maintenance is to be attended on all-important machines.



Worn- Damaged by lone use.

(iii) **Process Related:** Process of operation selected for different jobs should be easy to operate and repeat, gets the accuracies and

consistency. A process should be chosen after trials so that once set for bulk production there should be no need to make changes. If the process itself is defect-proof, frequent checking or inspection is not required. Along with process tooling inspection stages, measuring instruments are to be decided.

(iv) **Materials Related:** Incoming materials not as per the specification, wrong dimensions, damage in handling and transportation will cause problems. Some times materials are supplied in loose packing creating mix varieties rather than making separate item wise or packing for easy identification and accounting. For example, more than one variety of nut-bolts-washers should not be sent in one package.

(v) **Environment Related:** Due to effects of rains, moisture, heat, cold, storm conditions some materials get deteriorated or change shape. For example, wood loses shape due to moisture, steel gets rusted etc.

All the above factors are to be taken care of not only by the quality department employees but also by all other department employees.



CHECK YOUR PROGRESS

Choose the correct answer

Q 1: Which one of the following is correct?

a) Quality is meeting customers expectation

b) Quality is exceeding customers expectations

c) Both (a) and (b)

d) None of the above

Q 2: Which one of the following is correct?

Quality is meeting or exceeding customers expectation at present

a) Quality is meeting or exceeding customers expectation in the near future

b) Both (a) and (b)

c) None of the above

Q 3: Causes of quality failure may be :

(a) Man power related

b) Facilities related

c) Process related

d) Materials related

e) All of the above

13.9 QUALITY CONTROL

All those efforts which lead to obtaining and keeping of quality as per specifications are coming under the category of quality control. These are (a) Quality planning, (b) Quality evaluation, (c) Corrective action and (d) Incorporate improvements in specifications and operation instructions.

As explained earlier the quality activity begins from design stage. Next the planning involves specifications for materials, tolerances to be achieved, and stages of inspection to be done.

Quality evaluation is to inspect the incoming materials, components, operations of manufacturing, assembly testing and trial run (if applicable) for any wrong supplies or errors in manufacturing, corrective action can be taken at that stage itself.

Corrective action is just not doing the correction of one part under process. If the process is defective or material is wrong, the corrective action has to be recorded and attended to such that in subsequent operations and batches the same error is not repeated.

Further, any improvement made in the change of material, process or corrective action has to be recorded and changes made in all the relevant documents, so that the benefits of improvements are derived in subsequent batch production as well.

Quality Control is a proactive approach to do preplanning, inspection and stage verification so that deviations are avoided, and if they are noticed the corrective action will be attend to without any delay. The in process inspection, trial inspection, final and trial run ensure the quality care for the satisfactory performance of the product.

Objectives of Quality Control:

Following are the objectives of Quality Control:

- ensure strict conformance to customer's specifications or product's specifications.
- continuously improve the quality of the product and the service.
- ensure on time delivery of the product.
- reduce scrap.
- reduce rework activities.
- achieve total customer satisfaction.

13.10 INSPECTION

The objectives of inspection are (i) To accept incoming materials that meet the specified standards and reject those which do not meet the standards specified, (ii) To check the in process components with specifications and accept or reject based on evaluation and (iii) To test the final product as per specification and to accept or suggest for corrections to be attended.

Inspection in common usage is called 'Post-mortem' as it is done after the processing is over. Since already labour, machine hours and materials cost is invested, there will be tendency to rework after the inspection rather than rejection. This kind of **salvaging** work costs more in terms of re-works, re-inspection and extra material needs. Different types of inspection are as follows.



Salvaging- Save from destruction or harm

(a) **Visual Inspection:** This is observed to get a feel of the surface condition, uniformity, smoothness, paralleling squareness, bend, holes, rust, dirt, rough edges, cracks, quality, damaged condition etc. For an experienced employee just a glance gives an idea about the general quality.

(b) **Sub-surface inspection:** In case of castings the top surface will be machined to see if pinholes, blowholes or porosity is found inside. For this X-ray testing is done.

(c) **Specification check:** Some specifications like chemical components, hardness, density, tensile strength, toughness dimensions, malleability, impact strength etc can be verified by specified methods.

(d) **Trial runs:** Components, equipment, machine systems have to be tried in real work conditions to verify acceptability. For example a Mixer-grinder buyer observes the trial run and buys if satisfied. Similarly, in industries some items have to be tried in test run and then accepted.

The commonly used measuring instruments for inspection are scales, tape, vernier caliper, micrometer, height gauge, and dial indicator with attachments, slip gauges, optical instruments, angle gauges, Go-No go gauges, rockwell hardness testing machine, birnnel hardness testing machine, etc. Annually the instruments are fine tuned by authorized laboratory to check for accuracies.

13.11 QUALITY ASSURANCE



QA- Quality Assurance

'Quality Assurance' refers to activities aimed to provide desired quality products to customer. This mainly involves the built-in process care for quality. The process system itself should be developed such that the output is of desired quality. The **QA** effects are of long range impact and involve R&D work and innovation. Hence, after inspection and quality control, quality assurance is higher stage in quality care. The important activities that help to take on quality assurance are as follows:

(i) **Reliable Process:** The processing method, tooling, machines should be selected and set so that the desired quality is obtained with minimum efforts and inspection. Next important thing is to ensure constancy of quality. The raw material, process system and operator's ability to ensure the quality on a long-range workability.

(ii) **Consumer Feedback:** Consumer feed back, suggestions come to production department through the sale personnel or dealers. Corrective actions and improvements based on feedback will ensure quality care. This method is a continuous process.

(iii) **Value Enqineering:** The material process, material movement and handling etc are to be evaluated in detail. This enables to avoid unnecessary operations and extra material. Also efforts could be made for material substitution.

(iv) **Service Aspects:** Besides providing a prompt and efficient service, there should be a guidance to the consumer to attend the minimum repair jobs. Basic maintenance skills with the consumers will save a lot of time, effort and costs on both sides.

(v) **Design of Product:** The product design should be easy to arrange, work on and be able to handle replacement system. The design should have components and tolerances which can be achieved locally and they should be easily available.

The above factors ensure quality assurance to this respect. All the departments are to be involved but the major responsibility will be that of the production, R&D and quality departments. In fact, even outside sources like sub-contractors, raw materials suppliers and customers can be involved. Only a combined effort of internal and external resources will help succeed the quality assurance plan. Quality assurance department can involve all other departments to take care of the quality aspects at all levels of work in their departments.

13.12 QUALITY IN SERVICES

For a long time it was felt that quality and reliability are concerned with the product and hence only the production personnel are responsible for this. There are some products where both product and service are involved (like hotels) and in some areas only service is involved (like travel). Gradually the service part in business has gained equal importance and hence the quality aspect also includes the service.

In banks you may have seen boards stating that (i) DD making will take 15 minutes, (ii) Pass-book updating takes 10 minutes, (iii) Cash payment 10 minutes etc. If they follow this, the service is good; if they do within the time specified then it is very good. Whereas if they take more time than announced, then the service is bad. Similarly, we have seen while attending Telephone repairs, TV repairs etc. that the service man is either late or comes without adequate tools and spares or he does a poor job. All these show a casual and less responsible attitude towards the cause of the customers.

The service works also is part of the marketing job and hence organizations should take it as an essential part of business. Only service after sales can help the increase in market share and create goodwill. The sale and service personnel are to be trained and properly counseled to attend the service work with promptness, good conduct in a way that the service work satisfies the customer.

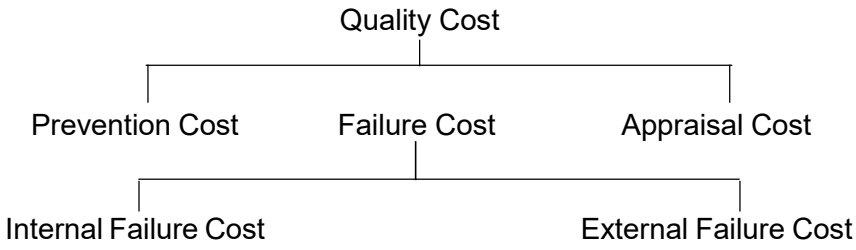
13.13 QUALITY COSTS

Here, we are considering the extra costs to both apprise and prevent the failures. Production process should take care of specified quality and this is already covered in the production costs. What the management has to be concerned with the extra cost necessitated to attend the specified quality requirements.

