PRODUCTION AND OPERATIONS MANAGEMENT-3

Directorate of distance education

M.B.A
1. PAPER 2.6: PRODUCTION AND OPERATIONS MANAGEMENT

Unit – 1

Introduction to Production and Operation functions – Understanding the relationship between production and other functions – Effect of time element on OM – Examples of manufacturing systems

Designing the product – Need – Factors to be considered – Considerations during PLC – Standardisation – Modular design – Reliability – Reverse engineering

Unit – 2

Capacity Planning – Importance – Capacity measurement – Planning process for manufacturing and service industry

Facility Planning – Location facilities – Locational flexibility – Facility design process and techniques – Locational break even analysis.

Unit – 3


Work Study – Significance – Methods, evolution of normal / standard time – Job design and rating.

Unit – 4


Unit – 5

Material requirement planning and control – Inventory control systems and techniques – Network techniques

Unit – 6

Maintenance functions – Preventive vs Breakdown – Query models.

Quality Control – Introduction to control charts and acceptance sampling procedures – Quality control – Total Quality Management
UNIT – 1

1A. PRODUCTION AND OPERATION

1A.1 INTRODUCTION

Management is an exciting subject because it deals with setting, seeking, and reaching objectives. We are all managers of our own lives, and the practice of management is found in every facet of human activity: schools, businesses, churches, government, unions, armed forces, and families. Establishing and achieving objectives are challenging and rewarding missions for any enterprise, and we will discover that the managerial hurdles to be overcome for success are surprisingly similar for all organizations.

A manager’s role is to set goals and amass and mobilize the resources of men and women, materials, machines, methods, money, and markets to accomplish the desired results within predetermined constraints of time, effort and cost.

1A.2 MANAGEMENT: DEFINED

There are numerous definitions of management. Probably the most popular are often quoted is “getting things done through other people.” This and most other definitions have merit and highlight important aspects of management. For the purpose of this book, the following definitions will be used.

Management is a distinct process consisting of activities of planning, organizing, actuating, and controlling, performed to determine and accomplish stated objectives with the use of human beings and other resources.

1A.3 KEY CHARACTERISTICS TO UNDERSTANDING MANAGEMENT

The following list will be beneficial to the beginning student of management. Although portions of the following were implied in the above discussion, this orderly list may prove helpful in systematizing your thoughts for this chapter.

a. Management is purposeful. Management deals with the achievement of something specific, expressed as an objectives or goal. Managerial success is commonly measured by the extent to which objectives are achieved. Management exists because it is an effective means of getting needed work accomplished. The fact that some executives have subordinates reporting to them does not ipso facto make them managers.

b. Management makes things happen. Managers focus their attention and efforts on bringing about successful action. They know where to start, what to do to keep things moving, and how to follow through. Successful managers have an urge for accomplishment. This means that in some cases the person practicing management may find that she or he is not winning a popularity contest, but members of the group still respect the managers. The management member gets along with people by not only liking them but also being firm and helpful and expecting the best.

c. Management is an activity, not a person or group of persons. The word managing is more precise and descriptive than management. Popular usage, however, has made management the widely accepted term Management is not people; it is an activity like walking, reading, swimming, or running. People who perform management can be designated as managers, members of management, or executive leaders. In addition, management is a distinct activity. It can be studied, knowledge about it obtained, and skill in its application acquired.

d. Management is accomplished by with, and through the efforts of others. To participate in management necessitates relinquishing the normal tendency to perform all things yourself and get tasks accomplished by, with, and through the efforts of group members. This is far more difficult than it sound. Normally a person acquires ability in a specialized type of work and wins promotions through easing knowledge and skill in this field of specialization. How ever, the time comes when further promotion requires shifting from the role of a specialist to that of a management member. The prime measures of success becomes setting or securing
agreement on the proper goals and getting others to accomplish these goals. How successfully this deliberate shift is made determines the potential of the new manager. This characteristic merit recognition by the ambitious specialist. All too frequently the best salesperson who is promoted to district sales manager remains a salesperson because he or she fails to comprehend the managerial difference between getting salespeople to sell and knowing how to sell. Likewise, the employee training expert who is advanced to assistant personnel manager may continue to be a training expert, thus not succeeding in the new managerial post.

e. Management is usually associated with the efforts of a group. It is common to associate management with a group. However, management is also applicable to an individual’s efforts. For example, a person manages many personal affairs. The group emphasis stems from the fact that an enterprise comes into existence to attain goals, and these are achieved more readily by a group than by one person alone. People become members of an enterprise to satisfy their needs and because they feel their giants will outweigh their losses or burdens as members of a group.

f. Management is intangible. It has been called the unseen force, its presence evidenced by the results of its efforts—orderliness, enthusiastic employees, buoyant spirit, and adequate work output. Strange as it may seem, in some instances the identity of management is brought into focus by its absence or by the presence of its direct opposite, mismanagement. The result of mismanagement is clear.

g. Management is aided, not replaced by the computer. The computer is an extremely powerful tool of management. It can widen a manager’s vision and sharpen insight by supplying more and faster information for making key decisions. The computer has enabled the manager to conduct analysis far beyond the normal human’s analytical capacities. It has forced managers to reexamine their analytical processes and judgment in view of the almost unbelievable data processing and feedback facilities of the modern computer.

However, a manager must supply judgment and imagination as well as interpret and evaluate what the data meant in each individual case. It is doubtful that General George Washington would have crossed the Delaware River if he had relied on a computer to help him decide. The data of using leaky boats at night during a snowstorm to face a numerically superior enemy would have indicated a low probability of success. However, despite such rationale, Washington believed he could succeed, seized the initiative, assumed the large risk, and won his objectives.

h. Management is an outstanding means for exerting real impact on human life. A manager can do much to improve the work environment, to stimulate people to better things, and to make favorable actions take place. Frustrations and disappointments need not be accepted and passively viewed as inevitable. A manager can achieve progress, bring hope, and help groups members acquire the better things in life.

1A.4 MEANING OF MANAGEMENT

The chief characteristic of management is the integration and application of the knowledge and analytical approaches developed by numerous disciplines. The manager’s problem is to seek a balance among these special approaches and to apply the pertinent concepts in specific situations which require action. The manager must be oriented to solving problems with techniques tailored to the situations; yet he must develop a unified framework of thought that encompasses the total and integrated aspects of the entire organization.

What, then, is management, and what does it do? In general usage, the word “management” identifies a special group of people whose job it is to direct the effort and activities of other people toward common objectives. Simply stated, management “gets things done through other people.” For the purpose of this book, management is defined as the process by which a cooperative group directs actions toward common goals. This process involves techniques by which a distinguishable group of people (managers) coordinates activities of other people, managers seldom actually perform the activities themselves. This process consists of certain basic functions which provide an analytical approach for studying management.
The concept of management has broadened in scope with the introduction of new perspective by different fields of study.

1A.5 HISTORY OF PRODUCTION AND OPERATIONS MANAGEMENT

The traditional view of production management began in the eighteenth century. Upto 1900, the traditional view prevailed and Frederick W. Taylor brought in the concept of scientific management. The important events in this field and the contributors are detailed in Table 1.1. below:

<table>
<thead>
<tr>
<th>Year</th>
<th>Contribution</th>
<th>Contributor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1776</td>
<td>Specialization of labour in manufacturing</td>
<td>Adam Smith</td>
</tr>
<tr>
<td>1832</td>
<td>Division of labour by skill, assignment of jobs by skill, basics of time study</td>
<td>Charles Babbage</td>
</tr>
<tr>
<td>1900</td>
<td>Scientific management, time study and work study developed</td>
<td>Frederick W. Taylor</td>
</tr>
<tr>
<td>1900</td>
<td>Motion of job</td>
<td>Frank B. Gilbreth</td>
</tr>
<tr>
<td>1901</td>
<td>Scheduling techniques for employees, machines and jobs in manufacturing</td>
<td>Henry L. Gantt</td>
</tr>
<tr>
<td>1915</td>
<td>Economic lot size for inventory control</td>
<td>F.W. Harris</td>
</tr>
<tr>
<td>1931</td>
<td>Statistical inference applied to product quality, quality control charts</td>
<td>Walter A. Shewhart</td>
</tr>
<tr>
<td>1947</td>
<td>Linear programming</td>
<td>George B. Dantzing</td>
</tr>
<tr>
<td>1955</td>
<td>Digital computer, large scale computations made easy</td>
<td>IBM</td>
</tr>
</tbody>
</table>

1A.6 FUNCTIONS OF PRODUCTION AND OPERATIONS MANAGEMENT

Production and operations management concerns not only with the production of goods and services but also all the activities connected with the production. When the word ‘production’ is mentioned, it brings in the things like factories, machines, equipments, assembly lines. This is nothing but things related to manufacturing. In the past, emphasis was on manufacturing management, which subsequently got changed into production management. Production concepts and techniques are being applied to a wide range of activities and situations which have little or nothing to do with factories or manufacturing. These activities resulted not in the realization of goods but in services like banking, hotel management, health services, educations, transportation, recreating, government operations. Due to the widening of the scope, the name was changed from production management into operations management, where the concepts, tools and techniques are applied on diverse nature of activities.

First let us define production. This is a process or a set of procedures to be executed in order to convert or transform a set of inputs into a pre-determined set of outputs in accordance with the objectives assigned to the production system. Generally, a system consists of a transformation or conversion process for a given input to be converted into the required output with a feedback mechanism, so that any deviation or irregularities can be identified and corrected.

In the production environment the input may be labour, energy, capital, information and technology, the transformation process is the production processes and the output may take the form of products or services or processed information.
Operations management, with its widened scope, is responsible for the management of productive systems, that is, it is responsible for systems which either create goods or private service or both.

The operations management personnel have the ultimate responsibility for the creating of goods or services. The variety of jobs which the operations group will oversee will differ from one organization to another. But the basic task of coordinating the use of resources through the management process, which involves planning, organizing, staffing, directing and controlling.

Planning involved determining a future course of action. The planning process begins by deciding what is desired and then designing the way for accomplishing that objective.

Organizing refers to the administrative structure of the organization. It involves putting the parts of the system together in such a way that desired results can be achieved.

Staffing involves selection and training of personnel who will operate the system.

Directing refers to the release of commands or orders, making suggestions or otherwise motivating subordinates to perform their assigned duties in a timely and efficient manner.

Controlling involves measuring the results of operations, deciding if they are acceptable and instituting corrective action if need be.

1A.7 RELATIONSHIP BETWEEN “POM AND OTHER FUNCTIONS

There are three primary functions, which exist in most of the organizations and they are Operations, Marketing and Finance. These three cannot be mutually exclusive and the functional overlap is unavoidable. The level of overlapping varies from one organization to another.

In addition to these three major functions of business organizations, the operation management function has to interact with many supporting functions. The supporting functions are research and development, product design, industrial engineering, maintenance, personnel, accounting, costing, materials, etc. The level of interaction and presence of some departments may be Exchange of information on current and future decided based on the size of the organization, product line and type of management.

![Diagram: Systems View of a Business](https://www.todaylibrary.com)
The operations management personnel and the other major of support functional personnel have to necessarily interact with each other in the activities identified below:

Finance:
- Economic analysis of investment products
- Budgeting and timing of funds
- Provision and release of funds

Marketing
- Developing and maintaining the market
- Advertisement and sales promotion
- Sales forecast
- Production improvement / new product development

Research and Development:
- Idea generation
- Product formulations
- Prototype Development
- Test Marketing

Product Design:
- Preliminary and final design
- Detailed Drawings
- Assembly and parts manufacturing drawings
- Quality standards
- Exchange of information on current and future capabilities

Maintenance:
- Evolution of maintenance policy
- Implementation for general unkeep of equipment

Industrial Engineering:
- Scheduling
- Setting up of standards
- Work methods: time study
- Quality audit and contact
- Material handling
Materials

- Procurement of materials and equipment
- Inventory control
- Economic order quantity and timing of purchase
- Inspection and clearance
- Vendor evaluation and rating

Personnel:

- Recruitment and training
- Labour relations
- Wage and Salary administration
- Manpower Projections

Accounting and Costing:

- Preparation of financial statements
- Cost data on labour, materials and overhead
- Report on scrap, downtime and inventories
- Payables, receivables management
- Insurance

1A.8 EFFECT OF TIME ELEMENT ON POM

In detail we have already seen the effect of production operations management (POM) in the management process. The decision of POM has to be there for short duration activities as well as for long duration ones like the jobs of corporate planning. The detailed task list and the time horizon on which its effect will be there are given in Table 1.2 below:

<table>
<thead>
<tr>
<th>Long Term Horizon</th>
<th>Intermediate Time Horizon</th>
<th>Short Time Horizon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product Design</td>
<td>Product variation</td>
<td>Transport and delivery</td>
</tr>
<tr>
<td>Quality policy</td>
<td>Methods selection</td>
<td>arrangement</td>
</tr>
<tr>
<td>Technology to be employed</td>
<td>Quality implementation, inspection</td>
<td>Preventive maintenance</td>
</tr>
<tr>
<td>Process, Site selection</td>
<td>and control methods</td>
<td>scheduling</td>
</tr>
<tr>
<td>Selection of plant and</td>
<td>Machinery and plant loading</td>
<td>Implementation of safety</td>
</tr>
<tr>
<td>Machinery</td>
<td>decisions</td>
<td>decisions</td>
</tr>
</tbody>
</table>

TABLE 1.2
Manpower training and development – phased programme

Forecasting

Checking / setting up work standards and incentive rates

Long – gestation period raw material supply projects – phased development

Deployment of man-power

Product scheduling

Warehousing

Overtime decision

Available materials allocation and handling

Insurance policy

Shift – working decisions

Manpower scheduling

Design of jobs

Temporary hiring or lay-off of man-power

Breakdown Maintenance

Setting up of work standards

Purchasing policy

Progress check and change in priorities in production scheduling

Effluent and waste disposal systems

Purchasing policy

Temporary Manpower

Safety and maintenance systems

Purchasing source selection developer and evaluation

Supervision and immediate attention to problem areas in labour, materials, machines, and other resources.

Make or buy decision

Inventory policy for new material, work – in – progress and finished goods

1A.9 PRIORITY

One of the primary responsibilities of the production and operations management is the productive use of resources. Productivity is a measure of the relative amount of input needed to secure a given amount of ailed and Feederick W. Taylor brought in the concept output. It is commonly expressed as the ratio of quantity of scientific management. The important events in this of output to quantity of input

Productivity = Output / Input

The enhancement of productivity is the need of the organisation and it can be made possible by either increasing the output and keeping the input at the same level or reducing the input and maintaining the output. The rate of increase in productivity will be very high if output is increased with simultaneous reduction of inputs.

1A.10 MANUFACTURING OPERATIONS VERSUS SERVICE OPERATIONS:

Manufacturing implies production of a tangible output, such as an automobile, a refrigerator, or something similar that we can see or touch and feel. Service on the other hand, generally implies an act rather than a physical product. A doctor’s examination, TV and audio repair, entertainment like film shows are examples of services. The difference between manufacturing and service are in Table 1.3 below:
Table 1.3

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Manufacturing</th>
<th>Service</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output</td>
<td>Tangible</td>
<td>Intangible</td>
</tr>
<tr>
<td>Customer contact</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Labour content</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Uniformity of output</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Measurement of productivity</td>
<td>Easy</td>
<td>difficult</td>
</tr>
</tbody>
</table>

1A.11 EXAMPLE OF MANUFACTURING SYSTEMS

JOB PRODUCTION

In job production the whole product is looked as one job which is to be completed before going on to next. The most common examples are building a ship or a large civil construction job. Job production is not confined to large projects, it could be the making of a special piece of equipment or a tool.

BATCH PRODUCTION

If qualities of more than one are being made, it is sometimes convenient to split the production into a series of manufacturing stages or operations. Each operation is completed as one of the single items being made, before the next operation is started. In this way a group of identical products, or a batch are made, which move through the production process together.

If more than one types of product is being made, then hatches of different products may be moving around the shop floor some times requiring operations from the same machine. This leads to problems of how long a machine should be processing a batch of one type of product before going on to the next process, a different one,. Or which batch should be worked on first. This type of problem tends to make the planning and control of batch production a difficult task.

FLOW PRODUCTION

When there is a continuous demand for a product, it is some time worthwhile setting-up facilities to make that product and no other product. In these circumstances flow production may be the best way of operating. Here the manufacturing is broken down into operations, but each unit moves, or flows, from one operation to the next individually, and not as one of a batch examples are motor manufacturing, fertilizer, pharmaceutical and urea manufacturing. Since only one product is being made there are no problem about priorities, but it is necessary to balance the work load at all stages of manufacture. Examples are motor car manufacturing.

INTERMITTENT PRODUCTION

The intermittent production system examples are machine shop production, building contractor. The continuous production examples are chemical plants automobile industry etc. most of the companies cannot be classified straight as intermittent or continuous production, rather in one department of the company continuous production is there while in other departments intermittent production exists. The time required for a continuous production system is always less than the intermittent production systems. The assembly line production of cars or scooters where the product is coming off every few minutes is considered as continuous production. On the other hand in intermittent production systems the products are in a state of partial completion for several weeks or days.
CONTINUOUS PRODUCTION

In continuous production system, the most common material handling equipments are belt conveyors, roller conveyors, chutes, rails etc. It is because in continuous production systems one or a few standard products are manufactured with pre-determined sequence of operations with inflexible material handling devices. In intermittent production system portable material handling equipments are used and various products are produced with greater flexibility in the systems.

Continuous production system require a larger investment than intermittent production system because of fixed path material handling equipments, costly control mechanism and special purpose machines for various operations. Even the marketing techniques also differ for continuous production system and intermittent production system.

Intermittent production system the marketing efforts are directed towards meeting the individual orders for various products while in continuous productions the marketing efforts are directed towards developing distribution channels for the large volume of output. The design of a production system starts with the firm and re-occurs intermittently when redesign is necessary. The major decision in the design of production system is the location of plant. Once the location, has been decided the next decision relates to layout of facilities. Another problem which concerns the decision of production system is how products are designed and manufactured.

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1B. PRODUCT DESIGN

1B.1 PRODUCT DESIGN

From the production manager’s point of view, the key output of the product design activity is the product specification. These specifications provide the basis for a host of decisions he must make, including the purchase of materials, selection of equipment, assignment of workers, and often even the size and layout of the productive facility. Product specifications, while commonly thought of a blueprint or engineering drawings, may take a variety of other forms ranging from highly precise quantitative statements to rather fluid guidelines.

At the outset, it should be understand that this is an idealized case, synthesized from a number of approaches to product design. It should also be mentioned that product design and development rarely follow the discrete sequence suggested by the diagram. Typically, there are frequently looped to the prior steps, and certain activities are often performed concurrently. Further, the extent to which these phase are formalized and specified varies from industry to industry. Generally, firms which require a good deal of research and tooling or heavily dependent on innovation to complete in the marketplace, adhere to a more formalized program than those that do not.

1B. 2 NEED FOR DESIGN

In the discussion of product selection noted that the product definition derived from the selection process varies in completeness and is often intervened with the product design decision. For a steel producer, for example, the decision to add a new alloy would constitute both the product decision and the product design. On the other hand, it is probably more typical for the product selection phase to yield just the ‘bare bones’ of the final product. A refrigerator manufacturer may decide to add a panatela to his line. In both instances, however, this decision would not require a detailed investigation of design factors ate the selection phase since these companies presumably have mastered the general skill required to produce these products.

PRELIMINARY DESIGN

Whether or not it is a separate phase in the sequence of design activities, preliminary design is usually devoted to developing several alternative design that meet the conceptual features of the selected product. If the refrigerator manufacturer decides that he will produce freezers, questions of style, storage capacity, size of motor etc. will likely be encountered here. During preliminary design it also is common to specify the key product attributes of reliability, maintainability, and service life.

FIGURE : 1.2 PRODUCT DEVELOPMENT STAGES
During the final design phase, prototypes are developed and ‘bugs’ are worked out of the design so that the product is sound from an engineering standpoint. Thus, the ultimate output of the final design includes the complete specification of the product, its components, and, in the case of a manufactured item, the assembly drawings, which provide the basis for its full-scale production. Again, the degree of design specificity varies according to the type of product being considered. To produce an automobile, precise quantitative statements regarding the tensile strengths of steel for the chassis, tolerances for the engine components, the composition and thickness of brake linings, and so on. In contrast, the final design of treatment given a hospital patient would be unspecified since the exact nature of medical care must be determined during the “production” stage.

At this point too, the effectiveness of alternative designs must be balanced with cost consideration, and – inevitably – compromises must be made.

This especially true in selecting the configuration and material for manufactured items. The complexity of this tradeoff can be seen when we consider that even such a relatively unsophisticated product as a home freezer has roughly 500 components, each of which could conceivably be subjected to an alternative cost analysis. Typical considerations that must enter the analysis are component compatibility and simplification.

1B. 3 FACTORS TO BE CONSIDERED

1. Materials
   - Should be cheap
   - Should be able to withstand design requirements
   - Minimum wastage during production
   - Easily workable and machineable

2. Manufacturing Facility

Product design should be commensurate with resources available like equipments,
Labour and layout

3. Ergonomics
   - Should be easy to operate
   - Look up position for overhead
   - Should cause minimum fatigue to the workers and provide comfort to them

4. Maintenance
   - Ease of maintenance and service

5. Standardization

6. Tolerance

7. Valve engineering

8. Inter-changeability

9. Simplification

Origin of the product idea and selection from among alternatives: The product decision involves two major activities prior to final product design. The first is gathering ideas for alternatives product, and the second is selecting from among the alternatives the product or products that are to be produced. We will consider these activities in order.

Before we consider where the product idea comes from, it is useful to defined just we mean by the term product. For our purposes, a product is the output from a productive system offered for sale (in the case of a business) or otherwise made available (in the case of a governmental or philanthropic organization), to some consumer. It should be noted that this is a production definition as opposed to a marketing definition. A marketing definition required that the concept of a product include reference to such intangible as satisfaction and symbolism in order to convey the fact that, for promotional purpose, a product that meet certain psychological demands for the consumer. Production, on the other hand, need only meet prescribed product specification; it is not required to determine how the product is perceived in the marketplace.

Product ideas may originate from any number of sources, some of which are not obvious. Marketing textbooks and journals frequently cite unusual examples of sources of new-product ideas to emphasize that business must be keenly attuned to all possible sources to ensure that the “golden idea” is not missed or passed over without adequate consideration. A meat packing company once got the idea of developing an onion soup from a suggestion of one of its executive’s wives. An appliance manufacturer developed a foot warmer on the basis of a customer inquiry. A maker of pottery designed a new vase after seeing a similar one at a museum exhibit. A producer of plastic products designed a film slide viewer after reading a list of needed invention published by a bank. While such examples constitute the exceptional rather than the more common sources of ideas for new products, they indicate that ideas are to be found almost anywhere and that aggressive firms cannot afford to discount an idea simply because it originates from an unusual source.

Nevertheless, one authoritative report of source for new product ideas indicates that the great majority of ideas are generated within the firm rather than by external sources.

Choosing among alternative products. The idea-gathering process, of properly carried out, will often lead to more ideas that can be translated into producible product. Thus a screening procedure designed to eliminate those ideas which clearly are infeasible must be instituted. The screening procedure seeks to determine if the product is generally compatible with the company’s objectives and resources. Regarding objectives, a product may be dropped
if it is deficient in profit potential or in prospective growth or stability of sales, or if its is deleterious to the company image. In terms of resource, a product may be dropped if its exceeds the company’s capital availability or is incompatible with the company’s managerial and technical skills or physical facilities.

Of the several techniques available to aid in the screening process, perhaps the most commonly used are rating check sheets. In one such sheet, a number of important consideration are enumerated— for example, sales volume, patent protection, competition — and the product is categorized from “very good” to “very poor” for each of these considerations. The product selected will show a rating pattern that meets the company’s standard, from favourable to unfavorable ratings. More refined rating devices apply numerical weights to the important consideration and quantify the ‘goodness’ categories.