(a) **Failure cost:** Extra costs due to failures have higher percentage of additional burden compared to other costs. Failure to comply with the specification causes rework or replacements.

(i) Internal Failure Costs

- Rejection creates scrap and this means instead of selling a product, scrap will be sold which is a big loss. More the generation of scrap more the losses in terms of material value, processing cost (machine hours and labour cost), power supply cost and inspection cost.
- For corrective action, re-work has to be done and the re-work requires additional investment of operations, consumables, electricity etc which is an additional cost.
- Extra cost will be incurred due to detailed tests, inspection, reinspection, and change of specializations, methods, expert consultation and sometimes outsourcing.
- Less effective utilization of manpower and machineries due to rework, re-inspection etc. This will affect speed, efficiency and concentration of employees. Hence output quantum will reduce.



(ii) External Failure Costs

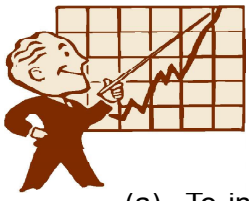
- During the warranty period free replacements of spares and servicing has to be attended which costs extra.
- Loss of reputation due to which further orders may get affected. Also the existing customer may delay balance payments due to failures.
- For attending customer complaints, movement of employees, materials etc. costs are very high. Further, if salvaging work has to be, attending outstations, the hiring of services and facilities cost extra.
- Demoralization of employees and low image in the market will be difficult to measure in terms of cost.

(b) **Appraisal Costs:** This covers inspection, re-inspection, repackage and related functions as narrated here under.

- Incoming raw materials, components, sub-assemblies, bought outs (like motor, bulbs) are to be tested, inspected or evaluated as per specifications.
- Stage inspection in process as per manual, either this will be on random sample basis, hourly basis or shift basis depending upon the product and specifications.
- Evaluation of finished product for all attributes of performance, aesthetics, packing etc.
- Costs of calibrating, measuring and test equipment towards keeping them in accurate condition.
- Costs of vendor evaluation, visit to their works and in turn to be their sub-contractors, if any.
- Cost of maintaining laboratories like chemical labs, physical labs, metallurgical labs, electronics labs for different types of tests required to attend on a regular basis.

(c) **Prevention Costs**

- Maintaining a quality department, training of personnel.
- Cost of preparing quality plan, systems and procedures as per the quality manual.
- Data collections of quality matter, data analysis, preparing charts to know the deviations and management reporting.
- Costs pertaining to vendor evaluation, value analysis methods, engineering and time study.
- Costs towards (i) Quality circles and (ii) R&D department.



CHECK YOUR PROGRESS

Choose the correct answer

Q 4: The objective of inspection are

(a) To inspect incoming materials that meet the specified standard

(b) To check in process components with specifications

(c) To test the final product as per specification

(d) Only (a) and (c)

(e) All of the above

Q 5: Generation of more scrap is

a) Internal failure cost

b) External failure cost

c) Appraisal cost

Q 6: Loss of reputation with customer is

a) Internal failure cost

b) External failure cost

c) Appraisal cost

Q 7: Cost of calibrating, measuring test equipment is

a) Internal failure cost

b) External failure cost

c) Appraisal cost

13.14 CONTROL SURPLUS AND WASTE DISPOSAL

The surplus materials should be packed adequately and stored. Packaging procedure must ensure the safety of the material. The information about the quantity of surplus materials is to be maintained and further production plan is to be formulated considering the surplus.

Proper waste disposal methods are to be adopted for disposal of waste and scrap. Scarps and waste should be marked separately and care should be taken to avoid mixing of the waste or scrap with finished goods. Waste disposal policy should consider the recyclables and different environment issues. Waste disposal methods must ensure the ecological and environmental balance.



13.15 LET US SUM UP

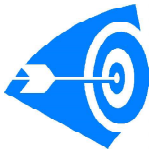
- In this unit, we have discussed quality management. Quality management is a method for ensuring that all the activities necessary to design, develop and implement a product or service are effective and efficient with respect to the system and its performance.
- Once the quality care is taken as per specifications and customer expectations the benefits are (a) Customers will repeat, (b) Customers will increase, (c) The sales volume and, hence profits will go up, (d) the costs will come down due to nil or less re-work and hence less expenses on service team, (e) the productivity will increase, (f) improves competitive edge of the product, (g) satisfied customers indirectly sell our products and (h) employee morale will be high.
- More employment can be created with the growth in business due to higher sales volumes. Sales volume can increase by constancy in quality. Hence, jobs, profits, sales volume are directly related to quality. This fact is practically observed in postliberalization era wherein companies, who are not quality and cost conscious, are not doing well or are out of business.

- There are primarily three quality costs, viz Prevention cost, Appraisal cost and Failure cost. Failure cost is further subdivided into, two types viz. external failure cost and internal failure cost.



13.16 FURTHER READING

- Kanishka Bedi (2013). *Production and Operations Management*, Oxford University Press, India
- B Mahadevan (2010), *Operations Management-Theory and Practice,* Pearson India, India
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- K Aswathappa and K Shridhara Bhat (2013). *Production and Operations Management*, Himalaya Publishing House, India



13.17 ANSWERS TO CHECK YOUR PROGRESS

Ans to Q No 1: (c) Both (a) & (b)

Ans to Q No 2: (c) Both (a) & (b)

Ans to Q No 3: (e) All of the above

Ans to Q No 4:. (e) All of the above

Ans to Q No 5: (a) Internal failure cost

Ans to Q No 6: (b) External failure cost

Ans to Q No 7: (c) Appraisal cost



13.18 MODEL QUESTIONS

Q1: Describe the basic concept of Quality Management

Q2: Define Quality

Q3: What are the various benefits of implementing quality management system?

Q4: What are the different determinants of quality?

Q5: Explain quality control and inspection

Q6: What are the different quality costs? Explain in detail.

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UNIT 14: MAINTENANCE MANAGEMENT

UNIT STRUCTURE

14.1 Learning Objectives

14.2 Introduction

14.3 Objectives and types of Maintenance

14.4 Maintenance Policy

14.5 Need for replacement

14.6 Criteria for Replacement

- 14.6.1 Technical aspects
- 14.6.2 Financial aspects

14.7 Replacement problems

14.8 Reliability

14.9 Determination of Maintenance crew size

14.10 Information system for Maintenance Management

14.11 Let Us Sum Up

14.12 Further Reading

14.13 Answers to Check your progress

14.14 Model Questions

14.1 LEARNING OBJECTIVES

After going through this unit, you will be able to:

- explain the concept of Maintenance Management
- outline the objectives of Maintenance Management
- describe the different types of Maintenance Management
- describe the criteria for choice of a Maintenance policy
- explain the need and conditions for replacement of machinery
- explain the bath-tub curve and its importance
- explain the concept of reliability in Maintenance
- determine the optimal crew size in a Maintenance Program
- assess the importance of information systems in Maintenance

14.2 INTRODUCTION

Maintenance Management is the application of techniques of operations management to ensure breakdown free and smooth running of all plant and machinery within a facility and controlling the costs of maintenance. Maintenance management ensures improvement in efficiency of a facility by reducing possible loss that may occur by way of sudden faults in operation, frequent breakdowns inviting repairs leading to loss in man and machine hours thereby reducing profitability. Maintenance activities in different machinery are different; which is again different for different equipments within machinery. The heterogeneity of the work adds to the heterogeneity in the type of work man required for attending maintenance jobs. The function is not only complex but also costly. However the necessity of ensuring error free operation necessitates the presence of it mandatorily in any facility.

14.3 OBJECTIVES AND TYPES OF MAINTENANCE

Objectives of Maintenance Management : The following are some of the objectives of maintenance management -

a) Early detection and diagnosis of problems in machinery within a facility
b) Minimal wear and tear of machinery to ensure enhanced performance of the plant and machinery.
c) Minimise repair time and the cost so involved
d) Ensure error free operation of machinery to prevent accidents costing life of workmen.
e) Attain optimal performance of the plant and machinery thereby reducing non-productive time and attaining economies of scale in performance.
f) Attain goodwill of customers by way of adherence to delivery schedules free from production stops, equipment breakdowns, etc.
g) Achieve profitability with minimal loss in productive time within a facility

h) To pursue policies of replacement of machinery and its parts to have reliability and availability of the facility at minimal costs.