“Compatibility” refers to the fitting together and proper articulation of parts during operation. Problems of compatibility arise not only with parts that must mesh, such as freezer door latches, but also with parts that must respond similarly to conditions of stress. Drawbridge components must of course fit together, but they must also have similar tensile strength so as to accommodate high winds and similar expansion coefficients as to adjust equally to variations in heat and cold. “Simplification” refers to the exclusion of those features that raise production costs. Problems of simplification arise mainly in manufacturing, where such seemingly innocuous requirements as rounded edges or nonstandard hole sizes may create production bottlenecks and subsequent repair problems when the items is in use. Where the product is a service, simplification arise in regard to such things as form design ) Employment agencies) or customer routings (baggage pickup at an airline terminal).

In addition to the above activities, which are more or less universal, some organizations engage in rather formalized product testing programs and redesign activities during the final design stage. Product testing may take the form of test marketing in the case of consumer products or test firing of a weapons system in the case of military. In both instances a good deal of planning would necessarily precede the tests. Product redesign generally takes place after the prototype has been tested, and may be major or minor in scope. If the design in major, the product may be recycled through the preliminary design phase, if the change is minor, the product will probably be carried through to production. It should be noted, however, that there are ‘minor changes and minor changes’. In some instances an apparently slight modification to some component may greatly alter the integrity of the entire product.

1B.4 PRODUCT LIFE CYCLE

Every product has it’s life as human beings to have. The life span of a product is decided by many factors, viz., the product itself, the substitutes competitor’s strategy, company’s own position in the market.

This concept is widely used in marketing to describe the sales performance of a product over time. The basic idea is that product go through five stages, viz.,

- Introduction
- Growth
- Maturity
- Saturation
- Decline
1B.5 CONSIDERATIONS DURING PLC

Introduction: The product is put on the market and awareness and acceptance are minimal.

Growth: The product begins to make rapid sales gains because of the cumulative effects of introductory promotion, distribution, and word-of-mouth influence.

Maturity: Sales growth continues but at a declining rate, because of the diminishing number of potential customers who remain unaware of the product or who have taken no action.

Saturation: Sales reach and remain on a plateau (market by the level of replacement demand).

Decline: Sales begin to diminish absolutely, as the product is gradually edged out by better products or substitutes.

During the introduction stage, sales volume is yet to pick up due to the factor that the product is yet to be fully positioned by the company. In this stage the supply outstrips the demand.

The growth stage sees an increasing sales volume, which outstrips the supply. The company derives the maximum benefit from this stage. Efforts are made to stretch this phase, as this is highly beneficial to the very existence of the organisation itself.

The difference between output and sales represents inventory, which is built up because output exceeds demand. During steady state operations at the product maturity stage. Supply and demand for the product have reached equilibrium, so that a replacement is available for each item sold. When the product begins to decline in sales, some excess inventory is again built up, but then is eliminated as the system cuts back production. During the final stage residual demand for the product at last exceeds production. During the final stage, residual demand for the product at last exceeds production. Theoretically, the amount of this demand is equal to the amount of the previous inventory build-up, since management would plan to stop production at that point in time when existing inventory...
stocks would satisfy all remaining demand. If we assume that the system is shut down at this stage, the resources are sold off, and the work force sent home – we would label this an example of permanent termination.

1B.6 MODULAR DESIGN

Modular design and component standardization are two aspects of product design with special significance to operations management because they directly affect the complexity and cost of the conversion process.

Modular design is creation of products from some combination of basic, preexisting subsystems. In selecting a personal computer system, for example, you may have your choice of three video monitors, two keyboards, two computers, and three printers, all of which are compatible. All possible combinations make a total of 36 (3X 2 X 2 X 3) different computer systems from which to choose. The modular design concept gives consumes a range of product options and, at the same time, offers considerable advantages in manufacturing and product design. Stabilizing the designs of the modules makes them easier to build. Problems are easier to diagnose, and the modules are easier to service. Production proficiency increases as personnel make refinements to and gain experience with the manufacturing processes for standardized sets of modules. Similarly, materials planning and inventory control can be simplified, especially in finished goods inventories. Now, rather than storing inventories of all 36 finished computer systems, only some of which will be needed, we instead store just the subsystems or modules. Then, when a particular computer system is demanded, the producer can focus on quickly retrieving and assembling the appropriate modules into the desired configurations and avoid the high costs of idle finished goods inventories.

1B.7 STANDARDIZATION

In reality, numerous variety of components are used in various equipments. Some product will be sold by different companies (like two wheelers, washing machines, cycles, mixies, refrigerators, electric motors, etc.). if we closely examine the components used in each of the above products supplied by different vendors, we find exact similarity in terms of shape and size among the components like bearings, nuts, bolts, springs, screws, axle, etc.

Bearings, tyres, etc, which are manufactured by third parties can be used in any two brands of products manufactured by two different companies. under this situation, one should establish a common standard so that the parts / components can be interchangeably used in both products.

Standardization is the base of all mass production systems. When one purchases a new V-Belt for a scooter, he knows that it will fit into the V-groove. This is mainly because V – belt are standardized. Standards convey the sense that only certain specific sizes are made and sold. One can provide numerous components/parts in numerous sizes/shapes. But maintaining a proper stock of all the items will be a problem for the retailers. Moreover, it is not possible to take advantage of mass production, because some parts need to be manufactured in small batches. So, standardization solves all these problems because standardization is the process of establishing standards or units of measure by which quality, quantity, value, performance, etc. may be compared and measured.

1B. 8 STANDARDIZATION PROCEDURE

The steps involved in standardization are as follows:

- With the help of market research, sales statistics, etc determine what is to be sold in future.
- Define a range of products
- From range of products, select the minimum variety of components matching the range for manufacturing. Introduce new materials, components, etc., if necessary.

An approach to standardization necessitates the classification of materials and component parts.
1B. 9 CLASSIFICATION

Classification will be of great value in material and component standardization. Classification aims at systematically grouping together items, based on their common features and subdividing them by their special features. A system of classification and codification is necessary for the design of new products within the defined range. Such systems should readily:

- Identify and locate identical items
- Facilitate the use of standard items in new designs
- Identify substitutes in case of stock out.
- Help to develop group technology which will be of more use in designing layout and facilities.
- Aid to improve parts location in the store.

1B. 10 ADVANTAGE OF STANDARDIZATION

The advantages gained from standardization procedure are as listed below:

- Fewer specifications, drawings and part lists have to be prepared and issued
- Better quality products
- Lower unit costs
- Increased margin of profit
- Easy availability of spares
- Minimum inventory cost.
- Quantity discounts are possible because of purchase or raw materials in large volume.

1B. 11 APPLICATION OF STANDARDIZATION

Standardization can be applied to a major extent in the following fields:

- Finished products, e.g. cars and televisions
- Sub-assemblies and components, e.g. automobile gearboxes and auto-electric bulbs
- Materials, e.g. both direct materials (plan carbon and alloy steels, welding electrode, core wire, etc.) and indirect materials such as oils and greases.
- Production equipments, e.g. that of machine tools, press, welding equipments, etc.

1B. 12 RELIABILITY AND MAINTAINABILITY

"Maintainability" refers to the ability of the user to keep the product or system in operating condition with a reasonable amount of effort. This ability to maintain operation may entail the availability of some required service from the manufacturer or authorized repair facility, provision of a stock of replacement parts available to the user, and written maintenance and repair procedures. Good product design for maintainability usually implies ease of product disassembly and case of access to within the product to facilitate routine service or replacement. Switches, valves, motors with brushes, oil fills, etc. should be located for ready across, with removable covers placed at convenient
locations. The alternative to providing maintaining is to “overdesign”. This approach reduces the need for repair but raises production costs.

Maintainability consideration, to the consumer’s charging, often come after the fact. Although good product planning dictates that maintainability be considered at the design stage, it is frequently built into subsequent models of the product in response to consumer complaints. Clearly, this procedure may also have an adverse effect on production because it may entail retooling added inspections, and other changes to remedy maintainability faults.

“Reliability” may be defined as the probability, or degree of confidence that a product will perform a specified number of times under prescribed conditions. For example, the reliability of an electrical relay may be defined as 0.9999. This may hold true only when it is operated with an input voltage of 24 volts DC, in an environmental temperature range of 0 to 80 degrees C, with humidity less than 90 percent, if its housing has never been opened, if it has been operated less than 1 million times, and if its is less than five years old. Even if any one of these conditions is violated, then the reliability concepts goes off. When parts are interdependent, and especially when there is a large number of them, achieving a high degree of reliability for a product presents and real challenge.

1B. 13 REVERSE ENGINEERING

There is yet another way of designing a product. So far, we have seen the procedure and details about designing a product form the scratch. The product idea goes through the stages and get converted into a product, which finally reaches the customer.

In the reverse engineering process, it is done exactly in the reverse way. The product is available with the product designer. The job of the designer is to go through the details of the existing product and the system specification for that product. The job also includes the preparation of detailed assembly, sub-assembly, component drawings. This apart, the designer has to develop the material requirement, material specification, quantity of material required to produce the item.

After identifying the details, detailed design drawings and subsequently the engineering drawings are developed. Using these, the normal production techniques are adopted to product the product.
2A. CAPACITY PLANNING

A.1 CAPACITY

Capacity is defined as the ceiling on the maximum load a production unit can handle at a given point of time. In other words, capacity is defined as an upper limit on the rate of output.

The capacity question does not arise alone. It comes in conjunction with:

- New facility planning
- Leasing or buying the equipment required to maintain the output.
- Expansion of the existing facilities
- While introducing new product or services
- While finalizing the fund and energy requirements

The above mentioned situations, if come across alone, are easy to tackle. It becomes complicated when more than one situation is encountered at the same time.

A facility’s Capacity is the rate of productive capability of a facility. Capacity is usually expressed as maximum productive volume of output per time period. Operations managers are concerned with capacity for capability, usually several reasons. First, they want sufficient capacity to meet customer demand in a expressed as volume of output per period of timely manner. Second, capacity affects the cost efficiency of operations, the case or time. Difficulty of scheduling output, and the costs of maintaining the facility. Finally, capacity requires an investment. Since managers seek a good return on investment, both the costs and revenues of a capacity planning decision must be carefully evaluated.

2A.2 DEFINITION OF PRODUCTION CAPACITY

Facility planning includes, determination of how much long-range production capacity is needed, when additional capacity is needed, where production facilities should be located and the layout and characteristics of the facilities.

Capacity in general is the maximum production rate of a facility or a firm. It is usually expressed as volume of output per period of time. Capacity indicates the ability of a firm to meet market demand. Operations managers are concerned with capacity because.

(a) They want sufficient capacity to meet customer demand in time

(b) Capacity affects cost efficiency of operations, the case or difficulty of scheduling output and the costs of maintaining the facility.

(c) Capacity requires an investment of capital.

2A.3 Capacity planning

Capacity planning design is the first level planning for the inputs, conversion activities and outputs of a production operation. Design decisions are very important because they are often associated with significant investment of funds. The initial outlay and operating expenses are established based on design decisions, and these in turn affect productivity of the concern in future. So they affect fixed cost and variable cost.
DESIGN CAPACITY: preliminary estimate of capacity is done based on long-range forecast extending 5 to 10 years into the future.

The design capacity of a system is the rate of output of goods or services under full scale operating conditions. For example, a cement factory may be designed to produce 200 tons per day. The projected demand for period anywhere from 5 to 10 years is taken as the estimate for the design capacity, since frequent expansion will lead to productivity loss.

SYSTEM CAPACITY: In practice, it may not be possible to achieve production to the extent of design capacity mainly because of mismatch between required resources and available resources. The maximum output of a specific product or product mix that the system of workers and equipments is capable of producing as an integrated whole is called system capacity. This may be less than that of the design capacity.

The actual output may be even less than the system capacity since it is affected by short-range factors such as actual demand, equipment breakdowns, and personal absenteeism or productivity.

2A.5 NECESSITY OF CAPACITY PLANNING

Capacity planning is necessary when an organization decides to increase its production or introduce new products into the market. Once capacity is evaluated and a need for new or expanded facilities is determined, decisions regarding the facility location and process technology selection are taken.

Capacity planning is the first step when an organization decides to produce more or a new product. Once capacity is evaluated and a need for new or expanded facilities is determined, facility location and process technology activities occur. Too much capacity would require exploring ways to reduce capacity, such as temporarily closing, selling, or consolidating facilities. Consolidation might involve relocation, a combining of technologies, or a rearrangement of equipment and process.

2A.6 IMPORTANCE OF CAPACITY PLANNING

The importance of capacity planning lies in the fact that it is more fundamental. Every organization looks at the future with its own focus and develop and adjusts its strategies to reach the goal. Capacity planning relates to the organization potential impact on the ability of the organization to meet the future demands for its product / service. This is because of the fact that the possible rate of output is limited by the capacity.

a. There is also link between the capacity and the operating cost. Every managers wants to minimize the operating cost of the final product. Also they are interested in utilizing the established capacity to the fullest possible extent. This trade-off puts the whole process, into a vicious circle.

b. Minimizing the operating cost is not possible always, as the demand is a variable factor. The demand variation is due to:

- Increased competition (through the entry of new players; (or) due to the change in the strategies of the existing players).
- Technological changes (through some inventions (or) entry of MNC’s through joint ventures)
- User’s perception (which changes from time to time)
- Nature of the product (accordingly the demand will be seasonal or cyclical)
Possible demand patterns are:

- Growth
- Decline
- Cyclical
- Stable

c. The Initial Investment involved. This is due to the fact that, the capacity is a major determinant of the cost of a product, which will decide about the organization’s position in the market.

d. Long term commitment of resources. Once a capacity is created, it is very difficult – not impossible – to modify. In future, if modification is needed, it calls for heavy investment.

2A.7 CAPACITY PLANNING DECISIONS

Capacity planning involves activities such as:

(a) Assessing existing capacity
(b) Forecasting future capacity needs
(c) Identifying alternative ways to modify capacity
(d) Evaluating financial, economical and technological capacity alternatives
(e) Selecting a capacity alternative most suited to achieve the strategic mission of the firm. Capacity planning involves capacity decisions that must merge consumer demands with human, material and financial resources of the organization.

Often decisions about capacity are inseparable from decisions about locations: Capacity depends upon demand and demand often depends on location. Commercial banks, for example, simultaneously expand capacity and demand by building branch banks. Decisions about the size and location of the branch are made according to projections about neighborhood population densities and growth, geographic locations of market segments, transportation (traffic) flows, and the locations of competitors. Adding a new branch offers greater convenience to some existing customers and, management hopes, attracts new customers as well. Obviously this decision affects the revenues, operating costs and capital costs of the organization.

In the public sector, the capacity decision involves similar considerations. Municipalities face ever-increasing demands for public services, strong public sentiment for tightening budgets, and greater performance accountability. Consequently, officials have increased their efforts to rearrange public resources so that service capacity is increased but the cost of operating is not. Municipal emergency services, for example, are periodically expanded by adding to show population growth and shifts. Next, municipal officials plan where to locate new stations, taking into consideration both areas of greatest need and costs of operation and facilities. Although the capacity may not involve direct revenues, cost savings for citizens can be considered a form of indirect revenues. These cost savings can result in reduced tax burdens of lower insurance rates in areas with improved emergency services.

Modeling techniques, are playing a central role in these planning processes. One study, for example, explain how mathematical programming is used for greater ambulance effectiveness considering time-to-scene, time-to-hospital, an distance-to-hospital factors, thereby increasing effective service system capacity. Another study shows how mathematical modeling can determine optimal fleet sizes and vehicle routes for a commercial common carrier. Yet another study demonstrates the value of queuing models in a computer-based information system for the St. Louis County Police Department. The system gives a way to allocate police patrols, thereby using existing capacity more efficiently or reducing the size of operations without diminishing existing service levels. All these examples show how systematic analysis and planning can lead to effective use and improvement of capacity.
2A. 8 CAPACITY PLANNING STRATEGIES

Capacity is a measure of the ability to produce goods or services or, it may be called as the rate of output. Capacity planning is the task of determining the long – and short – term capacity needs of an organization and then determining how these needs will be satisfied.

Long-term capacity strategies: Top management may have the following strategies to cope up with major changes in products and services that it can provide to customers in the long run which will have significant impact on the capacity. The major changes will altogether revise the demand and resource requirements. There are:

- develop new product lines
- expand existing facilities
- construct or phase out production plants

Technological obsolescence may force some industries to use phase-in strategy for introducing the next model of the same product or service to retain and/or improve its market segment. The phase – in strategy is nothing but het planning for the next model even when the present model is moving well. Especially, in electronics industry, any company should do continuous research and development to improve the operational features of the product through advanced technology so that the company will be in a position to bring out products into the market with the latest technology without any time lag.

At the same time, all the products will not have continued demand for ever. Moreover, continuing the production of some products will be uneconomical over a period of time. This will force a company to diversify and/or phase out some of the existing products. Phasing out of a product should be done over a period of time properly by taking the re-employment features into account.

Short – term capacity strategies: In short-term planning, horizon, capacity decisions are taken by considering the fluctuations in demand caused by seasonal and economic factors. The purpose of short-term capacity planning is to respond to variations in demand during the short-term planning horizon. Strategies like, overtime, subcontracting, hiring firing, etc. can be used to cope up with the fluctuations in demand.

2A.9 FACTORS AFFECTING CAPACITY PLANNING

The capacity variables are:

(a) CONTROLLABLE FACTOR’S such as amount of labour employed, facilities installed, machines, tooting, shifts worked per day, days worked per week, overtime work, sub-contracting, alternative routing of work, preventive maintenance and number of production set-ups.

(b) LESS CONTROLLABLE FACTORS are absenteeism, labour-performance, machine break-down, material shortage, scrap and rework and unexpected problems such as strike, lockout, fire accidents etc.

2A 10 WAYS OF CHANGING CAPACITY

Once the long-range capacity needs are estimated through long-range forecasts, there are many ways to provide for the needed capacity. Firms may have a capacity shortage situation where present capacity is insufficient to meet the forecast demand for their products and services or have excess capacity i.e., capacity in excess of the expected future needs. Long-range capacity planning hence may require either expansion or reduction of present capacity levels.

2A 11 TYPES OF CAPACITY

1. FIXED CAPACITY: The capital asset (buildings and equipments) the company will have at a particular time is known as the fixed capacity. They cannot be easily changed within the intermediate time range. Capacity
represents an upper limit to the internal capacity, that the company concentrates can use in its efforts to meet demand.

2. ADJUSTABLE CAPACITY: It is on and the size of the workforce, the number of hours per week they work, the number of shifts and the extent of sub-contracting.

3. DESIGN CAPACITY: It is the planned rate of output of goods or services under normal full-scale operating conditions. It is also known as installed capacity. It sets the maximum limit to capacity and serves to judge the actual utilization of capacity.

4. SYSTEM CAPACITY: It is the maximum output of a specific product or product-mix that the system of workers and machines i.e., the productive system is capable of producing as an integral whole. It is less than or equal to the design capacity of the individual components because the system may be limited by:

   (a) The product mix
   (b) Quality specifications and
   (c) The current balance of equipment and labor

5. POTENTIAL CAPACITY: It is that, which can be made available within the decision horizon of the top management.

6. IMMEDIATE CAPACITY: It is that, which can be made available within the current budgeted period.

7. EFFECTIVE CAPACITY: is the capacity, which is used within the current budget period. It is also known as practical capacity or operating capacity. No plant can work up to the maximum or the theoretical capacity (installed or design capacity) because of the loss of capacity due to scheduling delays, machine break-down and preventive maintenance. This result in the plant working at an efficiency of loss than 100%. Also, the actual output will be less than the designed output due to rejections and scrap.

8. NORMAL CAPACITY OR RATED CAPACITY: This is the estimated quantity of output or production, that should be usually achieved as per the estimation done by the Industrial Engineering department. Actual capacity is usually expressed as a percentage of rated capacity. For example, the rated capacity of a steel plant may be expressed as 1 lakh ton of steel per month. This is also sometimes called as average capacity of the plant.

9. ACTUAL OR UTILIZED CAPACITY: This is the actual output achieved during a particular time period. The actual output may be less than the rated output because of short-range factors such as actual demand, employed absenteeism, labour inefficiency and low productivity levels.

   Design capacity is Reduced by long-range effects, and System capacity is Reduced by short-range effects.

   Long-range effect: Product-mix, long range market conditions, tight quality specifications, inherent imbalance between equipment and labour.

   Short-range effect: Actual demand, management performance vis scheduling, staffing, strategy and control, labour inefficiencies, wear scrap loss machine breakdown etc.

   System efficiency is the ratio of the actual measured output of goods/services to the system capacity.

2A. 12 CAPACITY DECISIONS

Major considerations in capacity decisions are:

(a) What size of plant? How much capacity to install?
(b) When capacity is needed? When to phase-in capacity or phase-out capacity?

(c) At what cost? How to budget for the cost?

2A. 13 FACTORS AFFECTING DETERMINATION OF PLANT CAPACITY

- Market demand for a product service
- The amount of capital that can be invested
- Degree of automation desired
- Level of integration (i.e. vertical integration)
- Type of technology selected
- Dynamic nature of all factors affecting determination of plant capacity, viz., changes in the product design, process technology, market conditions and product life cycle, etc.
- Difficulty in forecasting future demand and future technology
- Obsolescence of product and technology over a period of time
- Present demand and future demand both over short-range, intermediate-range and long-range time horizons.
- Flexibility for capacity additions.

2A. 14 EQUIPMENT SELECTION

Equipment selection is the process of identifying a set of suitable equipments which are most suitable for processing a set of products.

In the case of mass production, our task is to establish a product line for a single product or for a set of products which are having similar processing requirements. While determining the process sequence, the equipment availability must be taken into account. At each and every stage of a product line, it is possible to identify different equipments to satisfy the processing requirements. But, one should carefully select a machine which can fully satisfy the processing requirement. But, one should carefully select a machine which can fully satisfy the processing requirements at a particular operation, or can club processing of two or more consecutive operations in the line. This will reduce the line length. In fact, this is the concept followed in machine centres. Machine centres will have several processing capabilities. If a product line is formed with few machine centres, then the products will travel minimum distance before they are completed. For this type of production, it is obvious that the production volume of the products should be high enough to utilize the capacities of the machine/machine centers in the product line.

In the case of batch production using process layout, it is very difficult to dedicate a special machine for a particular product. Several products will be snaring a given machine. So, at the time of doing process planning, we should select the machines by simultaneously taking the availability of the machines and processing requirements of the products into consideration, so that the products travel minimum distance and they are produced with minimum set-up times.

In all the situations, the economy of cost must be taken into consideration. So, we will have to list out different alternatives for equipment selection and finally, the best one is to be selected.
2A. 15 DETERMINATION OF CAPACITY

Capacity determinations is a strategic decisions in plant planning or factory planning. Capacity decisions are important because:

(a) They have a long-term impact.
(b) Capacity determines the selection of appropriate technology, type of labor and equipments, etc.
(c) Right capacity ensures commercial viability of the business ventures.
(d) Capacity influences the competitiveness of a firm.

2A. 16 CAPACITY MEASUREMENT

Capacity of a plant can be expressed as the rate of output viz., units per day or per week or per month, tones per month, gallons per hour, labour hours/day, etc. But for organizations whose product lines are more diverse, it is difficult to find a common unit of output. More appropriate measure of capacity for such firms is to express the capacity in terms of money value of output per period of time (day, week or month).

Capacity may be measured in terms of inputs or outputs of the conversion process.

Since, capacity is defined along with the constraints, the capacity measurements becomes subjective, as different interpretations of the terms are made by different people in the organization. For example, if the capacity is measured on the sale of products in rupees or dollars, the forex fluctuations will result in different results on capacity.

In situations where the organization has more than one product in the product mix, a question arises on which product the capacity should be measured? If done on one product alone, it may not cover the whole infrastructure created and may mislead. For example, if a refrigeration company produces Deep Freezers and Refrigerators using the same machineries, capacity has to be expressed by taking into consideration of both the products and not a single one.