Types of Maintenance : The following are the types of maintenance management :

a) Planned Maintenance
b) Preventive Maintenance
c) Breakdown maintenance
d) Predictive Maintenance
e) Let us discuss it one by one.

a) Planned Maintenance :

Planned maintenance carries out maintenance activities of plant and machinery in a prescribed format to prevent possible occurrences of faults, breakdowns, etc. the practice follows inspection, servicing and overhauling of machinery prior to the alarm of danger (breakdown) rings. The objective is to ensure smooth operation within a facility with minimal stops. Planned maintenance follows the larger premise of a planned shutdown of a facility with conscious attempts of improving on the performance of all stages in an operation. Planned maintenance is religiously practised in continuous industries where a minor error could cause shut down of the entire operation. Planned maintenance is conducted in complete two phases viz., running maintenance and shut down maintenance. Running maintenance is performed in the normal operating condition of the machinery without any halts in production. Shut down maintenance is performed with a complete overhaul of the plant or its machinery. It is normally performed once in one or two years in continuous processes.

b) Preventive Maintenance

Under preventive maintenance, maintenance is carried prior to occurrences of its need. It performs maintenance of possible locations of failures through periodic servicing and inspection of machinery. Usual lubricating, cleaning, set-up adjustments and other

activities performed at regular intervals and during equipment slowdowns are part of preventive maintenance programs. Preventive maintenance aims at reducing repetitive repairs through identification by inspection of machinery susceptible to breakdowns. It provides a safe working environment to workers through reduced repairs and better control of machinery.

Preventive maintenance maintains the reliable and optimal efficiency at nominal cost of maintenance. It ensures maximum availability of machinery for production.

c) Breakdown maintenance

Breakdown maintenance is a rather a reactive program designed to activate on occurrence of breakdowns only. Whenever breakdown of machinery or its parts surfaces maintenance, which begins with repair works, is required to restore normalcy to the machinery and it's functioning. It is an emergency Breakdown maintenance is an expensive program since it is unpredictable in the costs of maintenance and the time involved. The facility may come to a sudden unpredictable halt for uncertain time in the process.

Breakdown maintenance performs necessary repairs at the point of breakdown to prevent replacement costs. Such maintenance is normally common in smaller factories where planned maintenance may be too expensive compared to the cost of a sudden halt or has been running under capacity. Common breakdowns handled by breakdown maintenance those which have occurred due to lack of lubrication, wear and tear of parts, etc.

d) Predictive Maintenance

Predictive maintenance is rather a new technique wherein equipment conditions are periodically observed to assess unusual operating behaviour like unusual sounds, vibrations, coolant failures, misalignment, abrasion, etc. Sensitive instruments like audio gauges, vibration analysers, amplitude meters, etc are employed

for the purpose to asses and observe unusual behaviour in operating conditions of the machinery. Predictive maintenance is also known as condition monitoring and is conducted based on adequate study on the performance and behaviour of the machinery. Normally, mathematical analysis serves as a criterion in the decision of conducting predictive maintenance.



CHECK YOUR PROGRESS

Q1: Define Maintenance Management.

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Q2: State two objectives of Maintenance Management.

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Q3: What are the different types of Maintenance Programs?

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14.4 MAINTENANCE POLICY

Maintenance policy involves policy decisions in conducting maintenance of machinery, tools and equipment within a facility. It involves planning and scheduling of maintenance activities for error free smooth operation. The following considerations are taken care of while designing the maintenance policy for a facility.

a) Type of process:

A job shop operation caters to diverse types of jobs at any instant. The volume of jobs handled for each sequence of operation is low. Such a process need not go for a planned maintenance program, through stoppage of all the activities within the process. Furthermore

the process of planned maintenance would be expensive compared to expenses incurred owing to sudden breakdowns. A continuous process however cannot afford to face sudden breakdowns in any stage of the process leading to complete halt in the entire process. The set-up time, setup costs, the loss of profitability, and goodwill due to gaps in production are too costly for a continuous process. Such a process cannot afford to wait and watch for error to creep in the operation in order to diagnose them.

b) Type of machinery:

A stage in an operation will stop performing whenever machinery engaged in the stage stops performing. Some machinery works on simple techniques and are easily assembled and disassembled. Such machinery, if can be repaired without much of technical assistance and by the shop floor workmen, need not be maintained under planned or preventive maintenance programmes. There are however, equipments in operations which are installed and serviced by third party service providers. Repair and maintenance of such equipments require specialised know-how which cannot be easily sourced or cannot be performed by unauthorised staff and need to be maintained under supervision of competent maintenance personnel.

c) Costs involved

All said and done the choice of maintenance program is ultimately a result of the costs associated. The costs here refer to the costs involved in production stoppages due to maintenance in one hand and the cost of running a maintenance program on the other. Another cost is the one occurring due to the necessity of replacement of machinery for non-performance of maintenance. It is the economics of maintenance cost, loss of production units and goodwill that decides which maintenance type is to be followed. Following a planned maintenance necessitates in taking prior decisions to

ensure a smooth flow of production units during the period of planned maintenance. Enabling an uninterrupted flow of output in the market takes care of the goodwill and profitability of the organisation. However the cost of a planned maintenance program is high, it can be justified only with cost incurred due to sudden breakdowns requiring breakdown maintenance. Preventive maintenance leads to consistency in the quality of the products produced. In case of breakdown maintenance, need based repairs are performed which often cost the quality of the output products so produced. Such inconsistency can be inconsistency in quality, deteriorated products leading to frequent returns from customers and a tarnished brand image.

d) Safety at the work place

Workplace safety is a priority in any organisation. Maintenance programs are designed to prolong the productive life of any machinery and to reduce sudden breakdowns as far as possible. Maintenance ensures that operational parameters are set in safe limits to prevent accidental leakage of fluids, breakage of items, auto-ignition of vapour due to excessive heat generation, etc. Such operational limits ensure safety at the workplace. Cleaning being a part of maintenance prevents accidents that may be caused from spillage of fluids, scattered tools and equipments, etc.

14.5 NEED FOR REPLACEMENT

Replacement is a necessary requirement in any facility. Machinery and other equipments wear out in performance and gradually the cost of supporting them follows a cost curve. Replacement is done for machinery and equipments whose productive life has elapsed. Additionally, it is done for machinery whose cost of maintenance is so high that it justifies replacing it with another. Sometimes the machinery stands no longer remains suitable to produce products demanded in the market. Under such circumstances it becomes imperative to substitute the functioning of the machinery with

one of a higher specification or specifications that which may produce required products. In certain instances the technology of working of machinery can no more be serviceable necessitating the replacement of the same. Replacement has a cumulative effect in a facility. Replacing one equipment or machinery may necessitate modifications in the related machines or those immediately preceding or succeeding in the stages of operation. Efficiency or better performance obtained by way of replacement of certain machinery may not get revealed in the entire facility performance unless the performance of other machinery is also enhanced.

Replacement is imperative under the following conditions:

a) Wear and tear of machinery has lead to high costs of maintenance,
b) Loss in efficiency,
c) Deteriorated quality of the products produced, frequent and sudden break downs, etc
d) Obsolescence in the technology used in the machinery
e) Advanced technology being available which can produce better quality products, efficiency in power consumption, etc.
f) Servicing and maintenance cannot be arranged easily
g) Inability to produce products as per market demand.
h) Machinery creates unfit creating conditions hazardous or unsafe for the workmen.

14.6 CRITERIA FOR REPLACEMENT

Machinery can be replaced if it is technologically not suitable for use and if the costs of the replacement can be arranged by the organisation. Factors for deciding replacement of machinery can be discussed under two heads.

a) Technical aspects and
b) Financial aspects

14.6.1 Technical aspects

a) Functioning and deterioration of equipment
b) Technological life of the machinery

c) Adherence to safety and environmental regulations

d) Frequency of breakdowns and shut downs

e) Quality of products produced and demand in the market

f) Adherence to production deadlines

14.6.2 Financial aspects

a) Cost of maintenance and repairs

b) Cost of replacement of parts

c) Cost of power consumed

d) Salvage value towards end of service life

(e) Cost of deteriorated quality products produced by the machinery



CHECK YOUR PROGRESS

Q4: What are the conditions on which the choice of a Maintenance policy for machinery depends?

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Q5: State three conditions in which replacement becomes imperative.