Details of the industries and the capacity measurements are given in Table 2.1

<table>
<thead>
<tr>
<th>Type of business</th>
<th>Measurement of capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Education</td>
<td>Faculty, Infrastructure</td>
</tr>
<tr>
<td>Automobile</td>
<td>Man-Machine hours</td>
</tr>
<tr>
<td>Agriculture</td>
<td>Acres</td>
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<tr>
<td></td>
<td>Cows</td>
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<tr>
<td>Steel Mill</td>
<td>Furance Size</td>
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<tr>
<td>Theatre</td>
<td>Number of Seats</td>
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<tr>
<td>Restaurant</td>
<td>Number of Tables</td>
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<tr>
<td>Oil Refining</td>
<td>Size of Refinery</td>
</tr>
</tbody>
</table>
For more organizations capacity is simple to measure. Amul can use “tons of cheese per year”. General Motors Corporation can use “number of automobiles per year.” But what about organizations whose product lines are more diverse? For these firms, it is hard to find a common unit of output.

As a substitute, capacity can be expressed in terms of input. A legal office may express capacity in terms of the number of attorneys employed per year. A custom job shop or an auto repair shop may express capacity in terms of available labor hours and / or machine hours per week, month, or year.

Capacity, then, may be measured in terms of the inputs or the outputs of the conversion. Some common example of capacity measures are shown:

Measures of operating capacity

Output

- Automobile manufacturer-number of autos
- Brewery-Barrels of beer
- Cannery-Tons of food
- Steel producer-Tons of steel
- Power company-Megawatts of electricity

Input

- Airline-Number of seats
- Hospital-Number of beds
- Job shop-Labour and/or machine hours
- Merchandising-Square feet of display or sales area
- Movie theater-Number of seats
- Restaurant-Number of seats or tables
- Tax office-Number of accountants
- University-Number of students and/or faculty
- Warehouse-Square or cubic feet of storage space.

It's often difficult to measure capacity realistically because of day-to-day variations. Employees are absent or late, equipment breaks down, facility downtime is needed for maintenance and repair, machine setups are required for product change over and vacations must be scheduled. Since all these variations occur from time to time, you can see that the capacity of a facility can rarely be measured in precise terms, so measurements must be interpreted cautiously. It's not unusual, for example, for a facility to operate at more than 100% capacity.
2A. 18 CLASSIFICATION OF CAPACITY PLANNING

Capacity planning can be classified as:

(a) Long-term capacity planning
(b) Short-term capacity planning
(c) Finite capacity planning
(d) Infinite capacity planning

2A. 19 LONG-TERM AND SHORT-TERM CAPACITY PLANNING

Long-term or long-range capacity planning is concerned with accommodating major changes that affect the overall level of output in the longer run. Major changes could be decisions to develop new product lines, expand existing facilities, and construct or phase out production plants.

Short-term or short-range capacity planning is concerned with responding to relatively intermediate variations in demand. In the short-term planning horizon, capacity concerns involve the fluctuations in demand caused by seasonal or economic factors.

Ways of adjusting the capacity to the varying demands in the short-term time horizon are:

(i) Use of overtime or idle time
(ii) Increasing the number of shifts per day to meet a temporary strong demand.
(iii) Sub-contracting to other firms.

Service industries use flexible work hours, part-time employees, and overtime work scheduling to meet peaks in demands.

2A. 20 FINITE AND INFINITE CAPACITY PLANNING

In operations planning, two conflicting constraints are time and capacity. If time is fixed by the customer’s required delivery date or processing cycle, it is possible to accept time as the primary constraint and plan backwards to accommodate these times. In such cases, planning backwards to infinite capacity offers a potential solution to the problem. On the other hand, if the processing time is not a constraint in cases where products are produced to stock and sell, it is simpler to use a forward plan based on finite capacity i.e., based on available resources.

2A. 22 CAPACITY PLANNING MODELS

Several models are useful in capacity planning. Present value analysis is helpful whenever the time value of capital investments and fund flows must be considered. Aggregate planning models are useful for examining how best to use existing capacity in the short term. Break-even analysis can identify the minimum break-even volumes when comparing projected costs and units produced per time period (output rate).

2A. 23 “CRP’ INPUTS

The major inputs for CRP process are:

(a) Planned orders and released orders from MRP system
(b) Loading information from the work centre status file
(c) Routing information from the routing file
Changes which modifies the capacity, give alternative routings or altered planned orders. All these inputs must be given in time if the system is to function effectively.

2A. 24 ESTIMATING FUTURE CAPACITY NEEDS

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

SHORT-TERM REQUIREMENTS: Managers often use forecasts of product demand to estimate the short-term work load the facility must handle. By looking ahead up to 12 months, managers anticipate output requirements for different products or services. Then they requirements with existing capacity and detect when capacity adjustments are needed.

2A.25 PLANNING THE CONVERSION SYSTEM

Estimated cost for building the entire addition now are $50/Square foot. If expanded incrementally, the initial 50,000 square feet will cost $60/Square foot. The 50,000 square feet to be added later are estimated at $80/square foot. Which alternative is better? At a minimum, the lower constructions costs plus excess capacity costs of total construction now must be compared with higher costs of deferred construction. The operations manager must consider the costs, benefits, and risks of each option.

The costs, benefits, and risks of expansion pose an interesting decision problem. By building the entire addition now, the company avoids higher building costs, the risk or accelerated inflation (and even higher future construction costs), and the risk of losing additional future business because of inadequate capacity. But there may also be disadvantages to this alternative. First, the organization may not be able to muster the financial investment. Second, if the organization expands now, it may find later that its demand forecasts were incorrect, if ultimate demand is lower than expected, the organization has overbuilt. Finally, even if forecasted demand is accurate, it may not fully materialize until the end of the five-year planning horizon. If so, the organization will have invested in an excess-capacity facility on which no return is realized for several years. Since funds could have been invested in other ways, the organization has forgone the opportunity of earning returns elsewhere on its investment.

LONG-TERM RESPONSES

- Contraction
- Constant Capacity

Capacity Contraction most often involves selling off existing facilities, equipment, and inventories, and firing employees, as serious declines in demand occur, we may gradually terminate operations. Permanent capacity reduction or shutdown occurs only as a last resort. Instead, new ways are sought to maintain and use existing capacity. Why? Because a great deal of effort, capital, and human skills have gone into building up a technology. Often this technology and skill base are transferable to other products or services. As one product reaches the decline phase of its life cycle, it can be replaced with others without increasing capacity. This phasing in and out of new and old products is not by accident. Staff for product research and development and market research should engage in long-range planning to determine how existing capacity can be used and adapted to meet future product demand.

PLANNING ACTIVITY

Planning is of two types:

- Infinite loading
- Finite loading
Infinite loading is the process of loading work centres with all the loads when they are required without regard to the actual capacity of work centres. This given information about actual released order, demands upon the production system, so that, decisions about overtime, using alternative routings, delaying selected orders, etc., can be taken.

FINITE LOADING can be done automatically with computerized loading systems, limiting the load assigned to work centres in each period as per the installed/available capacity at each work centre. This method of loading forces changes back into the MPS, which is not always the best solution to scheduling problems and hence not useful at CRP stage. Finite loading is more useful to single work-centres in the capacity control stage where jobs are being scheduled.

2A. 26 “CRP’ OUTPUTS

1. Rescheduling information which calls for capacity modifications or revision of MPS.
2. Verification of planned orders for MRP system
3. Load reports

2A. 27 AGGREGATE CAPACITY PLAYING STRATEGIES

Aggregate capacity planning involves planning the best quantity to produce during time periods in the intermediate-range horizon and planning the lowest cost method of providing the adjustable capacity to accommodate production requirements.

Traditional aggregate plans for a manufacturing operation involve planning the work force size, production rate (working hours per week) and inventory levels. Two types of aggregate plans that are commonly used are:

1. ‘Level capacity’ plan
2. ‘matching capacity with aggregate demand plan

2A. 28 LEVEL CAPACITY PLAN

Level capacity plans have uniform capacities per day from time period to time period. The underlying principle of level capacity plan in produce to stock and sell firms is ‘operate production systems at uniform production levels and let finished goods inventories rise and fall as they will, to buffer the differences between aggregate demand and production levels from time period to time period’.

The capacity of a unit is its ability to produce or do that which the consumer requires, and clearly there must be some match between needs characterized by market forecast and abilities characterized by capacity. A statement of capacity is rarely simple, and it is useful to distinguish between three different capacity levels:

Potential capacity is that which can be made available within the decision horizon of the most senior executive. Immediate capacity is that which can be made available within the current budget period.

Effective capacity is that which is used within the current budget period. The production/operations controller is generally concerned with the second and third of these levels, since he must deal with immediate, rather than long-term, problems. Furthermore, it should also be recognized that one of the objectives of the marketing department is to try to ensure that the effective and immediate capacities coincide. It should be noted that the more ‘nearly effective’ approaches ‘immediate’, the more rigid must the organization become flexibility can only be achieved when immediate capacity is not fully used.
2A. 29 CONSTRAINTS ON IMMEDIATE CAPACITY

Immediate capacity is limited by:

(a) The plant/equipment size;
(b) Availability of equipment;
(c) Availability of manpower;
(d) Availability of cash;
(e) Financial policies;
(f) Purchasing policy;
(g) Sub-contracting policy;
(h) The technical demands of the tasks;
(i) The number of different tasks being undertaken.

For example, the capacity of a restaurant is limited by the size of the ‘eating’ area, or the number of tables.

2A. 30 INFLUENCES ON EFFECTIVE CAPACITY

Effective capacity can be influenced by:

(a) Technical abilities in the pre-operations stages;
(b) Organizational skills in the planning stages;
(c) Purchasing skills;
(d) Sub-contracting skills;
(e) Maintenance policies and abilities;
(f) Versatility of workforce;
(g) Efficiency of workforce.

2A. 31 DIFFERENCES BETWEEN EFFECTIVE AND IMMEDIATE CAPACITIES

A great deal to work has been carried out on the utilization of equipment, i.e. the differences between effective and immediate capacity. Frequently these studies have involved the use of activity sampling to establish the proportion of time the equipment was being used productively, and to identify the reasons for and quantify the extent of non-productive time. These reasons range across preparation time, planned maintenance, emergency maintenance, idle (no planned work), idle (operator absent), and so on. The picture that emerges is that effective capacity is frequently less than 50 percent of immediate capacity. While it is unlikely that these two capacities will ever coincide, it is clear that significant increases in capacity are possible, often by improved production/operations control. It is also clear that to measure capacity solely on the basis of available time is likely to give gross errors. Allowance must always be made for current local performance.
2A. 32 CAPACITY CHANGE

Within a production / operations environment, it seems probable that:

1. The ability of an individual to chance capacity is directly related to that individual’s position in the organization’s hierarchy
2. The time necessary to implement a capacity increase in proportional to the magnitude of the increase.
3. The number of acceptable capacity changes which can be handled at any one time is finite.

Every programme implies a certain level of capacity and, if the above statements hold true, it is important that the implicit capacity decisions are made by an individual at the correct level in the organization. To present the production/operations controller with a programme which requires a capacity change greater than his hierarchical position will permit him to effect, can only result in frustration and the non-achievements of the programme. Similarly, if the need for a capacity change is recognized too late, it will not be achieved either, and failure must again result.

Capacity changes may be achieved in a number of ways and stages, ranging from a number of small incremental changes to a large step changes depending on environmental constraints. If a university reached the limit of its physical teaching capacity, it could increase the hours of availability (from 9.00-5.00 to 8.00-7.00) or by constructing further buildings.

2A. 33 THE MEASUREMENT OF CAPACITY

Capacity, being the ability to produce work in a given time, must be measured in the units of work, i.e. resource-standard time units available in unit time. Thus, a work centre with a capacity of 1,000 machine hours in a 40-hour week should be able to produce 1,000 standard hours of work of the type appropriate to that work station during a 40-hour week. In order to calculate the volume of actual work, it is necessary to know:

(a) The work content of the product;
(b) The ancillary times involved in the production;
(c) The effectiveness of the work station

The measurement of capacity and the above factors is frequently undertaken by the production engineering department in manufacturing organizations, and it is useful to confirm these measurements by records of actual performance.

The above comments can also be interpreted in non-manufacturing contexts. Consider measuring the capacity of a small taxi firm which has four cars available from 9.00 to 5.00 five days per week. It could be argued that the capacity is 4 X 5 X 8 hours per week (ignoring breaks). The work (or number of ‘trips’) will depend on the start and finish locations, traffic conditions, and so on.

As with load, it is not uncommon to find capacity quoted in terms of quantity of products made in unit time. Such statements should be treated with great caution; changes in methods, procedures, materials, quantities etc. can result in changes in effective capacity. Unless the work unit is dedicated to a single product, it is safer always to refer to units of work rather than to units produced.

2A. 34 FINITE OR INFINITE CAPACITY PLANNING

In detailed planning, two conflicting constraints – time and capacity – have to be considered. If time is fixed, for example by the customer’s required deliver date or transaction-processing cycle, then it is possible to accept time as the primary constraint and also plan backwards to accommodate these times. However, this can be somewhat difficult in practice, since it is not generally possible to determine beforehand whether all of the tasks can be fitted in with the currently available capacity, and much time can be spent trying to solve an insoluble problem. Indeed, even
after recognition that capacity needs to be temporarily increased, the extent of this increase and its timing still has to be established, clearly there are variety of options open to the decision-maker, all with different cost implications.

Planning backwards to infinite capacity offers a partial solution to this problem. Man manufacturing and transaction-handling processes go through a number of stages in a sequential manner. If the plan is being prepared on a period-by-period basis (say week), then the backward plan can be prepared on the basis of one stage per period. This means that the final stage (operation) of the task is allocated to the period representing the delivery date, the penultimate task is allocated one period earlier, and so on. This produces a slightly more realistic plan of what might happen. This pro indicates where overloads are likely to be and give a far better picture of when and to what extent extra resources will be required. However, to confirm or propose revised delivery dates, a finite capacity plan must be developed. Generally, it is far simpler to produce a forward (rather than a backward) plan to finite capacity. For this, tasks are put into some priority order and, following this sequence, added to the plan in such as way that they are started as soon as possible at each stage, but only using as much resource as is available. Clearly the criterion used for prioritizing the tasks will have a significant effect on the performance of the plan. This will be discussed in a later section.

2A. 35 SCHEDULING AND LOADING

A schedule is a representation of the time necessary to carry out a task, and should take account of the technical requirements of the task, marketing forecast and available capacity. It is not simply a list of the operations required, since additionally it takes into account the technological relationships between these various operations.

2A. 36 INFORMATION REQUIREMENTS

The nature of a product may allow several operations in its manufacture to be carried out concurrently, whilst other operations may need to be completed before the next one can be started. A route or list of work to be done would not show this situation, whereas a schedule would take this into account. The graphical presentation of the bar chart for the schedule is essential for this clarity. With complex interdependencies between operations, use of a ‘precedence diagram’ rather than a bar chart may be desirable.

A job schedule shows the plan for the manufacture of a particular job. This is the work study input into production / operations control, indicating method and times insufficient detail for the function to be adequately carried out. Once this schedule has been produced, it need not be changed unless there is a change in either the job (for example in the product being produced) or in the method of manufacture. A company which makes a range of products cold draw up a number of schedules which are kept filed and used as the basis for production/operations control. These schedules should show elapsed time the time between successive – operations – rather than specific.

2A. 37 INTERRELATIONSHIP BETWEEN CAPACITY AND OTHER FUNCTIONS

1. Relationship between capacity and locations decisions : Decisions about capacity are often inseparable from location decisions. Usually, capacity is expanded by installing new units at new locations taking into consideration location factors such as market segment, transportation costs, location of competitors etc.

2. Relationship between capacity and plant layout The plant capacity determines the physical relation between various processes used in the conversion process, which in turn determines the layout of the plant. In product-layout or product-focused productive system, the capacities of various work centres or machines have to be balanced to get approximately the same rate of output from various work centres or machines. Once the layout is installed, it is not possible to change the capacity in the short term time horizon.

3. Relationship between capacity and process design: In some cases, the rated capacity depends on the type of conversion process selected. For example, the conversion processes selected for manufacture of steel is different for the mini-steel plants from that used for major steel plants.
4. Relationship between capacity and equipment selection: The installed capacity of plant determines the standard labour or equipment hours that can be achieved and also determines the number of machines or equipments that must be installed to get the desired output capacity.

2A. 38 SERVICE CAPACITY

Service organizations, for the capacity measurement, can be divided into the companies offering:

- Homogenous Services
- Heterogeneous Services

In the case of Insurance companies, the service offered is homogenous i.e. it is based on the number of policies serviced per year.

Banks and Transport companies offer heterogeneous services. Their offer is restricted by the availability of limited resources under their possession. For example, in banks, it is measured by the man hours available per week; and in case of transport companies, it is tonnage per kilo-meter.

2A. 39 DIFFICULTY IN CAPACITY PLANNING IN SERVICE ORGANIZATIONS

- The nature of service itself, i.e. the output cannot be stored.
- Average demand for the service will be far less than the peak demand. This will lead to lower capacity utilization during the off-peak demands. This results in low productivity. (Example: Electricity Production and Consumption)
- Demand fluctuation during the course of time. (Example: Placement of funds by the Financial Institutions)

2A. CAPACITY PLANNING PROCESS IN SERVICE ORGANIZATIONS

i) Predict future demands
ii) Determine the available capacity
iii) Translate prediction into physical capacity requirement.
iv) Develop alternate capacity plans for matching required and available capacities.
v) Analyse the economic effects of alternate capacity plans.
vi) Analyse the risk and other Strategic consequences of alternate plans
vii) Recommend a course of action
viii) Implementation of the selected course of action.
2B. Facility Planning

One of the major strategy decisions that must be made by any organization is where to locate its producing and storage facilities. For manufacturers, the problem is broadly categorized into factory location and warehouse location; within this categorization, we may be interested in locating the firm’s first factory or warehouse or locating a new factory or warehouse relative to the locations of existing facilities. The general objective in choosing a location is to select that site or combination of sites that minimizes two classes or costs – regional and distribution or sites that minimizes two classes or costs – regional and distribution costs. Regional costs are those associated with a given locate and include land, construction, manpower, and state and local expenses and regulations. Distribution costs are those directly related to the shipping of supplies and products to customers and other branches of the distribution network. Since the location of the firm, economic analysis of facility location has focused on the problem of adding warehouses or factories to the existing production-distribution system.

In service organization, the facility location decision is also a major one, but as a rule, the choice of a locate is based upon nearness to the customer rather than on resource considerations. With the shift in the U.S. economy away from manufacturing and toward service, there is little question that opening of new service facilities has become more common that opening new factories and warehouses. Indeed, there are few communities in rapid growth in public private branch offices, franchises, and entertainment facilities.

2B. LOCATION OF FACILITIES

Location decisions represent an integral part of the strategic planning process of virtually every organization. Although it might appear that location decisions are mostly one-time problems pertaining to new organizations, the fact is that existing organizations often have a bigger stake in these kinds of decisions than new organizations have.

Existing organizations become involved in location decisions for a variety of reasons. Firms such as banks, fast food restaurants, super market and retail stores view locations as a marketing strategy, and they look for locations that will help them to expand their markets. A similar situation occurs when an organization experiences a growth in demand for its products or services that can not be satisfied by expansion at an existing location. The addition of a new location to complement an existing system is often a realistic alternative.

Some firms become involved in location decision through depletion of raw materials. For example, in the case of mining, in the long run, the company has to change its place of operation due to reduced availability of minerals.

Location decisions for many types of businesses are made rather infrequently, but they tend to have a significant impact on the organization. There are two primary reasons that make location decisions a highly important part of production systems design. One is that they entail long-term commitment, which makes mistakes difficult to overcome. The other is that location decisions often have an impact on operating costs (both fixed and variable) and revenues as well as on operations. For instance, a poor choice of location might result in excessive transportation costs, shortage of qualified labour, loss of competitive advantage, inadequate supplies of raw materials or some similar conditions which would be detrimental to operation.

Profit oriented organizations base their decisions on profit potential, while non-profit organizations strive to achieve a balance between cost and the level of customer service they provide. The organizations will try to identify the best location available. The location options for any organization are as follows:

- Expanding the existing facility
- Add new locations while retaining existing ones, as is done in many retail stores
- Shut down one location and move to another.
- Option of doing nothing and maintaining the status quo.
2B. 3 LOCATIONAL FLEXIBILITY

(a) Availability of Raw Material: Nearness to the place of the raw material will give advantage on the transportation cost, so that overall profitability can be improved. When the raw material is heavy or is consumed in bulk, then plant location has to be nearer to the raw material site.

(b) Nearness to Markets: It reduced the cost of transportation as well as the chances of the finished products getting damaged and spoiled on the way, especially the perishable products. Moreover, a plant being near to the market can capture a big market share and render quick service to the customers.

(c) Transport Facilities: A lot of money is spend both in transporting the raw materials and the finished goods. Depending upon the size of raw material and finished goods, a suitable method of transportation like roads, rail, water or air is selected and accordingly the plant location is decided. One point which must be kept in mind is that cost of transportation should remain fairly small in proportion to the total cost.

(d) Availability of Labour: Stable labour force, of right kind, of adequate size and at reasonable rates with its proper attitude towards work are a few factors which govern plant location to a major extent.

(e) Availability of Fuel and Power: The main sources of energy are electrical power, coal, oil, etc. In the case of power intensive industries like steel manufacturing units or continuous process industries like petrochemical and cement, the availability of fuel and power will be one of the major deciding factors in plant location.

(f) Climate: Depending on the type of industry and the products that are being manufactured, this is a different factor. For instance, in the case of textile mills climatic conditions with adequate humidity is a basic essential criterion. That is the reason many textile mills have been put up in Bombay, Coimbatore region.

(g) Water Availability: In industries like textile dying, paper or chemicals, the requirements of good quality water is one of the basic requirement for plant location. The water is required for processing or for effluent rejection into the rivers or specifically for waste disposal.

(h) Government Policies: The central and state governments may declare many talks as backward and give numerous concessions like tax holiday, uninterrupted power supply, capital subsidy, easy availability of loans, etc. for balanced development of regions in the country.

(i) Land: Topography, area, the shape of the site, cost, drain age and other facilities, the probability of floods and earthquakes will influence the selection of the location.

(j) Community Attitude: Industries like matches, crackers, hosiery and leather have flourished because of the positive attitude of the community towards these.

(k) The presence of related industries will give many advantages like availability of skilled labourers, standard components.

(l) Housing facilities

(m) Security

(n) Local by-laws, taxes, building restrictions

(o) Existence of other service facilities like hospital marketing centres, schools, banks, post offices, clubs.

These factors, depending on the product to be manufactured or the industry, may separately or collectively have to be given the required weightage. In the process, many alternatives may emerge. The management decisions will be taken after weighing all the alternatives and selecting the best among them.
2B.4 COST FACTOR

In plant location, apart from the availability of technology, etc. the major deciding factor will be the cost of the final product. The ideal plant location is the one which results in lowest cost of production and distribution of the items in the market. For some production facilities, the basic necessity itself may be that it has to be located nearer to the market, that is, the facility has to be created in the urban area. For some others, it can be located at remote rural areas. Cost is associated with each decision. Other than this, there are other advantages as well as disadvantages.

2B. 5 PLANT LOCATION IN TOWN

The following are the advantages that can be derived by locating the plant in the urban area:

- Close to the market where the product can be sold.
- Skilled/specialized labour force is available
- Well connected by air/rail/road which is an essential one, if the raw material is brought from other places (or) finished goods are transported to other metros.
- Easy availability of power and water;
- Already established service facilities like hospitals, schools, banks etc.
- Existing buildings can be hired or can be taken on lease for factory/office usage.
- Accessibility to the various skilled professional, well equipped laboratories for testing purpose, etc is easy.
- For making purchases of standard items, market is readily available.
- Many small scale industries, with spare capacities, are available, which can be converted into ancillary units.

There are a few disadvantages also if we decide an urban location:

- The overall cost of establishing the facility is high compared to locating it in a rural area.
- Land available is limited. Future expansion, sometimes may not be possible.
- Land cost and construction cost will be high.
- Cost of labour is high due to high cost of living in towns
- Local taxes are high, like corporate tax which may not be there in rural centres.
- Labour unions and their related problems are more
- Conductive industrial climate may not prevail.

2B. Site selection in rural area

Advantages

- Easy availability of land for present construction and future expansion
- Land cost is cheap.
- Unskilled labour availability is more. But they have to be trained to make them skilled/semi – skilled
- Government subsides/concessions are there
Not much union problem; good industrial relations
Taxes will be low; at some places tax holidays are also made available by the respective government.

The disadvantages are:
- Cost involved in training the unskilled labour into skilled will involve high cost.
- Proper rail/road links may not be there; to establish them, high cost is involved.
- Availability of power may be a problem.
- Far away from the actual markets
- Ancillary services may not be available
- Facilities like hospitals, banks, post offices have to be established.
- The manpower turnover among the top executive will be more because of their attitude towards living in rural areas.

2B.7 PLANT LOCATION IN SUB-URBAN AREAS

The advantages of both urban and rural areas can be combined and derived if we decide about a location in the sub-urban area. From the cost point of view, the exorbitant cost involved in the purchase of land in case of urban selection and the non-availability of work force in rural area can be offset by locating the plant in the semi-urban area.

2B.8 FACILITY DESIGN PROCESS
1. Define the location objectives and associated constraints
2. Identify the relevant decision criteria, which may be:
   - Quantitative
   - Qualitative
3. Relate the objectives to the criteria using appropriate models like
   - Economics cost models
   - Break Even analysis
   - Linear Programming
   - Qualitative Factor Analysis
4. Fox for undertake research to generate relevant data and use the models to evaluate the alternatives.
5. Select the location that satisfies the criteria.

2B.9 TECHNIQUES USED FOR FACILITY LOCATION
a. Industry Precedence – Succeedence Technique
   - Basic Assumption: If the location is best for many companies in the same industry, then it holds good for a new company too.
No need for conducting detailed location study

Locations choice is subject to the “Principle of Precedence.”

b. Preferential Factor
Decision is dictated by Personal factor
Individual preference
Not a Professional approach; but widely used

c. Dominant Factor
Availability of raw material may be a dominant factor in case of Cement, Oil exploration, Mining industries.
Contrast to preferential factor
Existence of good infrastructure and skilled personnel is a dominant factor for establishing IT companies

For evaluating qualitative factors, the techniques used are:

- Factor Ranking
- Factor Weight Rating

The specific methods that can quantify the qualitative decisions are:

- Equal weights method
- Variable weights method
- Weight cum Rating method
- Factor point Rating method
- Composite measure method.

2B. 10 LOCATIONAL BREAK-EVEN ANALYSIS

We have already seen the factors which will influence the site selection for putting up the plant. The economic comparison of location alternatives is facilitated by the use of Cost-Volume-Profit analysis which is also known as ‘Locational Break-even Analysis’. The graphical approach will enhance the understanding of the concept, and it provides an indication of the range over which one of the alternative is superior to the others.
The procedure for the locational break-even analysis involves the following steps.

(i) Determine the fixed cost and variable costs associated with each location alternative.

(ii) Plot the total cost lines for all location alternatives on the same graph.

(iii) Determine which location has the lowest total cost for the expected level of output.

Following the above steps, the total costs of rural, semi-urban and urban site locations can be fixed.

In the case of urban location, the initial fixed is very high and the variable cost is comparatively low. In the case of rural location, the initial cost is low but there is an increase in the slope, which is due to the high variable cost. The semi-urban locational cost will be in between the two.

To conclude, if the volume (i.e. annual output) is low, then we can select the rural locations for the purpose of establishing the factory. If the volume lies beyond a point, we can choose the urban centre for locating the plant. If the annual output lies between, it is better to locate the factory in a semi-urban area so as to reap the maximum benefits.

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UNIT – 3

3A. PROCESS PLANNING

3A. 1 Process Planning

Process planning is concerned with planning the conversion or transformation process needed to convert the materials into finished products. A production process is a series of manufacturing operations performed at work stations to achieve the design specifications of the planned output. A vast number of different operations and various kinds of equipments and machines may be required to produce a complex product (for e.g. an aircraft or a ship). Simpler parts may require a few operations (for e.g. a bolt and a nut).

Process planning consists of two parts namely (i) Process design and (ii) Operations design. Both stages provide information which is required to effectively utilize existing equipment and machinery and to determine what new equipment and machinery would be required.

3A. 2 Process Design

Process planning is concerned with the overall sequences of operation required to achieve the product specifications. It specified the type of work stations that are to be used, the machines and equipments necessary and the quantities in which each is required.

The sequences of operations in the manufacturing process is determined by

(a) The nature of the product
(b) The materials used
(c) The quantities being produced and
(d) The existing physical layout of the plant

3A. FRAME WORK FOR PROCESS DESIGN

The design of the transformation process requires answers to several questions given below:

1. What are the characteristics of the product or service being supplied or offered to customers?
2. What is the expected volume of output?
3. What kinds of equipment or machinery by custom built?
4. What is the cost of equipment and machinery needed?
5. What types of labour skills are available, in what quantities and at what wages rates?
6. What types of labour skills are available, in what quantities and at what wage rates?
7. How much money can be spent on the manufacturing process?
8. Should the process be capital intensive on labour intensive?
9. Should the components or parts be made of purchased? (Make or buy decisions)
10. How best to handle materials?
3A. 4 PROCESS PLANNING PROCEDURE

a. Selection of Process
   - For converting raw material to finished goods.
   - Select the most economical process.

This selection depends on:
   - Current Production Commitment
   - Delivery date
   - Quantity to be produced
   - Quality standards

b. Selection of Material
   - Correct shape and size of the material for reducing the scrap
   - Right quality, chemical composition as per the given material specification.

c. Selection of Jigs, Fixtures and Special attachments
   - Support devices for higher production rate.
   - To reduce unit cost of production

d. Selection of Cutting tools and Inspection gauges
   - To reduced the production time
   - Separate tools for initial course machining and for fine finishing
   - Accurate inspection at a faster rate.
   - Find setup time and standard time for each operation
Preparation of Operation and Route sheets.

3A. 5 CHARACTERISTICS OF PRODUCTION PROCESS SYSTEMS

a) Job Production

In job production the whole product is looked as one job which is to be completed before going on to next. The most common examples are building a ship or a large civil construction job. Job production is not confined to large projects, it could be the making of a special piece of equipment or a tool.

b) Batch Production

If qualities of more than one are being made, it is sometimes convenient to split the productions into a series of manufacturing stages or operations. Each operation is completed as one of the single items being made, before the next operation is started. In this way a group of identical products, or a batch are made, which move through the production process together.

If more than one types of product is being made, then hatches of different products may be moving around the shop floor some times requiring operations from the same machine. This leads to problems of how long a machine should be processing a batch of one type of product before going on to the next process, a different one, or which batch should be worked on first. This type of problem tends to make the planning and control of batch production a difficult task.

c) Flow Production

When there is a continuous demand for a product, it is some time worthwhile setting-up facilities to make that product and no other product. In these circumstances flow production may be the best way of operating. Here the manufacturing is broken down into operations, but each unit moves, or flows, from one operation to the next individually, and not as one of a batch example are motor manufacturing, fertilizer, pharmaceutical and urea manufacturing. Since only one product is being made there are no problems about priorities, but it is necessary to balance the work load at all stages of manufacture. Examples are motor car manufacturing.

d) Intermittent production

The intermittent production system examples are machine hop production, building contractor. The continuous production examples are chemical plants automobile industry etc. most of the companies cannot be classified straight as intermittent or continent production, rather in one department of the company continuous production is there while in other departments intermittent production exists. The time required for a continuous production system is always less than the intermittent production systems. The assembly line production of cars or scooters where the product is coming off every few minutes is considered as continuous production. On the other hand in intermittent production systems the products are in a state of partial completion for several weeks or days.

e) Continuous production

In continuous production system, the most common material handling equipments are belt conveyors, roller conveyors, chutes, rails etc. it is because in continuous production systems one or a few standard products are manufactured with pre-determined sequence of operations with inflexible material handling devices. In intermittent production system portable material handling equipments are used and various products are produced with greater flexibility in the system.

Continuous production system require a larger investment than intermittent production system because of fixed path material handling equipments, costly control mechanism and special purpose machines for various operations. Even the marketing techniques also differ for continuous production system and intermittent production system.
Intermittent production system the marketing efforts are directed towards meeting the individual orders for various products while in continuous production the marketing efforts are directed towards developing distribution channels for the large volume of output. The design of a production system starts with the firm and re-occurs intermittently when redesign is necessary. The major decision in the design of production system is the location of plant. Once the location, has been decided the next decision related to layout of facilities. Another problem which concerns the decision of production system is how products are designed and manufactured.

3A. 6 RELATIONSHIP BETWEEN PROCESS PLANNING AND OTHER POM ACTIVITIES

Process planning is the basis for the design of buildings, layout of facilities and selection of production equipment and machinery. Process planning also affects quality control, human resource requirements, job design and capacity of the plant. Process design determines the details of how products/service will be produced.

Process planning and process design describe the specific steps in the production process and the linkages among the steps that will enable the production system to produce products/services of the desired quality in the required quantity, at the time customers want them and at the budgeted cost.

Intense process planning may be required for new products/services. Process re-planning may also occur as capacity needs change, business or market conditions change and technology improvements take place in materials and machinery.

3A. 7 FACTOR AFFECTING PROCESS DESIGN

The basic factors that affect the design of manufacturing process are:

- Nature of product/service demand
- Degree of automation
- Degree of vertical integration
- Level of product/service quality
- Product/service and volume flexibility
- Degree of customer contact
- The equipment that is available or that can be procured for the manufacture of the product.

3A. 8 TYPE OF PROCESS DESIGNS

The basic type of production system and the finished goods inventory policy to be used must be decided at the earliest stages of process planning. The common type of production system are:

(i) Product-focused production system
(ii) Process-focused production system
(iii) Group-technology/cellular manufacturing system
Because fixed and variable cost tend to differ from one form of production process to another, economic analysis is used for comparing alternative processing plans for the production of products. When deciding among the types of production processing organizations, it is important to consider the cost of each alternative. The cost function of processing alternatives, the concept of operating leverage, break-even-analysis and financial analysis are important aspects of economic analysis.

The amount of capital required for each type of process design tends to be different. Capital costs are fixed charges that occur every month. The fixed costs are greater when the initial cost of equipment, buildings and other fixed assets are high. The variable costs – the costs which vary with the volume of products produced in each month are also different for different forms of production processing systems.

Automated assembly line has the highest fixed cost as it consists of expensive robotics, computer controls and fixed-position material-handling equipments. On the other hand, the variable costs, (labour, material and variable overhead) for the automated assembly line is the least.

The fixed costs and variable costs of cellular manufacturing are intermediate and for the job shop, the fixed costs are very low and the variable costs are very high.

The conclusion is – If capital availability is not a factor and annual production costs (sum of fixed costs and variable costs) are the predominant consideration, the preferred process design depends on the production volume of the product.
3B. WORK STUDY

3B. 1 INTRODUCTION

Work study is mainly concerned with the examination of human work. In fact planning cannot be done unless one knows how long it will take to do a particular job. It is important in modern time that our lives take cognizance of time. Time is very important to the manufacturer who must keep to promise, to estimate quantities, and to other industrial and business arrangements. The need for this managerial tool arose in the middle of nineteenth century, when the greater use of machinery and increasing size of manufacturing units necessitated a more efficient means of controlling production schedules. It was F.W. Taylor who argued that greater attention should be paid to be an of timing tasks Taylor advocated the breaking down of a task into what the termed – elements of work and the timing of these elements separately with the aid of a stop watch. He also emphasized the use of a differential piece rate system. In this system a strong incentive was offered to those who reached or surpassed the standard established by Taylor's time study method.

A contemporary of F.W. Taylor was Gilbreth; he and his wife, Dr. Lilian Gilbreth were sure that the in which work was done was far more important than trying to devise timing systems of how long it took to do a set task. Gilbreth often found it necessary to take motion pictures and examine them frame by frame to examine the smallest elements of movements.

Improving the Productivity is an important tool to increase the profitability and overall efficiency of an organisation. Higher productivity means increase in output with lesser expenditure, i.e. by increasing Productivity, more quantity of goods are produced at cheaper cost. To improve the productivity, various working methods applied in the organisation have to be revamped. Method Study is a technique used to simplify the method of doing works. By method study, efficient and economical methods are developed. Improved methods will reduce tiredness of the workers, and hence Productivity will certainly increase.

3B. 2 WORK STUDY

Work Study investigates the work done in an organization and it aims at finding the best and most efficient way of using available resources, i.e. men, material, money and machinery. The main stress of work study is to examine the human work in all its contexts and to motivate the human efforts at all levels to make the life productive.

DEFINITION

Russel M. Currie defines work study as follows:

“The systematic objectives and critical examination of all the factors governing the operations efficiency of any specified activity in order to effect improvement.”

Another definition by Brig. K. Pannather says: “Work Study may be defined as one of the management techniques which can be applied to achieve the optimum use of the resources available to an establishment for the accomplishment of the work, it is engaged in.”

Frederick W. Taylor, one of the pioneers in the field of Work Study says that the greatest production results when each worker is given a definite task to be performed in a definite time in a definite manner.” This is the foundation on which modern Work Study stands today.

“Time Study” means the straight timing of work elements. Work measurement – it is that human effort is somehow measured and one of its objectives is the installation of financial incentive systems of payment. The object of motion study, method study, micro motion study is to devise new and improved working methods. Maynard suggested that to obtain the maximum effectiveness from the study of work it was necessary to use all the known techniques. He named his systematic approach to the development of improved methods “method engineering”.

Work study is term used to embrace techniques of Method Study and work measurement which are used to ensure the best possible use of human and material resources in carrying out a specified activity.
3B. 3 IMPORTANCE AND SCOPE

Work study is not a theoretical concept but essentially a practical one dealing with human beings who have their own style and attitude. The success of work study depends upon the existence of good relations between managements and workers. Work study involves lot of changes of various kinds of working methods. Since people in general do not like changes but prefer to carry on as they are already doing. There will always be a tendency to resist any new methods suggested by work study officers. But if relations are good and the workers have confidence in the ability, integrity and fair mindedness of work study man, there is a good chance that sound proposals will be accepted willingly by the workers.

3B. 4 VARIOUS MODELS

The layout diagram: It is a floor plant upon which the arrangement of all equipment is marked to scale. Such a diagram help an investigator record his findings in a form which is simple to visualize.

FLOW DIAGRAM: This is a sketch or model to scale of the layout of work places, machines, equipments, floor areas and building particularly showing the location or all activities in a flow process charts. This also indicates the paths and movements followed by men, materials, equipments in executing the activities.

STRING DIAGRAM: It is essentially the same scale plan of the layout as used in the flow diagram with the only difference that movements are shown by continuous threads. This diagram will help us in finding out the points of congestion band back tracking. Better routes could be chosen by following different routing of the thread and comparing it with the previous routing.

3B. 5 SIGNIFICANCE OF THE WORK STUDY

Work Study can be applied to any field of activity. Work Study finds the defects in the organisation. Work Study is always the first technique applied for increasing production. Work Study techniques are applied wherever human work is performed. The techniques of Work Study are necessary in the following circumstances

- Where the Productions Processes is time consuming
- When the rejection of finished goods is at a higher rate
- Where the efficiency in production is low
- If incentive wage plans linked with bonus is in practice in the organisation.

Work Study techniques are applied in Industries) Production operations, research and development, marketing, sales and distribution) offices, stores, and warehouses material handling, design building and other constructions, transport, hospital, army and agriculture.

3B. 6 WORK STUDY AS A SCIENCE

Work study have been criticized on the grounds that many of its techniques depend upon human judgment and therefore the result have only limited application. Let us see how far this criticism hold true. It is true that some of the techniques such as rating as used in work measurement depend upon the estimates of work study man. Thus properly trained and qualified man with correct judgment should be acceptable for all practical purposes. As we know that it any time the predictions of weather forecasts are wide of the truth but this by no means that we should ignore all weather forecasts. In any area new concepts and knowledge keep emerging similarly in work study new and more accurate technique will emerge.

3B. 6 WORK STUDY AND PRODUCTIVITY

Productivity increase is the key factor in raising the standard of living Work Study indicates how resources can be effectively utilized and study would help in realizing this aim.
Selecting the Work to be Studied: We could select for study the work that is likely to have the longest production run, offers the greatest scope for improvement, and which promises the greatest financial saving for a given outlay.

Recording Facts: The techniques used in recording the facts may be divided into following three categories:
(a) Process and time
(b) Charts
(c) Process Charts

It is useful diagrammatic means of presenting information on the major activities associated with particular investigation.

The advantages of process chart are:
(a) It is convenient means of presenting 'information'
(b) It shows clearly the relationship between several sets of data.
(c) It permits quick analysis of the problem
(d) It provides a record for future reference.

Charts are like machines, which require the fuels on which it runs. Chart is a means to an end. It cannot solve the problems by itself but it shows up inefficiencies and the way to speedy solution.

3B. 7 OUTLINE PROCESS CHARTS

It is graphic presentations of the points at which materials are introduced into the process, the sequences of operations and inspections carried out. Chart includes information as the time required the grade of labour, type and location of machine employed. Outline process chart records the following two type of activities.

Flow process chart: It is a graphic representation of the sequence of all operations. Transportation, inspections, delays, storage etc. occurring during a process or procedure. This will include in greater details all relevant information for analysis such as time of each activity distance moved frequency of movement.

The Flow Process Chart will assist in drawing a complete sequence of events occurring in process and keeps us in finding the delays, improper handling frequency of movement and keeps us in finding the tracking etc.

It is a means of recording information and is an extension of outline process chart. In addition to two activities – operation and inspection of outline process chart, it has three further activities:
(a) Transportations
(b) Delays
(c) Storages

Flow process charts can relate to material or individuals

MULTIPLE ACTIVITY CHART: These charts are the pictorial representative of relationship between man-time and machine time. These charts show the relation between two or more separate but selected operation cycles and may also be used to study the work of several operators on a group of operations. Multiple activity charts help us considerable to visualize the sequence and relationship of event.
TRAVEL CHARTS: This is drawn in conjunction with a flow diagram. In the case of multi-products and non-standardized products this chart helps us to indicate flow between processes, departments of shop areas.

Work Study is a short term approach to the problems of productivity. The advantages of Work Study are as follows:

a) It helps uniform and improved production flow
b) It helps higher productive efficiency
c) Manufacturing costs are greatly reduced
d) It helps us to secure proper performance of the plant, materials, and methods through standardization process.
e) It helps in the fixations of wages of different categories of personnel
f) It helps to introduce the methods and standards as accepted routine practice.
g) It helps better employer-employee relations. Also, it assures better service to customers.
h) Job security and job satisfaction to workers is also ensured by work study
i) It helps ensure the best possible and most effective use of existing and or potential resources of the firm.

3B. 9 USES OF TIME STUDY

- It is useful in determining the standard time for various operators which help in fixing wage rates and incentives
- It is useful to estimate the cost of a product accurately
- It helps in production control
- It helps in predicting accurately as to when the work will be completed and hence customers can be promised to take delivery on a fixed date.
- Using the time study techniques, it is easier to find out how many machines an operator could easily operate at a time and work can be allotted to him according to his capability.

Now, let us see the various procedures for conducting Time Study.

3B. 10 TECHNIQUES OF WORK STUDY

Work Study consists of methods study (or motion study) and work measurement (or Time Study)

Techniques of Work Study

- Methods Study (Motion Study)
- Time Study (Work Measurement)

USES

Following are the important uses of work study

(a) Direct means of raising productivity
(b) It is systematic; to factor is overlooked
Most accurate method and yet provide production planning and control and incentives.

It is most important tool of analysis.

Every one concerned with industry benefit from it such as customer, worker and management.

3B. 11 DEFINITION METHODS STUDY

Method Study is a technique which analyses each operation of a given piece of work very closely in order to eliminate unnecessary operations and to approach the quickest and easiest method of performing each necessary operation; it includes the standardization of equipment, method and working conditions; and training of the operator to follow the standard method.

Method Study may also be defined as the systematic investigation of the existing method of doing a job in order to develop and install an easy, rapid, efficient and effective and less fatiguing procedure for doing the same and at lower costs. this is generally achieved y eliminating unnecessary motions involved in a certain procedure or by charging the sequence of operations or the process itself.

Frank Gilbreth defines method study as “the science of eliminating wastefulness resulting from ill-directed and inefficient motions”. The main purpose is to find the scheme of least wastage of labour.

The modern concept of method study is a development of Gilbreth’s. Technique of Motion Study.

3B. 12 OBJECTIVES OF METHOD STUDY

The following are the objectives of Method Study:

a) Improvement of manufacturing processes and methods. Better product quality
b) Improvement of working conditions
c) Improvement to plant layout and work place layout
d) Reducing the human effort and tactique
e) Reduced health hazards
f) Reducing material handling.
g) Improvement of plant and equipment design
h) Improvement in the utility of materials, machines and man power and
i) Ensuring safety

In the following paragraphs, let us discuss in brief the various procedures involved in Method Study.

3B. 13 METHOD STUDY PROCEDURE

a) Select the work worth studying and define the objectives to be achieved. An objective may be to reduce the manufacturing cost or to reduce bottleneck or to reduce fatigue incurred by the workers in order to increasing their efficiency.

b) Record all the relevant information pertaining to the existing method in details and in the form of a chart to obtain a more clear picture about the same. Recording can be done with the help of the following aids:

   - Process Charts
   - Diagrams
c) Examine the recorded events critically and in sequence. It involves answer to a number of questions. An activity can be eliminated, simplified or combined with another. The likely questions to be asked are:

- **Purpose** - What is done?
- **Person** - Who does it?
- **Place** - Where it is done?
- **Means** - How is it done?
- **Sequence** - When is it done?

d) Develop the best method as resulted from critical examination and record it. The developed method should be practical, safe effective and economical.

e) Installation of the (best) developed method or the improved method. It involves planning, arranging and implementing. During planning and arranging, necessary arrangements of resources, equipments, tools and instruction to workers overtime etc. are made. The actual installation involves the introduction of developed method as standard practice.

f) Maintain the new method

We should ensure the proper functioning of the installed method by periodic checks and verifications. If there are any deviations, the reasons for deviation should be explored and corrected. Views of the workers, supervisors and other person related with the authorize method can be of immense help in exploring further improvements.

The above mentioned are the procedures and steps in Method Study.

A chapter on method study will be incomplete without a mention about the Therbligs’ motion study.

### 3B. 14 THERBLIGS

Frank Gilbreth developed a set of 17 elementary motions commonly found in manual operations and called them ‘Therbligs’ reversed spelling of his name. We know that motion study is used for deciding the best way of doing work for which present and proposed methods are observed by experts by recording on charts. For the purpose of recording the motions, he split up different motion of process into 17 fundamental elements made by various members of human body and each event was allotted a symbol and letter abbreviation. These symbols and abbreviations are used for preparing Motion Study charts.

### 3B. 15 PROCESS CHART

A chart representing a process is called as a process chart. A process chart records graphically or diagrammatically, in sequence the movements connected with a process. This chart portrays and process with the help of a set of symbols and aids in better understanding and examining the process with a purpose to improve the same.

The process charts are of three types:

a) Outline Process Chart

b) Flow Process Chart and
c) Two Handed Process Chart

a) OUTLINE PROCESS CHART

An outline process chart surveys and records an overall picture of the process and states only main events sequence wise. It considers only main operations and inspections.

b) Flow Process Chart

This is a graphic representation of operation, transportation, inspection, delays and storage occurring during production. This also gives the information regarding distances moved and times required for different items such as transportation and, delays and inspection etc. It is usually prepared for one component of an assembly at a time.

The first step in preparing this chart is filling out of the headings. Each activity is listed in order as the job is following thorough the plant and notations are made as shown. The symbols in such charts are short hand tools and serve as sign posts to make critical areas for improvement. In this way by preparing Flow Process Chart, a processor a job can be analyzed step by step. Activities can be eliminated in some cases, combined in others, rearranged for more effective processing or simplified.

c) Tow Handled Process Chart

Two handed process chart records the activities of the left hand and right hand of an operator as related to each other.

3B. 16 FLOW DIAGRAM

A flow diagram is a drawing or a diagram, which is drawn to scale. It shows the relative position of production machinery, jigs, fixtures gangways etc. and marks the paths followed by men and materials.

Process charts indicate the sequence of events, they do not illustrate the movements of men, materials etc. while the work is being accomplished. To know the path of movement of men and materials and to reduce unwanted movements these flow diagrams are preferred.