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Q6: What are the technical aspects that should be considered for replacing machinery?

……

……

14.7 REPLACEMENT PROBLEMS

Problem 1.

A Super bakery produces variety of cakes and biscuits everyday in Gurgaon. It has a number of machines for the same. The bakery recently purchased a blender of capacity 5000ml at a cost of Rs. 9,000. The cost of installation of the blender has been Rs. 500. The scrap value of it is Rs. 1200. The

blender needs oiling and servicing every year. The cost of oiling per year is given in the table below. Oiling has to be done by experts, service charges for each service is Rs. 200. The Board of Management is suggesting substitution of the existing blender with one from Germany of make Bl-1. The Finance department is however sceptical to purchasing the same immediately. The Board of Management wants to decide the year in which the blender should be replaced. Advise the Board of Management.

Year	1	2	3	4	5	6	7	8	9
Cost of oiling, etc. in Rs.	800	1300	1980	2800	3000	3300	4000	4300	4600

Cost of the blender = Rs. 9000

Cost of installation = Rs. 500

Scrap value of blender = Rs. 1200.

Service cost per service = Rs. 200

Solution:

The cost C of the blender includes the price P at which the blender is purchased and the cost of installation I.

P+I = C

9000 + 500 = 9500 = total cost of the blender

Since the salvage value S of the blender is Rs. 1200, the cost C_1 of the machine stands at

C_1= C- S

= Rs.(9500-1200)

= Rs. 8300

The annual cost incurred every year on the machine should hence include the cost of maintenance annually. The following table gives the annual cost incurred on the blender

Year	Cost of maintenance (oiling etc)	Cost of maintenance add service charge	cumulative maintenance charges	C-S (Fixed over all years)	Cost of blender and maintenance less scrap value	Amount spent on blender per year
1	800	1000	1000	8300	9300	9300.00
2	1300	1500	2500	8300	10800	5400.00
3	1980	2180	4680	8300	12980	4326.67
4	2800	3000	7680	8300	15980	3995.00
5	3000	3200	10880	8300	19180	3836.00
6	3300	3500	14380	8300	22680	3780.00
7	4000	4200	18580	8300	26880	3840.00
8	4300	4500	23080	8300	31380	3922.50
9	4600	4800	27880	8300	36180	4020.00

It has been observed from the table that year 6 onwards the annual cost incurred on the blender increases, hence the blender need to be replaced at the end of year 6.

Problem 2.

Delight bakery in Gurgaon purchased a blender for Rs. 55000. The cost of servicing is Rs. 15000 for the first four years and thereafter increases by Rs. 3000 every year. The blender has a salvage value of Rs. 0. The servicing of the blender is to be done at the beginning of each financial year. For a time value of money at 10 %, determine when Delight bakery should replace the blender.

Solution

Cost of blender = Rs. 55000

Salvage value = Rs. 0

Time value of money = 10 %

Year	1	2	3	4	5	6	7	8	9	10	11	12
Maintenance cost in Rs.	15000	15000	15000	15000	18000	21000	24000	27000	30000	33000	36000	39000

The cost of servicing for each year is to be calculated considering the Time value of money @ 10 % per year.

Cost incurred on the blender every year is hence the cost of blender together with the servicing cost discounted at 10 %.

Year Servicing cost in Rs. PV factor @ 10 % present value of servicing cost add servicing cost cumulative present value annual cost incurred

Year	Servicing cost in Rs.	PV factor @ 10 %	present value of servicing	cost add servicing cost	cumulative present value	annual cost incurred
1	15000	1	15000	70000	1	70000
2	15000	0.909091	13636.36364	83636.36364	1.90909091	43809.52381
3	15000	0.826446	12396.69421	96033.05785	2.73553719	35105.74018
4	15000	0.751315	11269.72201	107302.7799	3.48685199	30773.54019
5	18000	0.683013	12294.2422	119597.0221	4.16986545	28681.26648
6	21000	0.620921	13039.34778	132636.3698	4.79078677	27685.71766
7	24000	0.564474	13547.37432	146183.7442	5.3552607	27297.22274
8	27000	0.513158	13855.26919	160039.0134	5.86841882	27271.23239
9	30000	0.466507	13995.22141	174034.2348	6.3349262	27472.18031
10	33000	0.424098	13995.22141	188029.4562	6.75902382	27819.02554
11	36000	0.385543	13879.55842	201909.0146	7.14456711	28260.49663
12	39000	0.350494	13669.26208	215578.2767	7.49506101	28762.71141
13	42000	0.318631	13382.49434	228960.771	7.81369182	29302.50849

14.8 RELIABILITY

The probability that a product provides uninterrupted service under normal operating conditions is a measure of its reliability. The duration during which a product is reliable is a measure of the time in which maintenance is not necessitated. The more reliable a product is, the less is its possibility of breakdown requiring maintenance. Knowledge of reliability of a product enables operations Managers to make approximate predictions of time of failure and the time for requirement of spares, and servicing. A measure of reliability enables managers to predict the life of a product and the possible time of replacement.

A washing machine with a reliability of 0.97 refers to 97 continuous working hours out of 100 available hours. The machine thus has a 0.03 chance of being faulty. Reliability is quality of a product over time since it is a measure of uninterrupted service from a product in a specified time. The higher the reliability the lesser is the need for maintainability.

A measure of reliability is obtained by the bath-tub curve popular in maintenance engineering.

The bathtub curve is a representation of failures that occur in the lifecycle of a product till its wear out. A product in its initial period of use is likely to fail more frequently. Normally such failures are a result of manufacturing flaws, design flaws, uneven stress developed in parts or components, improper handling or operation of the products, etc. Such failures are handled through improvement in product design and manufacturing processes. This period of failure is termed as infant mortality since the product is more likely to fail in its infancy. Normally as the infancy period elapses for a product, the product performance becomes relatively stable; the product operates with minimal or without failure. Failure is however possible during this period due to accidental causes of failure. This period is termed a youth and forms the useful stage in the life of the product. With usage over time, the product gradually is subjected to wear and tear. Hence after a considerable period of use the products necessitates frequent maintenance as frequency of failures also rise. This is termed as

the old age period. The failure rates during the entire life period of a product when plotted against time along the horizontal axis takes the shape of a bath tub and hence the name.



Fig: 14.8: Bath-tub curve

The bathtub curve is significant for the operations managers since it shows the length of each period in the life of the product. Ideally the infant mortality phase should be as short as possible and the youth period should be significantly long. Furthermore, the length and the frequency of failures during the infant mortality period enable managers to take significant decisions with regard to warranty of the products. Maintenance policies are to be adequately designed to minimise failures during the youth period. The later part of the life faces frequent failures. The frequency and type of failure may help the managers to take steps on replacement of products.

14.9 DETERMINATION OF MAINTENANCE CREW SIZE

Crew size required for maintenance depends on average job load which includes scheduled maintenance and anticipated number failure or breakdown maintenance that might be required. Each type of maintenance has to be classified in terms of time required to attend the job. This in turn will help to assess the crew size. In case of breakdowns, the same needs immediate attention else it could prolong production stoppage. A larger crew size may render under utilisation of manpower whereas a smaller crew size may lead to backlog in the maintenance job. Non-occurrence of

breakdown may lead to increased idle time of the crew. This in turn raises the cost of holding crew. Hence an estimated backlog of jobs is maintained. The optimal crew size is based on the backlogs and is given by:

Crew Size = Scheduled man hours per week/ (hours per week X backlog)

Where, Scheduled man hours per week= man hours required for attending scheduled maintenance and breakdowns based on prediction.

14.10 INFORMATION SYSTEM FOR MAINTENANCE MANAGEMENT

It is the detailed information of the operations that can help managers to decide and plan for performing maintenance function smoothly. For any machinery a record of the necessary maintenance required, with the tentative time for the same, may feed valuable input for decisions in future. It is imperative to have stored such information and to have ease of access to information pertinent to maintenance. Information necessary for the same may furnish useful input of the following types:

a) The available or the possible bathtub curve to locate the infancy, useful life and wear out phase to locate the time of probable breakdowns.
b) Possible locations of breakdowns and the maintenance crew that might be required.
c) The detailed activities involved in the operation of the machinery to assess the costs.
d) The necessary mathematical models and /or record of readings to trace the presence or absence and the behaviour (if at all present) of unusual sounds, vibrations, etc. for predictive maintenance.
e) Schedules for proactive maintenance programmes.
f) A record of reliability of the machinery to assess for replacements.

Organisations are nowadays equipped with Maintenance Information System which is a robust package that tracks, and generates necessary information aiding operations managers for maintenance related decisions. Such a system is equipped with latest data on records of maintenance

schedules, costs of maintenance, and the crew size requirement. The system simplifies and serves as an essential tool in helping maintenance mangers in conducting error free and efficient maintenance functions.



14.11 LET US SUM UP

After going through the unit we have come through the following:

1. Maintenance management ensures improvement in efficiency of a facility by reducing possible loss that may occur by way of sudden faults in operation, frequent breakdowns inviting repairs leading to loss in man and machine hours thereby reducing profitability.
2. Some of the Objectives of Maintenance Management are
   - Early detection and diagnosis of problems in machinery within a facility.
   - Minimal wear and tear of machinery to ensure enhanced performance of the plant and machinery.
   - Minimise repair time and the cost so involved
   - Ensure error free operation of machinery to prevent accidents
3. Four popular types of Maintenance are
   - Planned Maintenance
   - Preventive Maintenance
   - Breakdown maintenance
   - Predictive Maintenance
4. Factors responsible for designing the maintenance policy for a facility are
   - Type of process
   - Type of machinery
   - Costs involved
   - Safety at the work place
5. Sometimes when machinery no longer remains suitable to produce products it becomes imperative to replace the machinery with one of a higher specification or specifications that which may produce required products.

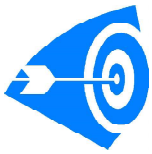
6. Replacement becomes necessary under the following conditions:
   - Wear and tear of machinery causing high costs of maintenance,
   - Loss in efficiency,
   - Deteriorated quality of the products produced
   - Obsolescence in the technology used in the machinery
   - Availability of advanced technology being available.
7. Replacement of machinery can be done in consideration technical aspects and financial aspects involved in the machinery.
8. The probability that a product provides uninterrupted service under normal operating conditions is a measure of its reliability. The more reliable a product is, the less is its possibility of breakdown requiring maintenance.
9. The bathtub curve is a representation of failures that occur in the lifecycle of a product till its wear out. The bathtub curve is significant for the operations managers since it shows the length of each period in the life of the product.
10. Crew size required for maintenance depends on average job load which includes scheduled maintenance and anticipated number failure or breakdown maintenance that might be required.



14.12 FURTHER READING

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14.13 ANSWERS TO CHECK YOUR PROGRESS

Answer to Question No.1: Maintenance Management is the application of techniques of operations management to ensure breakdown free and smooth running of all plant and machinery within a facility and controlling the costs of maintenance.

Answer to Question No.2: Two objectives of Maintenance Management are:-

- To attain minimal wear and tear of machinery for enhanced performance of the plant and machinery.
- To minimise repair time and the cost involved in repairs.

Answer to Question No.3: The four types of Maintenance are

- Planned Maintenance
- Preventive Maintenance
- Breakdown maintenance
- Predictive Maintenance

Answer to Question No.4: The conditions on which the choice of a Maintenance policy for machinery depends are

- Type of process
- Type of machinery used
- Costs involved in maintaining the machinery and the cost of replacing it.
- Safety at the work place

Answer to Question No.5: Three conditions in which replacement of machinery becomes imperative are

- Wear and tear of machinery leading to high costs of maintenance,

- Loss in efficiency
- Deteriorated quality of the products produced and frequent and sudden break downs, etc

Answer to Question No.6: The technical aspects that should be considered for replacing machinery are as below:-

- Functioning and deterioration of equipment
- Technological life of the machinery
- Adherence to safety and environmental regulations
- Frequency of breakdowns and shut downs
- Quality of products produced and demand in the market
- Adherence to production deadlines



14.14 MODEL QUESTIONS

Q1: Why is Maintenance Management essential in any facility?

Q2: What are the objectives of Maintenance Management?

Q3: What is preventive maintenance? How is it different from breakdown maintenance?

Q4: How is preventive maintenance different from breakdown maintenance?

Q5: How does safety of workmen serve as a factor in deciding maintenance programs for a facility?

Q6: Under what conditions of machinery does its replacement become essential?

Q7: What is a bath-tub curve? How does it help in estimating maintenance programs?

Q8: Why is backlog an essential factor in determination of maintenance crew size?

Q9: How does information system provide useful input in maintenance decisions?

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UNIT 15: TOTAL QUALITY MANAGEMENT , SIX SIGMA AND JUST IN TIME

UNIT STRUCTURE

15.1 Learning Objectives

15.2 Introduction

15.3 Essentials Of TQM Culture

15.4 Top Management Leadership In TQM Implementation

15.5 Human Resource Development

15.6 Process Management In TQM System

15.7 Benefits Due To TQM

15.8 TQM “Gurus” And Their Contributions

15.9 Components of TQM

15.10 Introduction To Six Sigma Quality

- 15.10.1 The meaning of Six Sigma (6 ó)
- 15.10.2 Six Sigma by Indian Organisation
- 15.10.3 Implementation Roles In Six Sigma

15.11 JIT Philosophy

- 15.11.1 Benefits Of JIT

15.12 Let’s Sum Up

15.13 Further Reading

15.14 Answers To Check Your Progress

15.15 Model Questions

15.1 LEARNING OBJECTIVES

After going through this unit you will be able to:

- understand the concepts of Total Quality Management
- know the process management in TQM system
- explain the philosophy of TQM
- describe the basic concepts of six sigma and its benefits
- know the basic concept of JIT (Just in Time)

15.2 INTRODUCTION

TQM is a philosophy that involves every department and every employee in an organization for the continuous improvement in quality in all aspects of work and to achieve customer satisfaction." In this definition three aspects are very clear i.e. (a) Continuous improvement, (b) Customer satisfaction and (c) Involvement of all employees. Quality is no more the job and problem of the production people neither quality is related to the product only. Quality is everyone's concern and it could be in product, packing, distribution, public relation, customer relation, attending telephone calls, writing letters, attending visitors etc. hence TQM involves all, concerns all to develop a new culture of quality altogether.

15.3 ESSENTIALS OF TQM CULTURE

- To be in constant pursuit of customer satisfaction. Attend customer feed back by in corporating in the organization work.
- Commitment of the management and giving a lead to develop TQM culture.
- To formulate organizational quality policy to be a guideline to all employees.
- Formation of organization structure, which should be effective from organization interest point of view. .
- Human resources involvement at all levels in the quality culture development.
- To keep watch on quality costs, especially those of repeat work and waste type.
- Involving outsiders (vendors) in the TQM system.
- To create an award/ reward system to good performers. .
- While individual talent can be appreciated group formation or team building for cohesive working leads to better performance.
- Continuous improvement about product related work and total organizational working is never ending quest.
- Method of internal and external customers is to be followed

- If process and work methods have taken care of quality work then inspection is least required.
- For achieving quality top management responsibility is 85% and the balance is worker's responsibility.
- Training and re-training in quality related functions are a necessity for continuous improvement.

15.4 TOP MANAGEMENT LEADERSHIP IN TQM IMPLEMENTATION

In developing TQM culture in an organization it is essential to obtain willing co-operation of all employees and especially of the workers. There is no way TQM system can be developed by hiring & -firing method of olden days. Moreover workers will do a good job and quality job, if they are provided with (a) Precision machineries, (b) Requisite tools, fixture, Jigs and measuring instruments. In addition to this, the work environment and minimum basic facilities are to be provided. The top management should take care of all these and then expect the quality work from employees. Employees must get customer feed back and the areas needing improvement. By providing information and training employees will feel motivated to be a part of quality improvement programme. Similarly the senior management must involve all vendors, sub-contractors to develop similar TQM culture in their organizations so that there is no mismatch of quality of internally and externally arranged components. While awarding contracts to vendors or suppliers quality should be given higher or equal priority to price factor. Mere awarding contracts on low price basis are likely to affect quality adversely.

15.5 HUMAN RESOURCE DEVELOPMENT

To meet the TQM expectations the voluntary participation of all the employees is essential. The HRD work starts from recruitment and selection stage for new recruits. The new employees can be groomed by making them work under an experienced supervisor. Developing the existing

experienced workforce is an important task for the senior managers. There are various methods for motivating people for TQM. Some of the methods are as follows.