3B. 17 STRING DIAGRAM

A string diagram is preferred over a flow diagram, if paths and movements are congested and repetitive. A string diagram is a layout drawing on which a length of string is used to record the extent as well as the pattern of movement of a worker or piece of equipment working within a limited area during a certain period of time. As explained earlier, it is used to study where the journeys and irregular in distance and the movements are repetitive and congested.

3B. 18 TIME STUDY

As discussed earlier, method study aims at reducing unwanted and unnecessary motions while performing a job. Once the method study has developed, an improved procedure for doing a job, the work measurement or time study will find the time allowed to complete the job.

Timely study or work measurement is the art of observing and recording the time required to do each detailed element of an industrial operation. Industrial operation means manual, mental and machining operations. Manual time is divided into three types of operation i.e. handling of tools, handling of machines and handling of materials. Mental time includes time taken by the worker for thinking over some operations. Machining time includes time taken by the machines in doing its share of work.

So, time study standardizes the time taken by an average worker to perform these operations. Time study or work measurements is also defined as follows “it is the application of techniques designed to establish the time for a qualified worker to carryout a specified job at a defined level of performance.
3B.19 OBJECTIVES OF TIME STUDY

Production cost of any commodity is made of three components

- Raw Material Cost
- Overheads
- Labour Cost.

A production manager can easily predict the cost of raw material and with some past experience and judgment overheads can be estimated pretty accurately. To estimate labour cost, we need to know the labour time. The practical experience of production specialists helps them exercise considerate judgment in estimating direct labour time. However, costly errors can occur if personal judgment is used exclusively. Time studies are conducted to make precise evaluation of direct labour time.

These time standards, in addition to establishing standard labor costs, also establish capacity of productive equipment. The standards are thus used for scheduling production orders.

Another use of time study is that as a result of time study, a time study engineer inevitably discovers constructive refinements in operation methods tooling, plant lay-out and materials handling. Thus he is in a position to compare the various alternatives and recommend the best possible method.

Also time standards are used for setting pay incentives. Any body who can do better than standards by his extra skill will earn more.

Work Measurement

a) Determines the time required to do a job. Also, it compares various alternative methods and established the fastest method.

b) Decided the manpower required for a job and also determines the equipment requirements.

c) Provides information for effective production planning and maintenance procedures.

d) Aids in calculating exact delivery dates.

e) Decides realistic labour budgeting and provides a basis for standard costing system

f) Provides for a sound incentive schemes and

g) Result in effective labour control.

3B. 21 PROCEDURE OF WORK MEASUREMENT

The general procedure followed in Work Measurement is as follows:

(a) The job is broken down in its elements

(b) The observed time for each element is recorded

c) Basic time is determined for those elements for which data is not available.

d) The values so determined for any of the elements which could conceivably secure in another job are added to the records of basic times.

e) Determine the frequency of occurrence of each element in the job, multiply the work content of each element with its frequency and add up the time to arrive at the work content for the job.
The proportion of rest required is assessed and added to the basic time for doing the work at the standard rate of working and for recovering from the effort i.e. the work content.

The addition of the relaxation allowance may be made element by element

If there are any contingent delays a blanket allowance (not exceeding 5% ) may be added since they are not economical to measure.

3B. 22 MICRO MOTION FILMS

In many cases the high speed movements made by the operators cannot be seen by the eye or with stop watch. The technique of micro motion is used to record rapid movements. It consists essentially of a cine camera which takes a film of the operator’s movements. Micro-motion study besides giving a more accurate recording of both movements, also provides a permanent record which can be studied at a latter date also. The equipment for micro motion study is a 16 mm cine camera, a tripod and exposure meter and a timing clock known as microchronometer.

Microchronometers is provided with a self-starting motor with geared movement designed to read 1/2000th of a minute.

3B. 23 MEMOTION TECHNIQUE

It is technique name after its inventor Marvin E. Mundel who developed this particular use of the cine camera for recording industrial activities and subsequent analysis of the film. It is mainly used to study the work of a dentist, a pharmacist and a group of men in a foundry. This technique is mainly used for long and irregular activities and work of a group of people. The equipment required for memotion is a cine camera capable of carrying a film magazine or at least 30 meters. Memotion is a kin to activity sampling activity.

It is the application of techniques designed to establish the time for a qualified, worker to carry out a specified job at a defined level of performance. Work measurement or time study is the technique for determining the standard time to perform a specific task. In other words motion study and time study is the systematic study of work system with the purpose of:

Developing the desired system and method usually the one with the lowest cost.

Standardize the system and methods

Determining the time required by a qualified and properly trained person working at a normal pace to do a specific operation.

Work measurement, as the name suggests, provides management, with a means of measuring the time taken in the performance of an application for series of operation in such a way that ineffective time is shown up and can be separated from effective time. In this way, its existence, nature and extent become known where previously they were concealed within the total. One of the surprising thing about factories where work measurement ahhs never been employed is the amount of ineffective time where very existence is unsuspected or which is accepted as the “usual thing” and something inevitable that no one can do much about built into the process. Once the existence of ineffective time has been revealed, and the reasons for it was traced down, steps can usually be taken to deduce it.

Here work measurement ahs another role to play. Not only ‘Can it reveal the existence of ineffective time; it can also be used to set standard time for carrying the work, so that if an ineffective time ‘does creep in later on it will immediately be shown up as an excess over the standard time and will thus be brought to the attention of the management. Work measurement may start a chain reaction throughout the organisation.

3B. 24 USEFULNESS OF TIME MEASUREMENT

It is indeed useful to the management to know how long it should take to carry out various kinds of work in a plant. Let us discuss various uses:
(a) It reveals the capacity of each machine and enables the planning department to apportion work correctly.

(b) It increases accuracy in forecasting delivery dates.

(c) It is useful in costing.

(d) It enables reliable forecasts to be made of machine when a new department or factory is planned.

(e) It helps in choosing the best method.

(f) It helps to prevent misuse of manpower in each department.

(g) It fosters the development of equitable incentive payments system.

It is the oldest work measurement technique. It is regarded as the fundamental technique. A systematic method study should be carried out before the time study because it is not good carrying out a time study on any work until the simplest way of carrying out that work has been determined by a systematic method study.

3B. 25 PROCEDURES

For conducting Time Study, average workers and average machines are selected and the study is conducted by the Time Study expert. He is normally expected to be familiar with all the information related to the job and should be thorough with all details or the job. To conduct the Time Study, a suitable location is found out in such a manner that the expert would be in a position to watch the operations and movements of the workers without disturbing them from suitable distance.

- Analysis of work
- Standardization of methods and
- Making Time Study

We shall discuss the above three stages in Time Study in detail.

1. Analysis of work

First, the complete job and its operations are split up into various elements. These elements are finalized after conducting Motion Study in the end, time required for job preparation, cleaning of machine and oiling etc. are also calculated. Thus, time study includes all the tasks performed by the worker and not only the effective work.

2. Standardization of Methods

Before conducting Time Study, all the constituents of the job such as materials, equipments, tools, working condition and methods are standardized.

3. Making Time Study

Time Study is done on a printed Time Study Record which is fixed on a board, known as Time Study Board. On one corner (generally right hand top corner) a Stop-watch is placed. This Stop Watch should have a decimal scale dial so that it can read up to 0.01 minute.

Different time reading of one element is recorded in the corresponding columns of the Record Sheet. Several sets of readings are taken to arrive at an accurate result. After noting all these readings average time is to calculated. This average time multiplied by a levelling factor also called Rating Factor which is generally assumed as 110-120% to get the time required by normal worker. A brief explanation about Rating Factor is warranted here.
3B. 26 RATING FACTOR

The study engineer multiplies actual time with a factor known as “Rating Factor” or leveling Factor to get the average time, which a normal worker would take. This is expressed as a percentage of the efficiency of representative operator, which indicates how efficient an operator in comparison to some of his average fellow workers.

Performance Rating = (Observed Performance / Normal Performance ) x 100

3B. 27 NORMAL TIME AND STANDARD TIME

This multiple of average time with the rating factor is known is “Normal Time.” Some allowance personal (5%), fatigue allowance (20%) and preparation allowance (5%) are added in the normal time to obtain the standard time. Thus, standard time is the basis for the calculation of wages and incentives. So,

Normal Time = (Average Time x Rating Factor)
Standard Time = (Normal Time) + Other Allowances

3B. 28 ALLOWANCES

In this connection, it should be mentioned here that it is not possible for a worker to do his job continuously without any break. There are many interruptions (stoppage of work) taking place. Extra time is added to the basic time to compensate this interruption. This extra time given is known as allowance.

Generally, interruptions occur due to the following:

1. Personal Factors: Going for drinking water, toilet etc.
2. Nature of Work: Taking rest after hard work
3. Other Factors: Tool breakage, listening to supervisor etc.

Various types of allowance are explained below:

Figure : 3.2 Standard Time

1. Rest and Personal allowance

This is the allowance given for the personal needs of the worker, (viz.) going to toilet, drinking water, taking rest etc. Personal allowance given, depends upon the working condition and the nature of work. For example, heavy work at high temperature (working near furnace) needs more allowance. Light work, like radio assembly needs lesser allowance. This allowance is also known as relaxation allowance.

2. Process Allowance:

This is also known as unavoidable delay. A worker working in an incentive system may have to be ideal due to unavoidable delays. This delay may be due to process, machine operation, waiting for work, waiting for material etc.

3. Contingency Allowance:

In a shop there may be small delays due to

- Waiting for the inspector
- Consulting the supervisor
• Obtaining special tools etc.

These delays are of very short duration. The allowance given to compensate these delays is called contingency allowance. Generally 5% of basic time is given as contingency allowance.

4. Special Allowance:

In a shop, some activities take place occasionally. These activities will not be part of the production cycle. But, these are necessary for production work. Examples of these activities are:

• Tool resting
• Cleaning
• Tool maintenance
• Shut down

For these activities and allowances known as special allowance is given.

5. Policy Allowance

This is an allowance given according to the policy of the management. It is not included for calculating the standard time. This is an extra benefit given by the management to the workers. This allowance is given to increase the worker’s earnings.

As explained earlier, while time study is made under the stop watch method, due consideration is given for the above allowances.

3B. 29 JOB DESIGN

There are strategic decisions – involving the design of products and / or services and the location of the system – which are an integral part of the overall productive system design. The core of that productive system, however, is located in the complex of technology and people where the productive process is centered – in factories, hospitals, banks, offices etc. We already noted that the entire design process contains interdependent components, and that the products, services, and locations are partially influenced by the core productive process, and vice versa. Since these productive systems involve the about blending of technology and people to form a core productive system, they often are called socio-technical system.

The goal of the entire design process is to develop a rationale for the organization of the work to be done, and to relate this rationale to machines and technology in terms of work sharing between worker and machines, work flow, and physical facilities. The layout, which on the surface shows the spatial relationships, illustrates the physical integration of these factors. Whether or not the layout permits an effective design from points of view other than work flow and physical efficiency depends on the effectiveness of process planning and job design, and how technology and people are molded into a system.

Now we can consider the really fundamental alternative of division of labor versus broad spectrum jobs – grouping tasks into jobs at fairly homogenous skill levels versus vertically integrating tasks into jobs. It is at these points that jobs can be created that either satisfies and fulfill workers or dehumanize them.

We shall consider process planning, job design and layout as an integral whole in the attempt to avoid the known effects that result when these elements are dealt with as separate independent concepts. The known effects are that process planning (that is technology and layout) has been thought of as the independent variable and that people and job designs have been thought of as the dependent variables. In that kind of framework, job designs were viewed as the results of process or technology planning. Currently developing concepts and practices consider the two components jointly to produce designs that satisfy the needs of both kinds of variables.
3B. 30 TECHNOLOGICAL VIEW OF PROCESS PLANNING AND JOB DESIGN

While the general methods we shall describe were developed in manufacturing systems, they have been adapted and widely used in many other situations (e.g. offices, banks, hospitals etc.) Thus, although we will take our examples from manufacturing settings, the methods are not restricted to only such settings.

Process planning takes as its input the drawings or other specifications that might indicate what is to be made, and also the forecasts, orders, or contracts that indicate how many are to be made. The drawings then are analyzed to determine the overall scope of the project. If it is a complex assembled product, considerable effort may go into “exploding” the product into its components of parts and subassemblies.

Then, for each part, a detailed routing through the system is developed. Technical knowledge of processes, machines, and their capabilities is required, as well as a knowledge of costs and production economics. Ordinarily, a range of processing alternatives is available. The selection may be influenced strongly by the overall volume and projected stability of product design.

3B. 31 PRODUCT ANALYSES

The product that is to be manufactured is analyzed from a technological point of views to determine what processes are required.

Assembly or “Gozinto” Charts: Schematic and graphic model-commonly are developed to help visualize the flow of material and the relationship of parts (e.g. where they flow into the assembly process, which parts make up subassemblies, and where the purchased parts are used in the assembly sequence). Thus, for the capacitor, a first step might be the preparation of an “assembly chart” or, as it is often called, a “Gozinto” (goes into) chart.

OPERATION PROCESS CHARTS:

<table>
<thead>
<tr>
<th>Event</th>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operation</td>
<td>![Circle]</td>
<td>It represents an action</td>
</tr>
<tr>
<td>Storage</td>
<td>![Triangle]</td>
<td>It represents a stage when material (raw or finished) awaits an action</td>
</tr>
<tr>
<td>Delay</td>
<td>![Square]</td>
<td>It represents a temporary of an item</td>
</tr>
<tr>
<td>Transport</td>
<td>![Arrow]</td>
<td>It represents movement of an item</td>
</tr>
<tr>
<td>Inspection</td>
<td>![Square]</td>
<td>It represents an act of checking</td>
</tr>
</tbody>
</table>

**Combined Activities**

| Operation cum Transportation | ![Arrow] | First activity represents outer part and second security the inner part |
| Inspection cum Operation    | ![Circle] |                                                                       |
If the product already is engineered, we have complete drawings and specifications of the parts and their dimensions, tolerances, and materials to be used. From the specifications and the forecast, we can plan of “how to manufacture”. Decision must be made concerning which parts to purchase and which to manufacture in-house. The engineering drawings specify the locations, sizes, and tolerances for holes to be drilled, surfaces to be finished, etc. for each part. With this information, together with estimates of quantities to be produced and of manufacturing processes, we can specify the most economical equipment, processes, and sequences of processes.

3B 32 CRITERIA AND VALUES

From the time of the Industrial Revolution to the present, the main pressures that have influenced the design of processes and jobs are productivity improvement and economic optimization. These pressures have been associated with specialization. Adam Smith stated the advantages of division of labor as the guiding principle, and managers have applied this principle progressively over time. The automotive-type assembly lines epitomize the result, although the general division of labour principle has been applied throughout history and currently is being applied in office work as well as in other productive systems.

In 1776, Adam Smith enumerated the three important advantages of division of labor.

(1) The development of a skill or a dexterity when a single task was performed repetitively.

(2) A saving of the time normally lost in changing from one activity to the next.

(3) The invention of machines or tools that normally seemed to follow when workers specialized their efforts on tasks or restricted scope.

To these three advantages, Charles Babbage added a fourth, the principles of limiting skills as a basis for wage payment. Babbage noted that (a) wages paid were directed by the most difficult or rarest skill required by the jobs, (b) divisions of labour enabled skills to be made homogenous within jobs more easily and (c) for each job, one could purchase exactly the amount of skill needed. The result would be a lower total labor cost.

Beginning in the early 1930s, however, another criterion was proposed as a counterbalance – job satisfaction. Results of the famous Hawthorne experiments indicated that workers responded to other factors in the work situation. In the late 1940s, the value of the job satisfaction criterion development from a morale building program at IBM [1950]. The term job enlargement was coined to describe the process of reversing the continuing trend toward specialization. Practical applications of job enlargement were written up in the literature. These applications described improvements in productivity and quality levels that resulted, from combining operations to create jobs of broader scope. While job enlargement concepts did not specify any stopping rule either, they did provide a counterbalancing criterion.

In commenting on job satisfaction research, Davis points to several values held by the organizations that applied the division of labor criterion, throughout the industrial era. He points out these widely held beliefs: that the worker could be viewed as an operating unit, and as such, could be adjusted and changed by training and incentives to suit the needs of the organization, that workers were viewed as square parts and therefore were interchangeable in work assignments, that labor was thought of as a commodity to be bought and sold, that materialism, in its narrow sense of achieving material comfort, justified the means required to achieve it, and that many managers regarded jobs as isolated events in the lives of individuals – a non career.

Davis, however, is also critical of most job enlargement and job satisfaction studies because they almost invariably accept the technology as given and merely attempt to maximize satisfaction within technological constraints. He concludes that, throughout the industrial era, as a basis for process planning and job design, technology predominately has determined job content. This even holds true for most of he applications that consider job satisfactions as a criterion.
b.) Synthetic Rating: It is the method of evaluating an operator's speed from predetermined motion time values. The ratio between the predetermined motion time standard for the element and the average actual time volume in minutes for the same element is called performance rating factor.

3B. 37 STANDARD PERFORMANCE

Standard Performance is the rate of output which a qualified worker will naturally achieve without over-exertion as an average – over the working day or shift provided they know and adhere to the specified method and provided they are motivated to apply themselves to their work.

This performance is denoted as the one on the standard rating and performance scales.

3B. 38 SCALES OF RATING

In order that a comparison between the observed rate of working and the standard rate may be made effectively, it is necessary to have numerical of scale against which we make the assessment.

The rating can then be used as a factor by which the observed time can be multiplied to give the basic time which is the time it would make the qualified worker, motivated to apply himself & carryout the element at standard rating.

There are several scales of rating where the most common of which are those designated the 100-133 scale, the 60-80 the 75-100 and the British Standard Scale which is 0-100.
UNIT – 4

4A. PLANT LAYOUT

4A. 1 LAYOUT

Layout concerns with configuration of departments, work centres and equipments, with specific emphasis on movement of men and materials through the system. Decision in any of these four design areas – plant location, products, capacity planning and plant layout often have impacts on the others. Thus, both layout and location decisions affect capacity. Conversely, efforts to increase capacity may involve modifications in layout and changes in location. Moreover, any time a new location is established or products or services are introduced or changed, layout is affected.

4A. 2 IMPORTANCE AND FUNCTION

Layout decisions are important for three basic reasons:

(1) They require substantial investments of both money and effort.

(2) They involve long-term commitments, which makes mistakes difficult to overcome, and

(3) They have a significant impact on the cost and efficiency of short-term operations.

The need for layout planning can arise as part of the design of new facilities as well as redesign of existing facilities. In the latter instance, the most common reasons for redesign of layout include the following:

(i) Inefficient operations resulting in high-cost bottlenecks

(ii) Frequent accidents or safety hazards.

(iii) Changes in the design of products or services

(iv) Introduction of new products or services

(v) Changes in volume of output or product mix

(vi) Changes in environmental or other legal requirements

(vii) Employee morale problem.

(viii) Obsolescence of technology / facilities

(ix) Reduced damage or spoilage of materials

4A. 3 PRINCIPLES OF LAYOUT

The basic principles of plant layout are as follows:

(i) The total movement of material should be minimum. For this, one has to consider the movement distances between different work areas as well as the number of times such movements occur per unit period of time.

(ii) The arrangement of the work area should have as much congruence as possible with the flow of materials within the plant (from the stage of raw materials to the stage of finished goods) By 'flow' we do not mean a particular straight – line direction, we mean the different stages through which the material passes before it becomes a finished product. The stages at which value is added to the product and the sequence of the work areas should correspond with each other, as much as possible. In effect, there should be no back-tracking and very little interruption in the flow of the product from the raw materials stage to the finished product.
The layout should ensure adequate safety and satisfactory working conditions for the employees.

A good layout should take into consideration all the three dimensions of space available. In addition to the floor space, the vertical space available should also be taken into account while designing the work areas.

The layout should be adaptable or flexible enough to allow for probable changes in the future as all systems should anticipate changes in the future.

A good layout has to satisfy, therefore, the availability of space, the size and work area requirements of machinery and other utilities, the flow direction, type and number of movements of the materials, the men working in the plant, and also the future anticipated changes. The principle is one of integrating all these aspects.

4A. 4 TYPES OF LAYOUT PROBLEMS

According to the types of facility under consideration, the layout problem can be classified. For example:

1) Production centre or manufacturing plant

2) Commercial establishments like shops, department stores, offices, banks.

3) Service facilities like hospitals, post offices.

4) Residential accommodations like apartments houses.

5) Town planning, real estate developing.

6) Recreational facilities or entertainment avenues like theatres, parks.

These layout problems may crop in at various stages in any organization. If the organization may plan to create a totally new complete facility or plan for expanding the existing capacity in the already existing plant or rearrangement of existing layout or minor modifications to be carried on the present layout, so as to maximize the profit of the organization.

4A. 5 FLOW PATTERNS

According to the principle of flow, size and content of the job, use of gravitational force, the layout plan arranges the work area for each operation of process so as to have an overall smooth flow through the production plant. Layout plan arranges the work area for each operation or process, so as to have overall smooth flow through the production facility. The basic flow pattern types that are employed in designing the layouts are I-Flow, L-Flow, U-Flow, O-Flow, S-Flow.

The specialties of different flows are:

I – Type Separate Receiving and shipping area

L – Type Adopted, when straight line flow could not be accommodated.

U – Type Popular, combination of Receiving and Shipping at one end

O – Type Adopted when it is required to terminal the flow nearer to the origin

S – Type When the production line in long and Zig Zaging on the production floor is required.
4A. 6 OBJECTIVES OF GOOD PLANT LAYOUT

a. Overall simplification of production process in terms of:
   - Equipment utilisation
   - Minimization of delays
   - Reducing manufacturing time
   - Better provision for maintenance
b. Overall integration of men, materials, machinery, supporting activities and any other consideration which may give a better compromise
c. Minimize of material handling cost
   - Achieved through facilities in the best flow sequences
d. Floor space saving
   - Effective space utilization
   - Less congestion and confusion
e. Increased output and Reduced work-in-progress.
f. Better working environment
g. Better working environment
h. Workers convenience
   - Worker / Job satisfaction
   - Improve morale
   - Waste minimization and higher usage.
   - Avoid unnecessary capital investment
   - Higher flexibility and Adaptability to changing conditions
   - Improved work methods and reduced production cycle time
m. Better product quality
n. Better utilization of cubic space.

4A. 7 FACTORS FOR GOOD LAYOUT

The layout is governed by many factors. The best layout is one, which optimize all the factors. These factors are grouped under eight categories. They are:

(i) Material Factors
- Product Design
- Product Variety
- Quantity Produced
- Necessary Operations of producers
- Sequence of Production

(ii) Men Factor
- The number of Direct Workers
- Supervision and Service help required
- Manpower utilization
- Safety of employees

(iii) Machinery Factor
- Process of Production
- Equipment used for production
- Tools and their utilization

(iv) Movement Factor
- Inter and Intra Department Transport
- Material Handling at various operations
- Storage and Inspection
- Material Handling Equipments

(v) Waiting Factors
- Permanent and Temporary Storage
- Delay and their location.

(vi) Service Factors
- Related to employee facilities such as, parking lot, lockers, toilets, waiting rooms.
- Related to material in terms of quality, production control, scheduled, Dispatching, Waste control.
- Related to machinery such as Maintenance

(vii) Building Factors
- Interior and Exterior of the buildings
- Utility Distribution and Equipments

(viii) Change Factor
• Versality
• Flexibility
• Expansion

4A. 8 LAYOUT DESIGN PROCEDURE

The overall layout design procedure has four phases. They are:

<table>
<thead>
<tr>
<th>Phase</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Location</td>
</tr>
<tr>
<td>II</td>
<td>General Overall Layout</td>
</tr>
<tr>
<td>III</td>
<td>Detailed layout</td>
</tr>
<tr>
<td>IV</td>
<td>Implementation</td>
</tr>
</tbody>
</table>

The systematic procedure involves the following steps:

a. Data input and activities
b. Preparation of flow of materials
c. Activity (Precedence – Succeedence) relationship
d. Plan of material handling
e. Relationship diagram preparation using steps: a to d
f. Calculation of space requirements
g. Identification of availability of space
h. Space Relationship Diagram preparation, using steps: e, f and g.
i. Modifying consideration
j. Practical Limitations
k. Develop Layout alternative, using steps: h, i and j
l. Evaluation of alternative
m. Selection of the best layout

4A. 9 LAYOUT TYPES

There are three basic types of layouts and these correspond to the three types of processing systems. Product layouts are most conducive to continuous processing, process layouts are used for intermittent processing and fixed position layouts are used when projects require layouts. There are another two types of hybrid layouts. Cellular or group layout is a special type of process layout. For example systems, the job shop layout is the solution.