- Organize training for employees on periodic basis to develop their requisite skills
- Ensure that, excess and partly busy staff is not provided in any department. Idle employees waste time of others as well.
- Job and responsibilities to be allotted based on merit and experience treating. Ensure that the right person- is allocated to the right job.
- Emphasize time and again on cohesive working and team building. This leads to employee participation in decision making i.e. empowerment.
- The senior management personnel should in addition to routine work do the mentoring work to develop future leaders for various functions.
- Employee should be encouraged to learn new-skills, obtain higher qualifications both for self-development and for contributing to organizational growth.

By taking care of the HRD activities, and with constant monitoring by maintaining their files and records, it is very clear that on the lines of continuous improvement in organizational activities, the human resources will also improve continuously in terms of skill, knowledge and added qualifications.

15.6 PROCESS MANAGEMENT IN TQM SYSTEM

In TQM system, the processing should take care of quality aspects from beginning to end. From design stage to delivering stage the documentation and instruments, operators and stage evaluation should be such that the desired quality is obtained effortlessly by the system and not due to few individuals.

During designing and engineering the customer expectations should be incorporated. The machinery tooling, Jigs, fixtures and measuring

instruments should have accuracies to obtain specified quality first time, next time and always. Consistency of quality is the hallmark of TQM system.

Prevention of defects is achieved by this and right person handling right job. By spending time and money on positive efforts not only company avoids rejections and re-work, but in fact, it saves cost. Moreover employee morale and company image will be high.

The processing at sub-contractors level also to be monitored to match the TQM system followed in the company. The sub-contractors are to be persuaded to follow. The vendors should be like business associates and not outsiders.

The internal customer method is to be followed during stages of processing. The second operator is the customer to first operator. Thus the evaluation is done right time before the mistakes continue to happen. Corrections can be done there and then to save further embarrassment and cost burden

15.7 BENEFITS DUE TO TQM

(a) Tangible Benefits

- Substantial reduction is quality costs.
- Increase in profitability due to increased productivity and nil or negligible re-work costs.
- Market share and sales will improve.
- Reduction in service expenses

(b) Intangible Benefits

- Employee morale and company image will be high.
- Employee involvement and team work will improve.
- A satisfied customer can be a good sales link.
- Flow of information and human relations will be better

Table 15.1

Comparison of Quality control and TQM	
Quality Control	TQM
• Certain percentage of rejection is considered as part of work culture. • Quality improvement cost is more • Customer is treated as buyer and treat acceptance at despatch level in final. • Inspection is done after work • Will do re-work on deviations • Concerned worker is blamed for deviations. • Major responsibility on supervisors	• Zero defect is the aim and efforts are made in that direction • Cost is compensated in terms of productivity and quality consistency • Customer is consumer and hence reliability is important. • Quality aspect attributes taken care in tooling and processing. • Problem is studied thoroughly to avoid recurrence. • All are responsible. • Top management is mainly responsible

15.8 TQM "GURUS" AND THEIR CONTRIBUTIONS

TQM study will never be complete without referring the names and their teachings of TQM Gurus. Dr. Walter Shewhart is the senior most amongst them and Dr. Edward Deming and Dr. Joseph Juran, his students come next. Other contributors of TQM literature, practical and books are Dr. Philip Crossby, Mr. Masaki Imai, Shigeo Shingo and Dr. Ishikawa. Each one of them are specialized in some of the aspects of quality practices and their theories are taught in detailed in full scale TQM subject. Their contributions are dealt here in briefly as a part of production management system.

(1) Dr. Walter Shewhart - An USA professor of statistics who was the first person to advocate the use of SQC method in quality evaluation. Both Dr. Deming and Dr. Juran were his students and went on to contribute much more in TQM system development at Japan.

(2) Dr. Edward Deming - Originally a statistics professor but went on to involve himself in corporate world. After 2nd World War he was sent to Japan by the USA government to improve the industrial scenario in Japan. After the war Japan was devastated and needed recovery.

Dr. Deming toured throughout Japan, conducted several seminars and workshops to train the Japanese executives for quality improvement with the help of SQC (Statistical Quality Control) techniques. About 1950 to 1960, hundreds of executives were trained in Japan in statistical process control. He advised one and all to build the quality expectations in the process rather than check only the end product. He was the first to highlight quality productivity link and the Japanese took this seriously and appreciated it.

(a) 'Deming's 14 points for management' -

These are advises on team work, commitment, facilities, training and employee involvement. They are as follows:

1. Create consistency of purpose for continual improvement of product and service.
2. Adopt the new philosophy of economic stability.
3. Cease dependence on inspection to achieve quality.
4. End the practice of awarding business on price tag alone.
5. Improve constantly and forever the system of production and service.
6. Institute training on the job.
7. Adopt and institute modem methods of supervision and leadership
8. Drive out fear.
9. Break down barriers of communications between departments, individuals and also with customers and suppliers.
10. Eliminate the use of slogans, posters and exhortations.
11. Eliminate target or quota for work standards.
12. Remove barriers between workers and their right to pride in their workmanship.
13. Establish a regular programme of education and retraining.
14. Top management must accept and involve in implementation of the above points.

Dr. Joseph/Juran: Dr. Juran of USA was an engineer and believed in practice of quality and he was also a student of Dr. Shewhart and worked in Japan to restore the industries there after World War II. He has written about dozen books on quality aspects of which "Quality control Handbook" (in 1981) is very popular. His contributions to TQM are as follows.

(a) Developing quality as a habit.

(b) Juran's quality Triology.

(c) Juran's "Universal breakthrough sequence".

This quality trilogy consisted of (a) Quality Planning, (b) Quality control and (c) Quality improvement. In his breakthrough sequence he wants us to identify problem, understand through diagnosis and solve it on long-range basis and hold on to gains. He has conducted several executive programmers to train Japanese executives to develop TQM culture in Japan.

(4) Prof Philip Crossby: He has published book on quality management and is teaching in "Crossby's Quality College". His contributions to TQM are:

(a) Crossby's "Four absolutes of quality"

(b) Crossby's "14 steps to quality improvement"

(c) Crossby's "quality Vaccine"

Crossby's Four Absolutes of Quality

Crossby's Four Absolutes of Quality are as follows:

1. Quality is defined as conformance to requirements, not "good enough".
2. The quality system should be prevention type and not appraisal type.
3. "Zero defects" should be standard of performance and not almost zero defects.
4. Management of quality is price of non-conformance.

Crossby's 14 Steps to Quality Improvement

These are similar to Dr. Deming's 14 points with little difference in emphasis and terminology.

Crossby's quality vaccine

Crossby's quality vaccine is represented by the following triangle. The word vaccine, used by Crossby gives more emphasis on preventive actions than corrective actions.

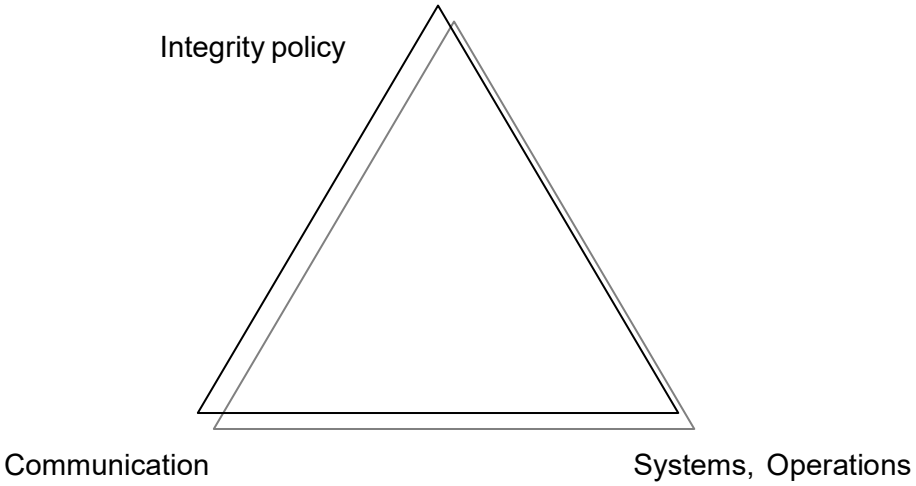


Figure 15.1

(5) **Mr. Masaaki Imai:** A management consultant became very famous for his 'Kaizen' concept which means continuous improvement. This one word has made a drastic change is Japanese work culture to make it a leading industrial nation.