4A. 10 PRODUCT LAYOUT

This type of layout is used to achieve a smooth and rapid flow of large volumes of products or customers through a system. This is made possible by highly standardized products or services which require highly standardized, repetitive processing operations. A job is divided into a series of standardized tasks, permitting specialization of both labour and equipment. The large volumes handled by these systems usually make it
economical to invest substantial sums of money in equipment and in job design. Because only one or few very similar items are involved, it is feasible to arrange an entire layout to correspond to the technological processing requirements of the product or service involved.

This layout is for product focused systems, and are popularly known as ‘Assembly Line”. The work centres are arranged in the job sequence. The raw materials enters at one end of the line and individual operations are performed in the pre-fixed sequence and get converted to the final shape. There is one flow for each product. This follows the I – pattern of flow. The work in-process and the material handling are minimum.

Following conditions favour the selection of product layout.

- High volume of production
- Standardization of product
- Reasonably stable product demand
- Uninterrupted supply of material
- Holding up of inventory is possible.

Product layouts achieve a high degree of both labour and equipment utilization, and this offsets the high equipment costs. the investment in work-in-process is minimum because the items move quickly from operation to operation. This also reduces congestion and ensures smooth flow of items in the shop floor. Overall supervision and control are effective.

4A. 11 PROCESS LAYOUT

These layout are designed to facilitate processing items or providing services which present variations in their processing requirements. The processing units are organized by functions into departments on the assumption that certain skills and facilities are available in each department. Similar equipments and operations are grouped together. For example, turning, milling, foundry, heat treatment. Items which require these operations are frequently moved in batches to the departments in a sequence dictated by technical considerations. Different products may call for different processing requirements and different sequence of operations. Consequently, variable path material handling equipment is needed to handle variety of routes and items.

These layouts, also known as ‘Functional Layout’ is process focused systems and are used widely in manufacturing and service sectors. The use of general purpose machines provides flexibility necessary to handle a wide range of processing requirements. Workers who operate the equipments are usually skilled or semi-skilled. The example of process layout includes hospitals, colleges and universities, banks, airlines and public libraries. For instance, hospitals have many departments like surgery, maternity, emergency, etc. Similarly universities have separate departments that concentrate on different areas of study as engineering, business management, mathematics, and physics. In business organization, there will be departments like accounts, personnel, and systems.

Because process layouts arrange equipments by type rather than according to processing sequence, the system is much less vulnerable to shutdown caused by either mechanical failure or absenteeism. Material handling in inefficient and unit handling costs are generally much higher than in product layouts. The investment in work-in-process is high and material movements will take a zig-zag route. The equipment utilization comparatively will be less. Hence, this layout is more suited for low volumes of production and particularly when the product is not standardized. It is economical when flexibility is the basic system requirements.
4A. 12 FIXED LAYOUT

In this, the material remains in a fixed position, but machinery, tools handling equipment, workers are brought to the place the material. This is in contrast to both product and process layouts. Such a layout may be preferred when the equipment and the machinery is small in number and size, and where the workmen are highly skilled to perform the various small jobs on the product. Fixed position layouts are sued in large construction projects, ship building, aircraft manufacturing.

4A. 13 “REL” Chart

This denotes Relations Chart. The chart depicts the relationships between various departments and their relative importance. The relationship is graded as:

A - Absolutely Essential
E - Essential
I - Important
O - Ordinary
U - Unimportant
X - Undesirable

<table>
<thead>
<tr>
<th>Assembly</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Fabrication</td>
<td></td>
</tr>
<tr>
<td>Job planning</td>
<td></td>
</tr>
<tr>
<td>Pattern shop</td>
<td></td>
</tr>
<tr>
<td>Shipping</td>
<td></td>
</tr>
<tr>
<td>Testing</td>
<td></td>
</tr>
<tr>
<td>Wiring</td>
<td></td>
</tr>
</tbody>
</table>

FIGURE 4.3 ‘REL’ CHART

The departments which falls in the “A” relationship has necessarily to be place together, whereas those falling under “x” relationship can be mutually exclusive. This give scope for the layout designer to position various departments of he organization for optimum utility.

4A. 14 LINE BALANCING

Many differences exist in the management of production activities in make-to-order and make-to-stock firms. In make-to-order situations, due dates are important, and hence the sequencing of customer orders at various machine centres is an essential function. This involves both planning and control of activities. Make-to-stock products are generally high-volume consumer goods, such as telephones, automobiles, wrist watches, etc. The manufacture of standardized, high-volume items, which involves flow shops requires control for effective production.
A flow shop consists of a set of facilities through which work flows in a serial fashion. The same operations are performed repeatedly in every work station, thus require lower-level skilled workers. The flow shop generally represents a mass production situation and hence the operations are carried out very efficiently e.g. when an operator has to install a gear box on an automotive assembly or assembling cooling system on a washing machine.

In flow shops, items enter the finished goods inventory one after another, often in the same order of the inputs for these goods, leaving very low in-process inventories. Since the items are mostly make-to-stock, forecasting is a difficult job, and hence the finished goods levels in terms of anticipation inventories are very high. For the same reason, raw materials are carried at higher inventory levels. Machines in flow shop tend to have a special – purpose design, and hence the initial investment level is generally high for heavy automated plants.

The production control system of continuous production is called flow control. Specialization, high volume, division of labour and efficiency are built into the design of assembly lines.

The main objective of flow control in flow shops is to balance the assembly line. The assembly line is represented in the form of a precedence diagram.

4A. 15 OBJECTIVE OF ASSEMBLY LINE BALANCING

The objective of assembly line balancing is to subdivide the network into several sub networks (stations) without violating the precedence relationships and allocating operations to each station without exceeding the cycle time, i.e. the sum of the times of operations allocated to each station should not exceed the cycle time.

While allocating operations to each station, the precedence relationships must be maintained. If these are followed, then we can ensure production of the specific volume of products or items using the assembly line. At an interval equal to the cycle time, a completed assembly will be related from the assembly line.
4B. PRODUCTION PLANNING AND CONTROL

4B. 1 INTRODUCTION

Production is an organized activity of converting raw material into useful products. Planning and control are two important components of management process. Before the commencement of production, production planning is done in order to anticipate possible difficulties and decide in advance as to how the production should be carried out in the best and most economical way. Planning involves the considerations of all input variables to achieve defined output goals. Mere planning is not sufficient for this. It has to be implemented strictly and within the standard time the jobs are to be completed. For this purpose control is essential, which involves the corrective actions taken when the actual output varies from the desired one by bringing the actual output in line with the planned output.

Production planning, in particular, would therefore consist mainly of the evaluation and determination of production inputs such as manpower, machinery and equipments, material handling equipments and utilities to achieve the desired goals. The definition of the goal is also a part of production planning process.

The aim of production control is to produce the duties of high quality, in right quantity and at the right time by using the best and least expensive methods.

Hence, the production planning and control is defined as the process of planning the production in advance, setting the exact route of each item, fixing the starting and finishing times for each item, to give production orders to shop floors and to follow up the progress.

The planning process can be divided into various stages:

(a) Defining objectives and setting priorities to achieve these goals
(b) Studying the external and internal environments
(c) Determining reliable targets
(d) Gearing up the inputs to achieve these targets.

The main functions of production planning and control are:

(i) Planning function
   • Planning
   • Process designing
   • Routing
   • Material control
   • Scheduling
   • Tool control
   • Forecasting
   • Loading

(ii) Control function
   - Dispatching
   - Follow up
4B. 2 INTEGRATIVE NATURE OF PRODUCTION PLANS

Production planning and control (PPC) is an effort to optimize the process of conversion of raw materials into finished products required in the market. Since various activities are involved in the conversion of raw materials into finished goods, PPC is and has to be an integrated function if the organization has to derive maximum benefit out of planning. The procurement of raw materials, the quality control and inspection of raw materials, inventory levels of in-process and finished goods, the production costs, the labour available, the machinery and equipments that is available, the Warehousing capacity available etc., all have their influence on the planning of production operations which convert the raw material into finished goods. All the functions have inter-links and the more such inter-links are considered in the planning process, the better will be the planning process.

Sometimes production and maintenance are planned separately, leading to conflicts between the preventive maintenance needs and the production requirements. Such conflicts can be avoided if the planning for maintenance is done in co-ordination with planning for production, allowing sufficient number of days of shut downs of different machines while drawing up the production plan for the year. The more integrative the PPC, the better will be the planning decisions.

Products are manufactured by the transformation of raw material (into finished goods). This is how production is achieved. Planning looks ahead, anticipates possible difficulties and decides in advance as to how the production, best, be carried out the control phase makes sure that the programmed production is constantly maintained.

A production planning and control system has many functions to perform, some, before the arrival of raw materials and tools and other while the raw material undergoes processing. The various functions are also sub-divided as follows:

- Planning Phase
  - Prior Planning
    - Forecasting
    - Order Writing
    - Product Design
  - Active Planning
    - Process Planning and Routing
    - Material Control
    - Tool Control
    - Loading
    - Scheduling
- Action Phase
  - Dispatching
- Control Phase
  - Progress Reporting
The details of various functions are:

(a) Forecasting: Estimation of type, quantity and quality of future work

(b) Order writing: Giving authority to one or more persons to undertake a particular job.

(c) Product design: Collection of information regarding specifications, bill of materials, drawings, etc.

(d) Process planning and routing: Finding the most economical process of doing a work and (then) deciding how and where the work will be done

(e) Material control: It involves determining the requirements and control of materials.

(f) Tool control: It involves determining the requirements and control of tools used

(g) Loading: Assignment of work to manpower, machinery etc.

(h) Scheduling: It is the time phase of loading and determines when and in what sequence the work will be carried out. It fixes the starting as well as the finishing time for the job.

(i) Dispatching: It is the transition from planning to action phase. In this phase the worker is ordered to start the actual work.

(j) Progress reporting:

   a. Data regarding the job progress is collected

   b. It is interpreted by comparison with the preset level of performance

(k) Corrective action:

   a. Expedition means taking action if the progress reporting indicates a deviation of the plan from the originally set targets.

   b. Replanning – Replanning of the whole affair becomes essential, in case expediting fails to bring the deviated plan to its actual (right) path.

4B. FORECASTING

a) Forecasting means estimation of type, quantity and quality of future work e.g. sales etc.

b) The survival of a manufacturing enterprise depends on its ability to assess, with reasonable accuracy, the market trends several years ahead.

c) Forecasters will be able to make use of sales trends, but these must be considered in the light of expected introduction of new materials, fashion changes, policies of competitors, unseasonable weather, threat of war and the general economic situation expected in the country and foreign markets. These circumstances and others necessitate changes in sales forecast from time to time during the forecast period.
Forecast represents a commitment on the part of the sales department and each of is divisions of expected sales. It becomes a goal against which the effectiveness of the sales department will be measured.

Forecasting plays a crucial role in the development of plans for the future.

Sales budget (estimate) forms the basis for manufacturing budget. It is the sales forecast which enables to determine production quantities, labour, equipment and raw material requirement (Refer to Chapter no. 28)

A sales forecast should be
a. Accurate
b. Simple and easy to understand and
c. Economical

4B. 4 PURPOSE OF SALES FORECASTING
Sales forecasting is essential because,
(i) It determines the volume of production and the production rate.
(ii) It forms basis for production budget, labour budget, material budget, etc.
(iii) It suggests the need for plant expansion
(iv) It emphasizes the need for product research development
(v) It suggests the need for changes in production methods
(vi) It helps establishing pricing policies
(vii) It helps deciding the extent of advertising, product distribution, etc.

4B. 5 BASIC ELEMENTS OF FORECASTING
- Forecasting means predicting future events by the best possible means
- In any sales forecasting analysis, there are four basic elements of economic data that should be used
  1. Trends
  2. Cycles
  3. Seasonal variations
  4. Irregular variations
- Trends are the long term, long range movements of a series of economic data. They have little relationship to the month-to-month changes that take place, and they manifest their direction slowly.
- Cycles are of shorter duration and they are usually featured by alternate periods of expansion and contraction.
- Seasonal variations occur within a certain period of year and recur at about the same time and to approximately the same extent from year to year.
- Irregular variations are the result of unforeseen or non-recurring events that have an economic influence. A strike in a key industry might cause an irregular variation.
4B. 6 SALES FORECASTING TECHNIQUES

Forecasting is the formal process of predicting future events that will significantly affect the functioning of the enterprise.

Sales forecasting techniques may be categorized as follows:

(a) Historic estimate
(b) Sales force estimate
(c) Trend line (or Time series analysis) technique
(d) Market survey
(e) Delphi method
(f) Judgmental techniques
(g) Prior knowledge
(h) Forecasting by past average
(i) Forecasting from last period’s sales
(j) Forecasting by Moving average
(k) Forecasting by Weighted Moving average
(l) Forecasting by Exponential Smoothing
(m) Correlation analysis
(n) Linear Regression Analysis

The details of the forecasting techniques are given below:

(a) Historic estimate

- This technique makes use of the assumption that what happened in past will happen in future. For example, a concern has sold 5000 blankets in winter last year, it will be able to sell the same quantity in winter this year also.

- Historic estimate is useful if the activity is affected by pattern of seasonality.

- It is useful for determining model, size and colors distribution.

- It is successful only when pattern of events remains unchanged, i.e., if economy is static. This is rarely true except for short period of time.

- Historic estimate is not scientifically valid and thus it is not an accurate method, the total sales forecast provided by this method should be modified by other techniques.

(b) Sales force estimate

- This technique is based upon the principle – that the persons in contact with the market know best about the future market tends.
Individual salesmen make sales estimates of their territories and submit it with the District Sales Manager who analysis it, modified it and sends the same to Factory Sales Manager. Factory Sales Manager in consultation with other related factory executive formulates the final estimate of sales.

This technique is useful when an industry is making a limited number of products (e.g., commercial power generating equipment) and there are a few large customers.

(c) Trend line technique

- Trend line technique is employed when there is an appreciable amount of historical data.
- This technique involves plotting historical data, i.e., a diagram (Fig. 7.3) between activity indicator, e.g. tons of material (say past sales) on Y – axis and time on X – axis.
- A single best fitting line (using statistical technique) is drawn and projected to show sales estimate for future.
- This technique is more accurate as it makes use of a large past data and possesses scientific validity.
- However, it is time-consuming, involves long mathematical calculations and assumes an infinite population of relatively small customers so that the decision of an individual customer cannot have an appreciable effect on total product demand.

(d) Market Survey, i.e. Market Research Technique

- This technique finds application when a concern introduces a new product in the market and is interested to estimate its sales forecast. For a new product, naturally, no historic or past data regarding sales will be available.
- This technique may be very informal, utilizing the sales force to feel out the potential customers in order to establish the extent of the market or it maybe a systematically conducted survey using special mathematical tools.
- Generally, the new product is introduced in a relatively small critical trial area, market reaction is noted and the total sale (country wide) is projected from these results.

(e) Delphi Method

- A panel of experts is interrogated by a sequence of questionnaires in which the response to one questionnaire is used to produce the next questionnaire. Any set of information available to some experts and not others is thus passes on to the others, enabling all the experts to have access to all he information for forecasting. The method solicits and collates from experts to arrive at a reliable consensus. This technique eliminates the bandwagon effect of majority opinion.
- Delphi method has fair to very good accuracy for short and long term forecasts.
- The method is applicable to forecasts of long-range and new-product sales.

(f) Judgmental techniques

- Opinions of consumers and customers. Questionnaires related to buying the product may be sent to a selected group of consumers and to the customers who have already purchased the product. The information thus received can be very useful in estimating product performance and its probable demand in future.
- Retail and wholesale dealers can provide some insight into the pace of current and future sales.
The opinion of area sales manager can also be quite useful.

(g) Prior knowledge

- This is used by ancillary units which are more or less a part of the large organisation. The large organisation informs each ancillary unit how many components parts to make.
- The forecast estimate is needed only to establish the material and tool requirements, etc.

(h) Forecasting by Past average

- If our objectives is to forecast or predict the sales of an item for the next sale period, then this method is used.

(i) Forecasting from last period’s sales

- The method eliminates the influence of past (old) data and bases the forecast only upon the sales of the previous period.

(j) Forecasting by Moving Average

- This method represents a compromise between the two above explained methods, in that the forecast is neither influenced by very old data nor does it solely reflect the figure of the previous period.

(k) Weighted Moving Average Method for Forecasting

- Whereas the simple moving average gave equal effects to each component of the moving average database, a weighted moving average allows any weights to be placed on each element, providing, of course, that the sum of all weights equals one.
- The weighted moving average method has a defined advantage in being able to vary the effects of past data, but it also has the disadvantage of remembering the total history for the time period.

(l) Forecasting by Exponential Smoothing

The main disadvantages of the moving average method are:

- The lengthy calculations involved
- The need to keep quantities of historical data.
- The fact that the normal (or simple) moving average method places equal weight on each of the historical figures used.
- The age of the data, which increase with the number of periods used.

All of these disadvantages are overcome by the exponential smoothing technique. Using this technique it is necessary only to retain the previous forecast figure and to know the latest actual sales figure. The technique works by modifying the old forecast in the light of new sales figure.

4B. 7 TOOL CONTROL

- Tool control implies (1) determining tool requirements (2) procuring necessary tools and (3) controlling/maintaining tools once they have been procured.
A tool or process planner must calculate tool requirements prior to the time of production to ensure that proper tools will be available when needed. Lost time resulting from incomplete tools planning can be expensive as well as causing work to delay.

In order to facilitate tool control and to limit the investment in tool inventory. It is important to standardize wherever possible all the tools within an organisation.

Need for tool control: It is very important to ensure:

- Against loss through theft or negligence and production delays through misplacement or non-availability of tools.
- That the investment in tool inventories is minimized consistent with proper tool availability.

**4B. 8 PROCEDURE OF TOOL CONTROL:**

Two methods are commonly used to control the issue and receipt of tools to and from the workers.

1. The Brass ring system. Brass rings with worker’s identification number marked on them are issued to every worker when he draws a tool from the crib, he gives one of his, rings to the attendant and the ring is hung on a peg at the tool bin. When the worker returns the tool, the ring is returned to him.

   This method is very simple and can be used where workers are not much educated. However it invites dishonesty because of the ease with which counterfeit rings can be made. The method also does not provide any means of determining tool usage.

2. The Mc Caskey System

   - This system is based upon 3-part carbon backed form. The worker fills it out and presents it to the tool crib attendant when he wishes to withdraw a tool. One copy of the form is maintained under a clip with the worker’s name or his clock number and a second copy under a clip of the tool number. The third copy is given to the worker for identification of the tool. The copy filed under tool number provides ready reference that particular tool is not available when a later request is made for it.

   - Periodic checks of the slips under the worker’s clip will indicate if tools are being hoarded or held for an excessively long time.

   - When the tool is returned along with the third copy of the form which the worker had kept for his information (identification of tool), the copy under the worker’s clip is removed and given to the worker. The copy under the tool number clip is removed and placed behind the tool inventory card at the back of each clip. Every month, the slips behind the card are counted to indicate tool usage and the individual slip thrown away.

   - This system is widely used in manufacturing establishments because of its excellent control features.

**4B. 9 LOADING**

- Loading means assignment of work to manpower, machinery etc., without specifying when the work is to be done.

- Loading results in a tabulated list or chart showing the planned utilization of the machines or work stations in the plant.

- The objective of the loading function is to be maintain an up-to-date picture of the available capacity of the plant.
Loading can be defined as the study of the relationship between load and capacity at the places where work is done. The information provided by loading is used (1) to ensure the efficient utilization of the plant and labour in a factory, (2) to help in the setting of reliable delivery promises, (3) and to assist in the forward planning of the purchase of new plant.

Capacity can be defined as the time available for work at work centres expressed in machine hours or in man hours.

4B. 10 AIMS OF LOADING

(1) To check the feasibility of production programmes
(2) To assist in the efficient planning of new work.
(3) To assist in balancing the plant to the existing load.
(4) To assist in the fixing of reliable delivery promises.

4B. 11: SCHEDULING AND CONTROL OF PRODUCTION

Once the planning (work) to meet sales is complete and a set of decisions have been formulated using Graphical or Linear programming methods the next step in the implementation of the decisions through detailed plans and schedules. Schedules are made for the use of facilities like equipment and manpower.

Scheduling and Control of production focus attention on the following:

(a) Knowing the total overall production targets – how to determine the amount of each product be manufactured if there are products of different types and sizes?
(b) How to decide about and deploy work force (different types of workers and kinds of skills) and equipment to achieve the target production rate?
(c) How to determine individual work assignments?
(d) What should be the information system to feed back quickly and accurately the actual output duly compared with the scheduled one?

Scheduling and Control of production have one stage in between them, which is known as dispatching and it will be discussed under Sec. 7.18. In general, first of all the order is scheduled, then it is dispatched for necessary operation (on the raw material) and lastly the progress of the order is tracked, to be certain that the schedule is being met. This (last) phase of tracking the progress of an order and making corrections (if necessary) is known is control of production.

4B. 12 SCHEDULING

In brief, scheduling means – when and in what sequence the work will be done. It involves deciding as to when the work will start and in certain duration of time how much work will be finished. Scheduling deals with orders and machines, i.e. it determines which order will be taken up on which machine and in which department by which operator. While doing so, the aim is to schedule as large amount of work as the plant facilities can conveniently handle by maintaining a free flow of materials along the production line.

Scheduling may be called the time phase of Loading. Loading means the assignment of task or work to a facility whereas scheduling includes in addition, the specification of time and sequence in which the order/work will be taken up.
A production schedule is similar to a railway time table and shows which machine is doing what and when. A production schedule is a statement of target dates for all orders or operations in hand and reveals their starting and finishing dates. Scheduling finalizes the planning phase of Production Planning and Control System.

### 4B. 13 FACTORS AFFECTING SCHEDULING

The following factors affect production scheduling and are considered before establishing the scheduling plan.

(a) **External factors**
- Customer’s demand,
- Customer’s delivery dates, and
- Stock of goods already lying with the dealers and retailers.

(b) **Internal Factors**
- Stock of finished goods with the firm,
- Time interval to process finished goods from raw material. In other words—how much time will be required to manufacture each component, subassembly and then assembly (i.e. the final product).
- Availability of equipment and machinery, their total capacity and specifications.
- Availability of materials, their quantity and specifications,
- Availability of manpower (number, type and kind of skills)
- Additional manufacturing facilities if required, and
- Feasibility of economic production runs.

### 4B. 14 SCHEDULING PROCEDURE AND TECHNIQUES

Scheduling normally starts with the Master Schedule. A master schedule resembles central office which passes information about all the orders in hand.

### 4B. 15 ADVANTAGES

1. It is simple and easy to understand,
2. It can be kept running (i.e., current)
3. It involves less cost to make it any maintain,
4. It can be maintained by non-technical staff, and
5. A certain percentage of total weekly capacity can be allocated for such orders.

### 4B. 16 DISADVANTAGES

1. It provides only overall picture, and
2. It does not give detailed information. Applications
4B. 17 APPLICATIONS

- In big firms, for the purpose of loading the entire plant,
- In Research and Development organizations, and
- For the overall planning in foundries, computer centres, repair shops, etc.

After framing the overall picture of production requirements through a Master Schedule chart, the detailed schedules are thought of and made for each component and subassemblies so that all parts are available at the time of assembly. There are a number of visual aides and techniques, both in the form of conventional charts and commercially available boards, which aid in detailed scheduling. The technique to be employed for scheduling purposes depends upon the type of production (intermitted or continuous), type and frequency of tasks, demand patterns, etc. A useful scheduling device normally portrays planned production, actual performance and their comparison. Actually, the Gantt Chart forms the basis of commonly used scheduling techniques.

Some of the techniques (besides master schedule) employed for Loading and Scheduling purposes are:

- Perpetual schedule
- Order schedule
- Loading by schedule period
- Commercial devices

(A) PERPETUAL SCHEDULING:

Like master scheduling, it is also simple and easy to understand, is kept current, involves less cost and can be maintained by clerical staff. But, the information which is provided is very gross and at the same time it is not clear from the chart—when the work will take place.