Kaizen involves thinking on all aspects of working systems for improvement. Process,

knowledge, methods, quality, service, utility all the areas need improvement and this is possible by mental approach by employees. Kaizen should be a way of life for everlasting progress.

(7) **Shigeo Shingo on TQM:** He has proposed an equivalent theory for zero defects as "Pokayoke" meaning fool proofing. He advocates identifying errors, looking for potential error and eradicating them to get the desired results. The theory is based on "prevention is better than cure". This thinking leads to fool-proof working system.

(7) **Dr. Ishikawa and TQM:** He was instrumental in developing (a) CWQC - company wide quality control, (b) Quality circles, (c) Team based problem solving and (d) Cause and effect analysis by fish-bone diagram. His other contributions of TQM are as follows :

(a) First thing to know in quality is customer expectations

(b) Ideal situation in quality control is when inspections become unnecessary

(c) Eliminate the root cause of the problem and not.symptoms.

(d) Quality control is everyone's concern.

(e) Quality starts and ends with knowledge.

(j) Quality is a long range thinking and planning.

(g) Market place is the entrance and exit of quality.



CHECK YOUR PROGRESS

Q.1: The basic aspects of TQM are

a) Continuous improvement

b) Customer satisfaction

c) Involvement of all the employees

(d) (a) & (b)

(e) (a) (b) and (c)

Q.2: In TQM implementation

a) All the employees are equally responsible

b) All are responsible and workers are more responsible

c) All are responsible and top level management is more responsible

Q.3: The suppliers and the subcontractors are not considered in the TQM implementation process (True/ False)

Q.4: The Quality vaccine triangle concept was suggested by

a) Dr. Edward Deming

b) Prof. Philip Crossby

c) Dr. Joseph Juran

15.9 COMPONENTS OF TQM

There are three manor components of Total Quality Management. They are as follows.

1. A Documented Quality Management System
2. Statistical Process Control
3. Teamwork for Quality Improvement

Documented Quality Management System

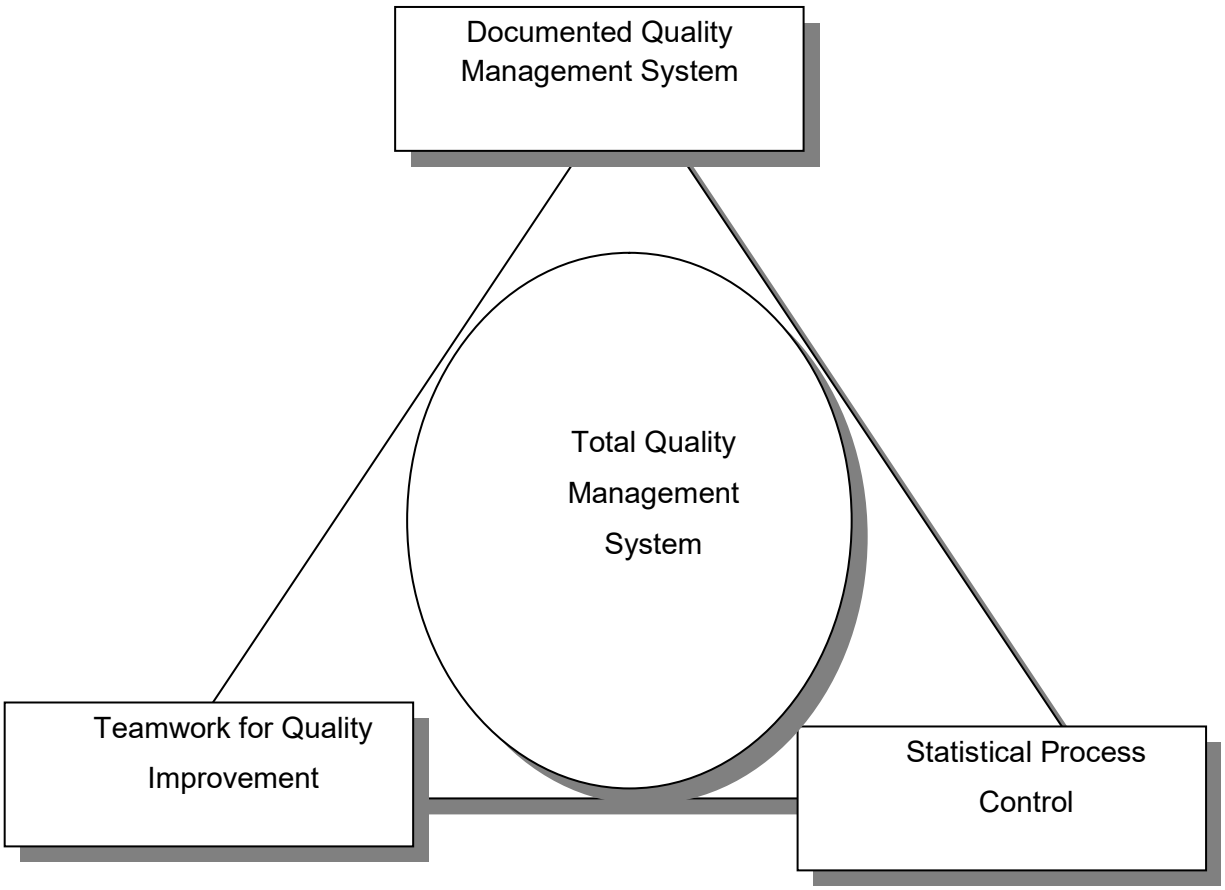


Figure 15.2

A systematic, structured approach to launch the quality improvement through a balanced introduction of a quality system, SPC and teamwork will provide a powerful spearhead with which to improve capability and thereby market share. The importance of the use of SPC and improvements in quality management systems cannot be overemphasized. With the increase in automation in industries and the use of flexible manufacturing systems (FMS), optimized production technology (OPT) and the adoption in Just in Time (JIT) the requirement for a total approach to quality is paramount.

15.10 INTRODUCTION TO SIX SIGMA QUALITY

Six Sigma (6 σ) is the stringent quality standard developed by M/s Motorola Company and this is yet to get wide publicity and adaptation. The non-conformance tolerated is 0.001 ppm (Parts per million) in each trial.

15.10.1 The meaning of Six Sigma (6 σ)

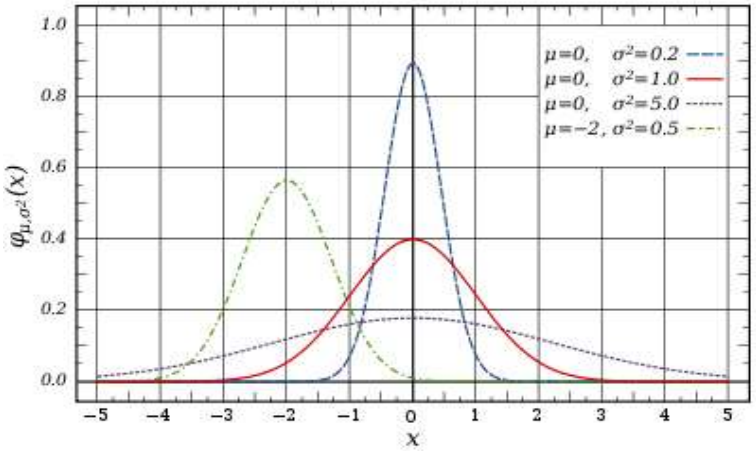


Figure 15.3

The above figure shows the graph of the normal distribution, which underlies the statistical assumptions of the Six Sigma model. The Greek letter ó marks the distance on the horizontal axis between the mean, μ, and the curve's inflection point. The greater this distance is, the greater is the spread of values encountered. For the bold line curve shown above, μ = 0 and σ = 1. The other dotted lines illustrate different values of μ and σ.

Role of The 1.5 Sigma Shift

Experience has shown that in the long term, processes usually do not perform as well as they do in the short. As a result, the number of sigmas that will fit between the process mean and the nearest specification limit is likely to drop over time, compared to an initial short-term study. To account for this real-life increase in process variation over time, an empirically-based 1.5 sigma shift is introduced into the calculation. According to this idea, a process that fits six sigmas between the process mean and the nearest specification limit in a short-term study will in the long term only fit 4.5 sigmas – either because the process mean will move over time, or because the long-term standard deviation of the process will be greater than that observed in the short term, or both.

Hence the widely accepted definition of a six sigma process is one that produces 3.4 **defective parts per million opportunities (DPMO)**. This is based on the fact that a process that is normally distributed will have 3.4 parts per million beyond a point that is 4.5 standard deviations above or below the mean (one-sided capability study). So the 3.4 DPMO of a "Six Sigma" process in fact corresponds to 4.5 sigmas, namely 6 sigmas minus the 1.5 sigma shift introduced to account for long-term variation. This is designed to prevent underestimation of the defect levels likely to be encountered in real-life operation.

Sigma Levels

Taking the 1.5 sigma shift into account, short-term sigma levels correspond to the following long-term DPMO values (one-sided):

One Sigma = 690,000 DPMO = 68.26% efficiency

Two Sigma = 308,000 DPMO = 95.24% efficiency

Three Sigma = 66,800 DPMO = 99.73% efficiency

Six Sigma = 3.4 DPMO = 99.9997% efficiency

15.10.2 Six Sigma by Indian Organisation

It will be interesting to know that the 'Dabbaawala' of Bombay have got six-sigma certification in India. This is pertaining to providing lunch boxes to employees working in different places in Bombay city and suburbs. Duty around 1.5 Lac lunch boxes are taken in morning and returned in the evening through local trains and bi-cycles. They have a coding system to identify person, office location, residence area and location. Due to this numbering and colour coding Lunch boxes (Dabbas) reach right person in office and their homes. This is taken care of by a cooperative society mostly consisting of young matriculates. This is going on since decades and an individual handles about 50 boxes per day and is paid Rs. 150 p.m. by the users. It is found that only about 2 to 3 mistakes happens in 2 months. This means 3 mistakes in 150 lac transactions and hence the

rejection level is lesser than six sigma (3.4 ppm) and they are awarded six-sigma certificate.

15.10.3 Implementation Roles in six sigma

One of the key innovations of Six Sigma is the professionalizing of quality management functions. Prior to Six Sigma, quality management in practice was largely relegated to the production floor and to statisticians in a separate quality department. Six Sigma borrows martial arts ranking terminology to define a hierarchy (and career path) that cuts across all business functions and a promotion path straight into the executive suite.

Six Sigma identifies several key roles for its successful implementation.

- **Executive Leadership** includes the CEO and other members of top management. They are responsible for setting up a vision for Six Sigma implementation. They also empower the other role holders with the freedom and resources to explore new ideas for breakthrough improvements.
- **Champions** are responsible for Six Sigma implementation across the organization in an integrated manner. The Executive Leadership draws them from upper management. Champions also act as mentors to Black Belts.
- **Master Black Belts**, identified by champions, act as in-house coaches on Six Sigma. They devote 100% of their time to Six Sigma. They assist champions and guide Black Belts and Green Belts. Apart from statistical tasks, their time is spent on ensuring consistent application of Six Sigma across various functions and departments.
- **Black Belts** operate under Master Black Belts to apply Six Sigma methodology to specific projects. They devote 100% of their time to Six Sigma. They primarily focus on Six Sigma project execution, whereas Champions and Master Black Belts focus on identifying projects/functions for Six Sigma.

- **Green Belts** are the employees who take up Six Sigma implementation along with their other job responsibilities. They operate under the guidance of Black Belts.

15.11 JIT PHILOSOPHY

The philosophy of JIT is simple - inventory is defined to be waste. JIT inventory systems expose the hidden causes of inventory keeping and are therefore not a simple solution a company can adopt; there is a whole working come from many different disciplines including statistics, industrial engineering, production management and behavioral science. In the JIT inventory philosophy there are views with respect to how inventory is looked upon, what it says about the management within the company, and the main principle behind JIT.

In short, the just-in-time inventory system is all about having **"the right material, at the right time, at the right place, and in the exact amount**", without the safety net of inventory. The JIT system has implications of which are broad for the implementers.

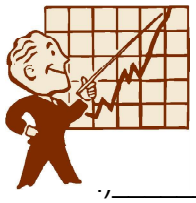
15.11.1 BENEFITS OF JIT

As most companies use an inventory system best suited for their company, the Just-In-Time Inventory System (JIT) can have many benefits resulting from it. The main benefits of JIT are listed below.

- Set up times are significantly reduced in the factory. Cutting down the set up time to be more productive will allow the company to improve their bottom line to look more efficient and focus time spent on other areas that may need improvement. This allows the reduction or elimination of the inventory held to cover the "changeover" time.
- The flows of goods from warehouse to shelves are improved. Having employees focused on specific areas of the system will allow them to process goods faster instead of having them vulnerable to fatigue from doing too many jobs at once and simplifies the tasks at hand. Small or individual piece lot sizes

reduce lot delay inventories which simplifies inventory flow and its management.

- Employees who possess multiple skills are utilized more efficiently. Having employees trained to work on different parts of the inventory cycle system will allow companies to use workers in situations where they are needed when there is a shortage of workers and a high demand for a particular product.
- Better consistency of scheduling and consistency of employee work hours. If there is no demand for a product at the time, workers don't have to be working. This can save the company money by not having to pay workers for a job not completed or could have them focus on other jobs around the warehouse that would not necessarily be done on a normal day.
- Increased emphasis on supplier relationships. No company wants a break in their inventory system that would create a shortage of supplies while not having inventory sit on shelves. Having a trusting supplier relationship means that one can rely on goods being there when he needs them in order to satisfy the company and keep the company name in good standing with the public.
- Supplies continue around the clock keeping workers productive and businesses focused on turnover. Having management focused on meeting deadlines will make employees work hard to meet the company goals to see benefits in terms of job satisfaction, promotion or even higher pay.



CHECK YOUR PROGRESS

Q.5: The three major components of TQM are i)_____ ii)_____iii)_____

Q.6: In Six Sigma we have_____DPMO(defective parts per million opportunities)

Q.7: The efficiency of a six sigma process is _____

Q.8: Implementation of JIT help in

a) achieving Zero defect

b) Continuous improvement

c) Having “the right material, at the right time, at the right place, and in the exact amount”.



15.12 LET US SUM UP

Total quality management (TQM) is a management strategy aimed at embedding awareness of quality in all organizational processes. TQM has been widely used in manufacturing, education, call centers, government, and service industries. The effective implementation of TQM can enhance the whole quality management culture of the organization.

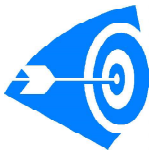
Six Sigma was originally developed as a set of practices designed to improve manufacturing processes and eliminate defects, but its application was subsequently extended to other types of business processes as well. In Six Sigma, a defect is defined as anything that could lead to customer dissatisfaction.

Just-in-time (JIT) is an inventory strategy implemented to improve the return on investment of a business by reducing in-process inventory and its associated carrying costs. In order to achieve JIT the process must have signals of what is going on elsewhere within the process



15.13 FURTHER READING

Production and Operations Management by S. Anil Kumar and N. Suresh, New age international publication (2008)



15.14 ANSWERS TO CHECK YOUR PROGRESS

Ans. to Q.No.1: (e) a) , b) & c)

Ans. to Q.No.2: (c) All are responsible and top level management is more responsible

Ans. to Q.No.3: false

Ans. to Q.No.4: (b) Prof. Philip Crossby

Ans. to Q.No.5: i) A Documented Quality Management System ii) Statistical Process Control iii) Teamwork for Quality Improvement

Ans. to Q.No.6: 3.4 DPMO

Ans. to Q.No.7: 99.9997%

Ans. to Q.No.8: (c) Having “the right material, at the right time, at the right place, and in the exact amount”



15.15 MODEL QUESTIONS

Q.1: Describe the philosophy of TQM

Q.2: What are the essentials of TQM culture?

Q.3: Describe the importance of top management leadership and human resource management in TQM implementation.

Q.4: Compare Quality control in general and TQM

Q.5: What are the different benefits of TQM

Q.6: Describe the contributions of Dr. Edward Deming in TQM philosophy

Q.7: Write short notes on Dr, Josph Juran, Prof. Philip Crossby, Taguchi and Dr. Ishikawa’s contribution in the TQM.

Q.8: Explain the basic concept of Six Sigma Quality

Q.9: Describe different implementation roles in six sigma

Q.10: Explain the basic concept of Just in Time. What are its benefits?

*** ***** ***



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