(B) ORDER SCHEDULING

It is most elaborate technique. Time is marked horizontally and the vertical axis shows the particular facility (say a machine). The information required to generate an order schedule is, regarding the number of parts to be manufactured, name of the machines, their Set-up times, total production time and the date of completion of the order.

The scheduling is started by placing the last operation at the date of completion and then working backwards.

Advantages of Order Scheduling

1. It is very detailed.
2. The earliest possible completion dates can be met.

Limitations

1. It is very costly
2. It requires accurate (production) time standards and good communication system.
3. It is difficult to maintain effectively if there are many active orders.
The task is broken into different operations which will be required to turn raw material into finished product. A Gantt type of chart is employed for scheduling purposes. The rows, mark different facilities and each column denotes a time period (TP). There are as many time periods as the number of operations. The first operation is carried out in the time periods as the number of operations. The first operation is carried out in the time period 1, second operation, in the time period-2 and soon. It is however not specified that, within the time period, when the operation will start and finish, but the operation is very much supposed to be completed during that particular time period. The shop supervisor does the detailed scheduling within the framework of the specified time period.

This type of scheduling involves a longer in – process (total) time because only one operation is to be performed in one time period. However, this makes it more flexible as an operation can be taken up at the most convenient time within the specified time period.

4B. 18 PRODUCTION CONTROL

Scheduling completes the planning phase of Production Planning and control. The next is ‘Dispatching’. After dispatching is the control phase or control of production which consists of two parts (a) Progress reporting, and (b) Corrective action.

A control system involves four stages namely: (1) observation, (ii) analysis, (iii) Corrective action, and (iv) Post-operation evaluation. A production control system considers these elements in its different functions.

The control of production is necessary to be sure that the production schedules are being met and the job will be delivered as per the pre decided (scheduled) plans. Production control involves an information feedback mechanism and a system of corrective action. Production control follows up the schedule plans, comprise the actual output with the planned one, and points out deviation, if any, so that the same can be corrected through the adjustments of men, materials and machines.

In brief, a production control group:
- Receives work progress reports;
- Compares them with the scheduled plans;
- Removes causes of delays in production;
- Modifies the schedules or plant capacities; and
- Expedites the work.

4B. 19 DISPATCHING

Dispatch function executes planning function. It is concerned with getting the work started. Dispatching ensures that the plans are properly implemented. It is the physical handing over of a manufacturing order to the operating facility (a worker) through the release of orders and instructions in accordance with a previously developed plan of activity (time and sequence) established by the scheduling section of the production planning and control department. Dispatcher transmits orders to the various shops. Dispatch function determines – by whom the job shall be done and it co-ordinates production. It is the key point of a production communications system. It creates a direct link between production and sales.

A dispatcher is familiar with the productive capacity of each equipment. He always keeps an eye over the progress of orders which move at different speeds on different routes.

Dispatch Procedure. The product is broken into different components and components into operations.

(a) Store Issue Order: Authorize stores (department) to deliver required raw material.
(b) Tool Order: Authorize tool store to release the necessary tools. The tools can be collected by the tool room attendant.

(c) Job Order: Instruct the worker to proceed with the operation.

(d) Time Ticket: it records the beginning and ending time of the operations and forms the basis for worker’s pay.

(e) Inspection Order: notify the inspectors to carried out necessarily inspections and report the quality of the component.

(f) Move Order: Authorize the movement of materials and components from one facility (machine) to another for further operations.

In addition, there are certain other dispatch aspects which have to be taken care of,

- All production information should be available before hand.
- Various order cards, and specification drawings should be ready.
- Equipments should be ready for use.
- Progress of various orders should be properly recorded on the Gantt charts or display boards.
- All production records should be properly maintained.

4B. 20 CENTRALIZED AND DECENTRALIZED DISPATCHING

Dispatch function may be centralized or decentralized. In a Centralized dispatch system, a central dispatching department, orders directly to the work station. It maintains a full record of the characteristics and capacity of each equipment and work load against each machine. The orders are given to the shop supervisor, who runs his machines accordingly. In most of the cases, the supervisor can also give suggestions as regards loading of men and machines under him. A centralized system has the following advantages:

1. A greater degree of overall control can be achieved.
2. Effective co-ordination between different facilities is possible.
3. It has greater flexibility
4. Because of urgency of orders, changes in schedules can be affected rapidly without upsetting the whole system.
5. Progress of orders can be readily assessed at any time because all the information is available at a central place.
6. There is effective and better utilization of manpower and machinery.

In a Decentralized dispatching system the shop supervisor performs the dispatch factions. He decides the sequence of handling different orders. He dispatches the orders and materials to each equipment and worker, and is required to complete the work within the prescribed duration. In case he suspects delay, with due reasons of the same, he informs the production control department. A decentralized dispatching system has the following advantages.

1. Much of the red tape is minimized
2. Shop supervisor knows best about his shop, therefore, the work can be accomplished by the most appropriate worker and the machine.
3. Elaborate reports and duplication of postings can be avoided
4. Communication gap is reduced
5. It is easy to solve day-to-day problems
6. It keeps the natural urge of a section to be self-sufficient.

The advantages of a centralized system, more or less give an idea about the disadvantages of the decentralized system and vice versa.

**4B. 21 ROUTING**

Routing lays down the flow of work in the plant. It determines what work is to be done and where and how it will be done. Taking from raw material to the finished product, routing decides the path and sequence of operations to be performed on the job from one machine to another. The purpose is to establish the optimum sequence of operations. Routing is related to considerations of layout, temporary storage of in-process inventory and material handling.

Routing in continuous industries does not present any problem because of the product type of layout, where the equipment is laid as per the sequence of operations required to be performed on the components (from raw material to the finished products).

In open job shops, since, every time the job is new, though operation sheets (sometimes) may serve the purpose, but the route sheets will have to be revise and this involves a greater amount of work and expertise.

**4B. 22 ROUTING PROCEDURE**

Various procedural steps are as follows:

(a) The finished product is analyzed from the manufacturing standpoint in order to decide how many components can be made in the plant and how many others will be purchased (Make/Buy decision) from outside through vendors, by subcontracting, etc. Make/Buy decision depends upon the work load in the plant, availability of equipment and personnel to manufacture all components, and the economy associated with making all components within the plant itself.

(b) A parts list and a bill of materials is prepared showing name of the part, quantity, material specifications, amount of materials required, etc. The necessary materials thus can be procured.

(c) From production, standards – machine capacities, machine characteristics and the operations which must be performed at each stage of manufacture are established and listed in proper sequence on an operation and route sheet. The place where these operations will be performed is also decided.

Actually, operation sheet and route sheet are separate. An operation sheet shows every thing about the operations, i.e., operation description, their sequence, type of machinery, tools, set up and operation times, whereas a route sheet besides the sequence of operations and relation between operation and machine, also details the section (department) and the machines to whom the work will flow.

The difference between an operation sheet and a route sheet is that an operation sheet remains same for the components if the order is repeated but the route sheet may have to be revised if certain machines are already committed to other orders (jobs) on hand. Except this small difference, both the sheets contain practically the same information and thus are generally combined into one sheet known as ‘operation and route sheet’.

(d) the next step is to determine the lot size or the number of components to be manufactured in one lot or batch. In the case of an order from a particular customer, it is generally equal to a number within 10% of the order quantity. In other cases the principle of economic batch quantity can be applied (refer Chapter 24) to determine the batch size.
(e) Standard scrap factors (single or cumulative) and the places (i.e., after a particular operation or assembly) where scrap is very likely to occur are identified. The actual scrap in each batch can be recorded on the control chart. Causes for points out of control limits are explored and corrected. The variables like workers, machinery and schedules may also be adjusted to minimize scrap.

(f) The cost of the component is analyzed and estimated through the information obtained in steps (a) to (e) above. The cost consists of material and labour charges, and other specific and general indirect expenses.

4B. 23 PROGRESS CONTROL

Once the actual production has started, it becomes essential to keep an eye at the progress of the work so that, if required, timely corrective action can be taken. Progress control means – trying to achieve the standards set, i.e., a certain level of efficiency or a certain volume of production in a specified duration. The system of progress control should be such that it furnishes timely, adequate and accurate information about the progress made, delay and under-or-over-loading.

4B. 24 STEPS INVOLVED IN PROGRESS CONTROL

(a) Setting up a system to watch and record the progress of the operating facility (production section).

(b) Making a report of the work progress or work accomplishment.
   - Control group for necessary control action.
   - Accounting group for recording material and labour expenditures.

(c) Interpretation of the information contained in the progress report by the control group

(d) Taking corrective action, if necessary.

4B. 25 CHARTS FOR THE WORK ACCOMPLISHMENT

Progress charts are normally employed for this purpose. They compare the work progress against a prescribed target, and point out the failure to achieve the same, thus progress charts draw attention for an action or investigation.

The chart construction may have the following four forms

1. The Bar Chart
2. The Curve chart
3. The Gantt Chart and
4. Mechanical chart

1. The Bar Chart consists of a number of bars. Each bar has its length proportional to the activity duration. A bar chart is generally used to point out and analyze interrelated data which otherwise is difficult to read.

2. A Curve Chart is a graph between two variables (like, number of days and number of items produced) marked along the X and Y axes. As the days pass, the number of items being produced is marked over the graph. When all such points are joined they indicate the production trend.

Both the bar and curve charts show the past data. They are not readily adaptable to current or future action.

3. The Gantt Chart was developed by Henry L. Gantt. It is frequently used to keep track of multiple machine schedules. Gantt chart is actually a modified bar chart, wherein load is marked against a time scale with one horizontal bar or line allocated to each machine. A Gantt chart displays the following.
1. Plans for future.
2. Progress on present operations
3. Past achievements till date,
4. Relationship among several variables
5. It focuses attention on situations threatening delays
6. It tells whether a plan has fallen short and if the delivery dates can be met, and
7. A cursor attracted to the Gantt chart (See fig. 7.30) can be moved across the chart to know the work progress till any particular day.

4B. 26 FOLLOW UP OR EXPEDITING

The manufacturing activity of a factory is said to be in control when the actual performance is as per the planned performance. Follow up or expediting regulates the progress of materials and the components through the production process. Follow up serves as a catalytic agent to fuse the various separate and unrelated production activities into the unified whole that means progress. Follow up is concerned with the reporting of production date and the investigating of any deviation from the predetermined production (or time) schedules. Follow up ensures that the promise (i.e. of delivery dates) is backed up by performance.

The work within the organisation can be expedited by the following two principles:

(i) the exception principle, and

(ii) the fathering principle

in exception principle, the scheduling group (on the basis of progress reports), explores the jobs behind the schedule. The expediting group takes up such jobs, procures necessary materials, tools, etc. i.e., (expediting group) solves all problems related to these jobs and intimates the scheduling group to reschedule them.

According to fathering principle each expeditor is made responsible for a job or a group of jobs for which he arranges the tools, materials, equipment, etc. Such a system works very well for controlling large projects.

4B. 27 LINE BALANCING

The assembly line should be balanced. Each work station should have the same operation time and the various operations should be sequenced properly. There should be perfect balance between the output rates of the parts and the subassemblies. However, it is not always possible that the parts reach in a steady stream immediately before subassembly. This may be because of the limitations as regards materials, men and equipments or it may be economical to manufacture and supply parts in batches. The flow control section has to cope with such situations and thus carry big inventories and arrange facilities for storage.

4B. 28 ROUTING AND SCHEDULING

A combination route and schedule chart showing the fabrication of parts subassemblies and final assembly in proper sequence, upon a time scale proves to be very advantageous, especially, when there is smooth flow of work.

4B. 29 LINE OF BALANCE (LOB)

- LOB is a manual planning and scheduling technique similar in nature to MRP (material resource planning)
This method was developed by the U.S. Navy during World War II. It is most appropriate for assembly operations involving a number of distinct components. In essence, it employs the principle of management – by – exception through a comparison of progress of individual components with the time schedule for completed assemblies. Regular progress checks reveal the future effect of any current delays and indicate the degree of urgency for corrective action.

It complements Gantt technique in determining production status. While the Gantt chart/technique primarily relates information on the effective and efficient utilization of resources (e.g., machine loading, man loading), LOB is more product – oriented.

LOB is not directly concerned with the resources expended but is utilized in determining production progress in terms of per cent of task completion. Major bottlenecks in the production process are emphasized.

LOB technique can be regarded as a slightly more sophisticated form of the Gantt chart, the objective being to study the progress of jobs at regular intervals, to compare progress on each operation with the progress necessary to satisfy the eventual delivery requirements, and to identify those operations in which progress is unsatisfactory.

LOB technique is an example of management-by-exception since it deals only with the important or crucial (exceptional) operations in a job, establishes a schedule (or plan) for them and attracts attention to those which do not conform to this schedule. It is particularly useful where large batches of fairly complex items, requiring many operations, are to be completed / delivered over a period of time.

4B. 30 LOB TECHNIQUE

LOB technique consists of five main stages, all utilizing graphic aids:

1. A graphical representations of the delivery objective.
2. A chat of the production program showing the sequence and duration of all activities required to produce a product.
3. A progress chart of the current status of component completion.
4. A line-of-balance drawn to show the relationship of component progress to the output needed to meet the delivery schedule.
5. Analysis of progress

FIGURE: 4.5 ‘LOB’ DIAGRAM

The objective chart shows the expected schedule of products (i.e. scheduled deliveries) and the actual completion rate (i.e. actual deliveries made by a date)
A dip in actual deliveries line below the scheduled deliveries line is an obvious cause for alarm.

(2) Program Plan

- A chart of the operations required to complete one unit of the finished product is called the program plan.
- Each major row of activities is associated with one component of the final assembly.
- The final completion date is zero and the time scale runs from right left.
- The completed chart serves as a reference to the amount of lead time by which each event must precede final completion. Events must be completed by their respective lead times to maintain anticipated output.
- Objective chart and Program plan are prerequisites for use of the LOB technique. They need to be constructed only once for any job, unlike the following documents which must be constructed each time the schedule and progress is examined.

(3) Progress Chart

![Figure: 4.6 'LOB’ – CUMULATIVE DELIVERY AND PROGRESS CHART](todaylibrary.com)

Progress chart shows the number of items which have been finished at each of the critical or important operations at a given date.

The results can then be depicted by means of a histogram.

(4) Line of Balance

Since the object of the exercise is to compare actual progress with scheduled progress, the information given in progress chart must be compared to required progress. This is done by constructing a line on the progress chart which shows the requisite number of items which should have been finished at each operations at the time of review.

This line-the Line-of-Balance-can be constructed analytically or graphically, the latter method being perhaps the more convenient. The L.O.B., shows the total number of items which should have been finished at each operation.

(5) Analysis of Progress

In comparing required progress with actual progress it is again convenient to work backwards, beginning with the last operation.

If shortage occurs, we must obviously attempt to ascertain the reasons. If operations other than those considered as critical are the cause of shortages, then those operations must be included in subsequent versions of the progress and line-of-balance chart.
4B. 31 ADVANTAGES

The L.O.B. is a simple and useful planning and control technique, its main advantages being:

- Like network analysis, it formalizes and enforces a planning discipline
- Which itself is useful
- It is a simple but powerful procedure, which relies on several assumptions.
UNIT – 5

5A. MATERIALS MANAGEMENT

4A. 1 INTRODUCTION

Materials, as we know, means the raw materials used in the manufacturing process to be transformed into finished product. It is a well-known fact that no production work is possible without materials. Also it has been estimated that most of the manufacturing concerns spend more than 60% of the money raw materials. In other words, materials constitute a major portion of the money we invest in production. In this connections, it should be noted that there are so many problems attached with the management of materials such as investment in materials, storage and obsolescence problems, under utilization and ideal capacity of funds, which require immediate attention of the management – that the cost of production may be reduced to the minimum a the quality of he product may be maintained.

5A. 2 DEFINITION

Materials management is the planning, directing, controlling and co-coordinating of all those activities concerned with materials and inventory requirements from the point of their inception to their introduction into the manufacturing process. It begins with determination of materials quality and ends with its issuance to productions in time to meet customers demand on schedule at the lowest cost.

P Gopalakrishnan and M. Sundaresan define management as “the function responsible for the coordination of planning, sourcing, purchasing, moving, storing and controlling materials in an optimum manner so as to provide a pre decide service to the customer at a minimum cost.”

Bethel and others define the term materials management “controlling me kind, amount, location, movement and timing of the various commodities used in and produced by the industrial enterprise.”

In general, materials management is a service function affecting the flow of materials in a manner in which it helps in conserving the materials cost, best utilization of materials and maintaining the quality of both incoming and outgoing materials. It covers all aspects pertaining to a) Materials cost, b) materials supply and c) Materials utilization.

Now, let us discuss the functions of materials management.

5A. 3 FUNCTIONS OF MATERIALS MANAGEMENT

Materials Management covers all aspects of materials and material supply which are very important for converting the raw materials and other inputs into the desired finished products. The various functions of the materials management are as follows:

a. Materials planning
b. Purchasing of Materials
c. Reducing store-keeping and warehousing
d. Inventory control
e. Standardization simplification and value Analysis
f. Transportation and material handling
g. Disposal of scrap surplus and obsolete materials

In the following paragraphs, let us discuss the importance of materials management.
5A. 4 IMPORTANCE OF MATERIAL MANAGEMENT

A survey conducted by the directorate of Industrials Statistics during 1954-57 showed that the average material cost is 64% of the sales value. In some industries, it costs up to 70%. These figures show the importance of materials management. Materials has its tentacles spread to all areas of production such as men, machines and marketing. The concept of materials management has been gaining importance very gradually now-a-days. In concerns, avoidance of wastage is very important for efficient utilization of materials. Materials management helps to avoid wastage to a greater extent. As emphasized earlier, materials management is a service function and is of very great importance to other sections like manufacturing, marketing, engineering and finance by way of providing assistance to these sections in their operations. Also, materials management is of very great help in efficient and judicious purchasing, minimizing wastages in handling, storing and transporting the materials and the utilization of materials very efficiently. It is worth mentioning here that the materials management contributes to the success or failure of a concern. Form the national point of view, materials management plays a pivotal role, for the success of national plans, because efficient materials management can exploit the national resources, materials efficiency and according to the plans. In addition to reducing material costs, efficient materials management is useful for the following purposes. A) for reducing foreign exchange by utilizing the imported items, to their maximum value and thus helps in reducing the imports b) by reducing the cost of finished goods, and maintaining the quality, it is possible for Indian manufacturing to compete better in foreign market and earn more foreign exchange.

5A. 5 OBJECTIVES OF MATERIALS MANAGEMENT

The main objectives of materials management are as follows

(i) The first and foremost objective of materials management, as discussed earlier, is to minimize the materials cost thus paying the way for reducing the cost of the product manufactured. The company is able to maintain the price at a reasonable level.

(ii) It also aims at procuring and providing materials of desired quality when enquired, at the lowest possible overall cost of the concern.

(iii) It also aims at reducing investment tied-up in inventories for use in other productive purposes and to develop high inventory turn-over ratios.

(iv) The next objective of materials management is to purchase, receive, transport and store materials efficiently and to reduce the related costs.

(v) Continuous supply of materials is an essential pre-requisite for uninterrupted production. materials management aims at finding our new sources of supply and to develop cordial elations with the suppliers.

(vi) The next objective of the materials management is to cut down costs through simplification, standardization, value Analysis, and import substitution etc.

(vii) Materials management aims at minimizing procedural delays in procuring materials.

In nutshell, various important objects of materials management can be summed up as follows:

1. To reduce material cost
2. For the efficient control of inventories which helps in releasing the working capital for productive purposes.
3. To ensure uniform flow of materials for production.
4. To ensure right quality of products at right place.
5. To establish and maintain cordial relation-ship with customer
6. To ensure economy in using the important items and to find their substitutes.
7. To increase the profit of the concern
8. To contribute towards competitiveness and
9. To report changes in market conditions and other factors affecting the concern, to the customers.

5A. 6 INTEGRATED MATERIALS MANAGEMENT

Management of Materials is one of the most important functions of a business organization. Its importance may vary from one industry to another but it is most important for a manufacturing organization as it is directly linked with profitability. The successful management of materials largely depends upon a) adequate availability of funds b) proper procurement, storage and utilization of materials c) effective handling, dispatch and disposal of incoming and outgoing material. In this connection, it should be noted here that material management is not an individual or isolated function in an organization. It is a combination of inter-related functions. It is a management function having close links with all other fields of a business enterprise. It has links with various aspects connected with materials such as purchasing, storage, inventory control, materials handling, standardization, etc. Also, it covers a very wide field and deals with the planning and programming of material and equipment, market research for purchase, procurement of material, packaging, storage and inventory control, transportation of materials, etc. To cite an example, purchase of material should be done according to production schedule with in turn should be determined on the basis of the marketing capabilities. If we want to change the design or appearance of the product, the help of Design, Technical and Marketing departments are very vital. Decrease and increase in the volume of production affects the financial position and ultimately affects all other activities of the concern.

To be precise, Materials management may be said to be an activity integrated and coordinated with such widely dispersed functions of management as Budgeting, Purchasing, Receiving, Production, Scheduling, manufacturing maintenance, Inventory and Material Quality control as also, Storage, warehousing, shipping, traffic and it begins working from the very inception stage of procurement of materials and then getting the materials through successive stages of operations for the final embodiment into an end product and distribution.

Every organization, or productions unit aims at a) decreasing the cost b) increasing the profitability and c) improved productivity. If any organization want to attain the above three objectives, we can easily conclude that coordination and integration of all the activities become essential. Also, in order to get the desired results, i.e. maximization of profits and minimizing the cost, the effective integrating of all the inter-related segments are very essential. In this context, integrated materials management is a function which integrates all the above said activities to financing storing and distributions for the efficient and smooth functioning of an undertaking.

Let us now highlight the aims of Integrated Materials Management.

5A. 7 AIMS OF INTEGRATED MATERIALS MANAGEMENT

An efficient and well-planned materials management programme serves the following aims:

a. COST REDUCTION

To bring down the prices of any products, the management, as far as possible, should try to exercise care and diligence in purchase and issue of materials. Efficient purchase of materials would result in reduction of costs.

b. ELIMINATION OF WASTE

Elimination of waste is a very essential phenomenon that a company should adopt to ensure better functioning of an enterprise. Wastages in receipt, issue, storage and movement of materials should be avoided. Laborers and employees are entrusted with these jobs should be trained well to exercise due care while at work.
C. COMPLETION OF WORK AS PER THE PRODUCTION SCHEDULE

Efficient Integrated Materials Management aims at completing the production job according to the predetermined programme. Dislocation of production schedules lead to unnecessary delay, expenses and waste of time. IMM integrates and aims at sticking on to the predetermined production schedule. IMM programme controls production at every step and stage of production.

5A. 8 ADVANTAGES OF INTEGRATED MATERIALS MANAGEMENT

A well coordinates IMM results in the following advantages both to the department and concern in general.

ADVANTAGE OF THE DEPARTMENT

1. Better Inventory Planning:

A well programmed IMM is a boon to Inventory Planning. Without much loss of time Materials department is in a position to know the quantum of existing materials stock. Also, it is easy to find out the future requirements of materials, stock to be kept in reserve etc.

2. Faster Inventory Turnover:

Both overstocking and/or understocking of materials is a dangerous phenomenon in an organisation. Not only, will it affect the smooth flow of material movement and continuous productions, but it will lock the capital without any better use which otherwise could have been used for a better purpose. Efficient Integrated Materials management helps to invest in an optimum manner on it. Faster inventory turnover brings about faster movement any cycling of funds in the organisation.

3. Material availability:

As IMM functions in a phased and programmed manner, production goes on without any interruption. This is achieved through availability of materials as and when required.

4. Efficient coordination:

IMM helps in the integration and coordination of all the departments.

5. Better communication:

Communication means exchange of facts, ideas, opinions and messages among persons. Communications has a very distinct place in IMM as it decides the success or failure of it. Thus IMM improves the communications system in the organisation.

6. Improved productivity and Increased profitability:

Productivity which is one of the ultimate results of the IMM, is achieved in a shorter period. Cost reduction. Elimination of wastes and productivity indirectly lead the concern to earn a higher profit.

ADVANTAGES TO THE ORGANISATION

Apart from the above advantages to the departments, IMM ensures the following advantages to the organisation:

1. Centralized authority and responsibility

IMM helps in centralizing the functions and duties pertaining to materials. A centralized organization always offers better accountability and responsibility. Under centralized system duties and responsibilities are clearly spelt out and works evenly distributed. This helps in detecting the errors and deficiencies of individual employees and workers.
2. Well coordinated efforts:

Under IMM, a well planned policy is installed. This ensures good support and cooperation from all who are working with him. Outside people dealing with the concern also extend their hearty co for the smooth conduct of the organisation.

3. Materials Manager benefited:

The material manager enjoys so many advantages after the installation of IMM. A well planned IMM helps him to predict the ales in a better way. It is also very helpful for him to check out the production plan efficiently. Material, requirements could easily be identified with the help of IMM. Various inventory levels such as Minimum Level, Maximum Level, Reorder Level and Economic Order Quantity can be easily fixed with the help of IMM. Better purchasing, efficient physical control of materials are some of the direct outcome of a well-coordinated IMM.

4. Performance Evaluation:

A well installed IMM helps to evaluate the performance of personnel attached to materials department. The performance should be easily evaluated if the organisation is able to achieve the following. They are reduced lead time, reduced storage and reservation cost, better communication judicious and speedy solutions to problems pertaining to materials department.

5A. 9 RESOURCE REQUIREMENTS

Aggregate capacity plans develop strategies for employment levels (man power) machinery and utility, sub-contract and purchase and facility modification. The planning horizon for aggregate capacity plans usually very from six to eighteen months and short range master production schedules (MPB) are developed within the capacity constraints stipulated by aggregate plans. The time horizon for short range master production schedules vary from a few weeks to several months and indicate the finished products or end items to be manufactured. The entire resource requirements planning system is based on the master production schedules.

5A. 10 RESOURCE REQUIREMENTS PLANNING

Resource requirement planning is directed at the determination of the amount and timing of production resources such as personnel, materials, cash and production capacity needed to produce the finished products or end items as per the master production schedule.

Resource requirements planning is also known as rough-cut capacity planning. It can be used to evaluate the feasibility of a trial master production schedule. It is an aggregate planning tool that is used to sum up and evaluate the workload that a production plan (MPS) imposes either on all work centres or on only selected key work centres where resources are limited, expensive or difficult to obtain from outside sources (sub-contractors). This step ensures that a proposed MPS does not overload any key work centres or departments or machines thus making the MPS unworkable. Rough-cut capacity planning is usually applied to the critical work centres which are most likely to be bottlenecks.

Steps involved in rough-cut capacity planning are:

1. Developing a trial production plan (or trial master production schedule) that indicates the company’s products that are planned for production during each week or month of the planning horizon.

2. Computing the work load that this production plan will impose on each key work centre and key sub-contractors for each period (week or month) of the planning horizon. The load profile i.e., the load on each work centre over time, is evaluated for feasibility, by comparing the load with the available capacity in each of the key work centres or key sub-contractors.
3. If the trial production plan does not appear to be feasible or does not make optimal use of the resources in the key work centres, the plan may be revised.

4. The capacity requirements of the revised production plan (revised MPS) can then be evaluated to determine the feasibility of the plan.

5. Step No. 4 and 5 are repeated until a plan considered to be satisfactory is developed.

There are two main elements of resource requirements planning systems namely

(a) Material requirements planning (MRP)

(b) Capacity requirements planning (CRP)

5A. 11 MATERIAL REQUIREMENTS PLANNING (MRP OR MRP-1)

For a manufacturing company to produce end items to meet demands, the availability of sufficient production capacity must be co-ordinate with the availability of all raw materials and purchased items from which, the end items are to be produced. In other words, there is a need to manage the availability of dependent demand items from which the products are made. Dependent-demand items are the components i.e. materials or purchased items, fabricated parts or sub-assemblies that make up the end product.

One approach to manage the availability of dependent-demand items is to keep a high stock of all the items that might be needed to produce the end items and when the on-hand stock dropped below a present re-order level, the items are produced or bought as the case may be to replenish the stock to the maximum level. However, this approach is costly due to the excessive inventory of components, fabricated parts and sub-assemblies to ensure high service level (i.e. availability of dependent demand items at a short notice)

An alternative approach to managing dependent-demand items is to plan for procurement or manufacture of the specific components that will be required to produce the required quantities of end products as per the production schedule indicated by the master production schedule (MPS). The technique is known as material requirements planning (MRP) technique.

MRP is a computer-based system in which the given MPS is exploded into the required amounts of raw materials, parts and sub-assemblies, needed to produce the end items in each time period (week or month) of the planning horizon. The gross requirement of these materials is reduced to net requirements by taking into account the materials that are in inventory or on order.

A schedule of orders is developed for purchased materials and in-house manufactured items over the planning horizon based on the knowledge of lead items for procurements or in-house production.

5A. 12 OBJECTIVES OF MRP

The objectives of material requirements planning in operations management are:

1. To improve customer service by meeting delivery schedules promised and shortening delivery lead times.

2. To reduce inventory costs by reducing, inventory levels.

3. To improve plant operating efficiency by better use of productive resources.

Three facts of MRP technique are:

a) The MRP technique as a requirements calculator

b) MRP – A manufacturing, planning and control system

c) MRP – A manufacturing resourced planning system.
The MRP technique as a requirements calculator was originally used as an inventory control tool, providing reports that specify how many components should be ordered, when they should be ordered and when they should be procured or produced in-house. Since MRP is a computer-based system, it was possible to expand the system into a manufacturing planning and control system by providing information for planning and controlling both the material and the capacity required to manufacture the products. Hence, MRP serves as a key component in an information system for planning and controlling production operations and procurement of materials. It is the basic foundation for production activity control or shop floor control, for vendor follow-up systems and for detailed capacity requirements planning. When both the MRP and CRP are integrated within one system, the system is known as “Materials Requirements Planning”, abbreviated as “MRP” or MRP-1. When MRP is extended to include feedback from and control of vendor orders and production operations, it is called ‘closed-loop MRP’ which helps managers achieve effective manufacturing control.

When the capabilities of closed-loop MRP are extended to integrate financial, accounting, personnel, engineering and marketing information along with the production planning and control activities of the basic MRP system, the resulting broad-based resource-coordination system is known as manufacturing resource planning or MRP-II. MRP-II is the heart of corporate management information system for many companies, as it provides information about inventory investment levels, plant expansion needs, and work-force requirements that is useful for coordinating, financial, engineering and manufacturing efforts to achieve the company’s overall business plans.

The projections of what materials and components will be purchased and when, can be used to develop purchase commitments and a projected purchasing budget. The labour hours projected in the capacity requirement plant for each work centre, can be aggregated to develop personnel needs and labour budgets. The projected on-hand inventory of material can be used to develop inventory budgets.

5A. 13 GENERAL OVERVIEW OF MRP

Basically, MRP consists of a set of computer programs that are run periodically (once a week or once a month) to incorporate the latest schedule of production requirements MRP performs three important functions viz.

- Order planning and control, i.e. when to release orders and for what quantity?
- Priority planning and control i.e., comparison of expected date of availability with the need date of each item.
- Provision of a basis for planning capacity requirements and development of broad business plans.

MRP is applicable primarily to companies that carry out the fabrication of parts and assembly of standard products in batch quantities.

The entire MRP system is driven by the MRP. The bill of materials file and inventory status file are fed in to the MRP computer program to generate the output.

5A. 14 MRP SYSTEM INPUTS
FIGURE: 5.1 'MRP' STRUCTURE

1. MASTER PRODUCTION SCHEDULE (MPS)

The MPS specifies what end products are to be produced and when. The planning horizon should be long enough to cover the cumulative lead times of all components that must be purchased or manufactured to meet the end product requirements.

2. BILL OF MATERIAL FILE (BOM) OR PRODUCT STRUCTURE FILE

This file provides the information regarding all the materials, parts and sub-assemblies that go into the end product. The Bill of Materials can be viewed as having a series of levels, each of which represents a stage in the manufacture of the end product. The highest level (or zero level) of the BOM represents the final assembly or end product. The BOM file identifies each component by a unique part number and facilities processing the end product requirements into component requirements.

3. INVENTORY STATUS FILE

The inventory status file gives complete and up-to-date information on the on-hand quantities, gross requirements, scheduled receipts and planned order releases for the item. It also includes other information such as lot sizes, lead times, safety stock levels and scrap allowances, etc. The gross requirements are total needs from all resources whereas the net requirements are 'net' after allowing for available inventory and scheduled receipt. Scheduled receipts are quantities already on order from a vendor or in house shop. Planned receipts are quantities that will be ordered on a vendor or in-house shop. Planned order release indicates the quantities and date to initiate the purchase or manufacture of materials that will be received on schedule after the lead time offset.

5A. 15 MRP SYSTEM OUTPUT

Two primary outputs are:

1. Planned order schedule which is a plan of the quantity of each material to be ordered in each time period. The order may be a purchase order on the suppliers or production orders for parts and sub-assemblies on production departments.

2. Changes in planned orders – i.e., modification of previous planned orders. The secondary output are:

   1. Exception reports which list items requiring management attention to control
   2. Performance reports regarding how well the system is operating – e.g. inventory turnovers, percentage of delivery promises kept and stock out incidences.
   3. Planning reports such as inventory forecasts, purchase commitment reports, etc.

5A. 16 DEFINITIONS OF TERMS USED IN MRP SYSTEM

1. MASTER PRODUCTION SCHEDULE (MRP): This is the schedule of the quantity and timing of all end products to be produced over a specific planning horizon. MPS is developed from customer’s firm orders or from forecasts of demand or both. It is an input to the MRP system.

2. PRODUCT STRUCTURE: Indicates the level of components required to produce an end product.

3. BILLS OF MATERIAL: A list indicating the quantities of all raw materials, parts, components, sub-assemblies and major assemblies that go into an end product. It gives details of the build up of a product. It may also be called as indented parts list.
4. **BILLS OF MATERIAL FILE**: A bills of material file, also known as product-structure file, is a computerized file listing all finished products, the quantity of raw materials, parts sub-assemblies and assemblies in each product. The bills of materials file must be kept up-to-date as and when the products are redesigned or modified with addition/deletion of some parts, components and sub-assemblies.

5. **INVENTORY STATUS FILE**: It is a computerized file with a comprehensive record of each and every material held in inventory. The information included in this file are, materials on hand or on order, planned orders, planned order releases, allocated materials, lot sizes, lead times, safety stock levels, costs and suppliers for each material. The inventory file must kept up-to-date taking into consideration the daily inventory transactions such as receipts, issues, scrapped materials, planned orders and order releases.

6. **MRP COMPUTER PROGRAM**: It is a computer program, which processes the MRP information. Its inputs are the MPS, inventory status file and bills of materials file. The primary outputs are: planned order schedule, planned order releases and changes to planned orders.

7. **AVAILABLE INVENTORY**: Materials that are held in inventory of which are on order, but are not either safety stock or allocated to other uses.

8. **ALLOCATED INVENTORY**: Materials that are held in inventory or on order but which have been allocated to specific production orders.

9. **ON-HAND INVENTORY**: The quantity of a material, physically held in inventory at a point of time. It may include safety stock and allocated inventory except materials on order.

10. **PLANNING HORIZON**: The number of time periods (days, weeks or months) included in the MPS, CRP, MRP and departmental schedules.

11. **ACTION BUCKET**: The unit of time measurement in MRP systems. It is a particular period of time in the planning horizon. For example, Bucket # 10 means the tenth period (usually a week in duration) of the planning horizon.

12. **GROSS REQUIREMENTS**: The total quantity of an item at the end of a period to meet the planned output levels, not considering any availability of the item in inventory or scheduled receipts.

13. **SCHEDULED RECEIPTS**: The quantity of an item that will be received at the beginning of a time period from a supplier as a result of orders already placed (open orders).

14. **PLANNED ORDER RECEIPTS**: The quantity of an item that is planned to be ordered so that, it will be received at the beginning of the time period to meet the net requirements for that time period. The order is yet to be placed.

15. **PLANNED ORDER RELEASES**: The quantity of an item that is planned to be ordered and the planned time period for releasing this order, so that, the item will be received when needed. This time schedule is determined by off-setting the planned order receipts schedule to allow for lead times. When this other is released, it becomes a schedule receipt.

16. **NET REQUIREMENTS**: The quantity of an item that must be procured to meet the scheduled output for the period.

17. **LOW-LEVEL CODING**: It is the coding of each material at the lowest level in any product structure that it appears. A component can appear at more than one level in the product structure. Because MRP computer programs process net requirements calculations for all products, level by level from end items, down to the raw materials, low level coding avoids redundant net requirements calculations.
18. LOT-SIZING DECISIONS: Whenever there is a need for the net requirement of a material, a decision must be taken regarding the quantity of material to be ordered (either purchase order or production order). Lot-sizing decisions include both the batch or lot-size (quantity) as well as the timing of these lots.

19. DEPENDENT DEMAND: Demand for raw material, part or a component, that is dependent on the demand for the end product in which these materials are used.

20. INDEPENDENT DEMAND: Demand for a materials that is independent of the demands for other materials. For example, demand for end products re independent of demand for parts, raw materials or components as their demands are determined, by customers outside the organizations.

21. LUMPY DEMAND: If the demand for the materials varies greatly from time period to time period (say week to week), the demand is said to be ‘lumpy demand’.

22. CAPACITY REQUIREMENT PLANNING: The process of reconciling the Master Production Schedule to the available capacities of production departments (viz., machine and labour capacities) over the planning horizon.

23. PLANNED ORDER RELEASES: Number in ‘planned order releases’ row indicate when orders should be placed to meet the requirement for the item. The time period at which the order should be released is found by subtracting the lead time from the ‘net requirement’ period (this procedure is called ‘offsetting’ by lead time).

5A. 17 ISSUES IN MRP

Some of the issues which deserve consideration in any comprehensive treatment of MRP are:

1. Lot-sizing
2. Safety stock
3. Scrap allowances
4. Pegging
5. Cycle counting
6. Updating
7. Time fence

The above issues are discussed below:

1. LOT-SIZING: The MRP system generates planned order releases, which trigger purchaser order for outside suppliers or production orders (or work orders) for in-house production departments. As certain costs such as the set-up cost (or ordering cost) and holding cost (or inventory carrying cost) are associated with each order, it is necessary to consider the trade off between these two types of costs and take decision regarding how much to order (i.e., batch size/lot-size). A question that should be examined is whether there is some economic lot-size (EOQ or EBQ) that should be purchased or produced as the case may be. In production, a minimum lot-size is sometimes established to reduce the set-up cost per unit produced. Such minimum lot-sizes may cause excessive inventory, if it exceeds very much the net requirement of a period and followed by periods with no requirements, which is counter to the benefit of the MRP system.

VARIOUS METHODS OF LOT –SIZING ARE:

(a) Lot-for-lot ordering (LFL) in which quantity equal the net requirement for a given period. Separate orders are released for each period’s net requirement.
(b) EOQ technique in which the order quantity is larger than a single period’s net requirement so that, ordering cost and holding costs balance out.

(c) Requirements may be batched until they reach some arbitrary minimum order size. If the requirement exceeds this minimum, the requirement will determine the order size.

(d) The lot size may be determined by the period order quantity (POQ) technique. The ordering policy is to order the net requirements of the number of periods equal to the EOQ.

(e) The lot size can be chosen to approximately balance ordering and holding costs. One method of doing this is known as part-period method or part-period algorithm (PPA). This is a simple approach to the lot-size selection when a series of requirements which are not necessary uniform, are to be batched into orders so that the total cost will be near the minimum. This method does not provide an optimal lot-size (i.e., EOQ) but it approaches optimality by attempting to make holding cost for a lot, nearly equal to the ordering cost for the lot.

Unlike the EOQ model, the part algorithm method may select a different quantity to be ordered each time the order is to be placed. The PPA assumes that an order will be scheduled in the first period in which, there is a net requirement. The requirement for the next period is added into this order, if the cost of holding these units until they are used, is less than the cost of receiving them as a separate order. Requirements for future periods continue to be added to the lot until the total holding cost for the incomes a close as possible to the order cost without dividing a period's requirement.

2. SAFETY STOCK: There are divergent views by MRP users regarding whether safety stock should be used MRP systems or not. One side of argument supporting the use of safety stock is that, it performs the function of avoided excessive stock-outs caused by uncertain lead times and daily demands. On the other hand, those who oppose the use of safety stocks in MRP, argue that, safety stock is not required because MRP systems adapt to changing conditions that affect demand and lead times.

The use of safety stock can be justified only by the sources of uncertainty, present during lead times. Safety stock is normally maintained for end items which have independent demand. For lower-level items such as raw material and parts, the uncertainty of demand is adequately controlled, because the demand is a dependent demand which is set by the MPS. However, uncertainties may be present during lead times because of uncertainty of the lead time and the uncertainty of demand that occurs because of changes in the MPS. Keeping some safety stock can be justified for raw materials, parts and other low-level items, although at significantly reduced levels.

3. SCRAP ALLOWANCES : The bill of materials explosion could include multiplication by a factor (more than one) to make an allowance for the usual scrap loss in manufacturing an item.

4. PEGGING: Pegging is a technique which enables the planner to trace from a work load in a work centre, back through its higher-level assemblies to determine, what end item in the MPS caused the load. Single level pegging is used often, which simply tells the immediately higher-level parent of a component. When materials plans are disrupted, pegging helps to identify which components are affected by such disruption. Pegging shows the level-by-level linkages among components and their time-phased status in MRP records. Pegging showing the current records for an end item ‘X’ and for its sub components Y and Z at two lower level in the product structure.

Similarly, if the master production schedule were to increase week 7’s gross requirements for X from 20 to 60 to meet a special customer order, the pegging procedure traces down through the MRP records to identify associated changes at lower levels. The planned order release of X in week 6 has to be raised from 40 to 60 and the associated requirements for Y and Z, has to be changed accordingly.
5. CYCLE COUNTING: Cycle counting is the process of counting on-hand inventories at regular intervals to verify inventory of components including defective items at each stage of production and in storage areas. This ensures that on-hand inventories tally with the quantities shown in the MRP records. Based on cycle counting, the MRP records are updated daily or weekly to show the actual inventory status. This knowledge of actual inventory is helpful in adjusting the production schedules at various work centres.

6. UPDATING: Whenever changes occur in MPS, in inventory status file, (e.g., revised lead times) or in product structure file, or changes in product design occurs, the MRP system must be updated. Two approaches to update MRP system are

   (a) Regenerative method which is a process used to update the MRP at regular intervals by reprocessing the entire set of information and regenerating the entire MRP.

   (b) Net change method in which only those portions of the previous MRP directly impacted by informational changes are reprocessed. Transactions are entered into a net change MRP program frequently to reflect conditions as they change.

7. TIME PERIOD: It is a length of time that must elapse without changing the MPS to stabilize the MRP system. The MPS may be changed only after this time period. The time fence is the shortest lead time form raw material to finished production for an end item. Within the time fence, the MPS becomes frozen and the planned order releases become firm planned orders.

5A. 18 Potential benefits from ‘MRP’

MRP is not just a way of calculating how much material to order and when; but it is a new way of managing manufacturing operations. MRP is a decision support system or managerial information system, which provides timely and valuable information to operations managers.

When properly developed and implement, MRP can provide the following benefits to the firm:

(1) INVENTORY: The information provided by the MRP system is useful to better coordinate orders for components with production plans for parent items. This results in reduced levels of average inventory for dependent-demand items (i.e., raw materials and work-in-process).

(2) PRODUCTION: Information from MRP facilitates better utilization of human and capital resources. Because of more accurate priority information from MRP, it is possible to improve delivery performance. It can also improve flow of work, thereby reducing intermittent delays and reducing the manufacturing cycle time for the jobs.

3. SALES: MRP helps to check in advance whether the desired delivery dates are achievable. It improves the company’s ability to react to change in customer orders, improves customer service by helping production, meet assembly dates and helps cut delivery lead times.

4. ENGINEERING: MRP helps in planning the time of design releases and design changes.

5. PLANNING: MRP can simulate changes in the MPS for the purpose of evaluations of alternative MPS. It facilitates the projection of equipment and facility requirements, workforce planning and procurement expenses for a proposed MPS.

6. PURCHASING: MRP helps the purchase departments by making known the real priorities and recommending changes in due dates for orders so that the purchase staff may expedite or delay the orders placed on vendors. Because of this, the vendor relations can be improved.

7. SCHEDULING: Better scheduling can result from MRP through better knowledge of priorities.

8. FINANCE: MRP can help better planning of cash flow requirements. It can identify time capacity constraints or bottleneck work centres, there by helping operations managers to make better capital investment decisions.
5A. 19 IMPLEMENTATION OF MRP

Successful implementation of MRP depends on the following factors:

1. MANAGEMENT COMMITMENT: Top level managers and other managers in all parts of the organization that will be affected by MRP must be aware of the efforts needed to achieve the new way of managing other activities.

2. USER INVOLVEMENT: A team consisting of people from all those parts of the company that will use the MRP system, will be responsible for the development and implementation of the MRP. This will ensure that the participation of users of the system in its development will make them more familiar with the system and its use.

3. EDUCATION AND TRAINING: All the people who work with the MRP system must understand it and must know how to use it. They must know what information to provide and how to provide it, what information to ask and how to obtain it. Hence, it is necessary that all people connected with the MRP system must be trained in its application and use.

4. SELECTION OF PACKAGES: the potential user must be able to decide about the use of the net change or regenerative MRP package, knowing their advantages and disadvantages. Also the user must decide whether to develop his own programs for MRP system or to purchase and adapt the available package.

5. DATA ACCURACY: After a MRP system is installed, careful attention and discipline must always be exercised to ensure that all data used by the system are accurate. Managers must exert effort to see that accurate and timely data are supplied to the system.

6. RELEASING MPS: The MPS developed should be realistic and achievable. The MPS should not overload the plant capacity. The company must develop MPS that effectively uses its capacity without causing bottlenecks or overloads.

5A. 20 Problems in using MRP

1. MPS: Preparations of MPS, which is realistic in the midst of uncertainties in market environment and non-availability of adequate lead time form customers for delivery of end products. Frequent changes in MPS aggravate the problem.

2. MAINTAINING ACCURATE BOM FILES: Changes incorporated in BOM by the design department should be communicated to all users of BOM.

3. INCORRECT STOCK (INVENTORY) STATUS: A major problem is to know the correct status of all materials at all stages. Incorrect stock status results in an erroneous net requirement of materials.

4. UNREALISTIC LEAD TIMES: Most crucial step in the MRP system which minimizes inventory is the time-phasing of requirements and release of orders; advancing by the lead time required, so that, materials arrive just when required.

5A. 21 PROBLEMS IN DESIGNING THE MRP SYSTEM

- Inadequacies of software chosen
- Deficient system design
- Improper and untimely information flow among various related departments.

5A. 22 SOLUTION TO MRP DESIGN PROBLEMS

Solution to overcome the above problems in the design of MRP system are:

1. Careful choice of software package to suit organization’s specific needs.
2. Careful planning of activities and scheduling
3. Assigning work to competent man-power.
4. Continuous monitoring of progress against schedule.
5. Substantial education and training at all levels.
6. Involvement of users at the systems design stage itself.
7. Maximum attention at the stage of creating the database.

5A. 23 PROBLEMS IN MANAGING THE MRP SYSTEM:

1. Need for formal systems and role of systems
2. Need for proper organization of function viz., production planning and control, materials, production, quality, engineering
3. Importance of proper appreciation of planning and control systems production and Operations Management
4. Timeliness of generating information required in managing the plant
5. Effective communication system
6. Proper motivation of people concerned with the implementation of the system
7. Right leadership

5A. 24 EVALUATION OF MRP

The advantages of the MRP system over conventional inventory-planning approaches viz., fixed order quantity system (Q system) and fixed order-point system (P system) are:

- Improved customer services,
- Reduced inventory level and
- Improved operating efficiencies of production departments.

However, MRP systems cannot be used in all the production systems. Conventionally, MRP is applied only to manufacturing systems which process discrete products for which BOM can be generated. MRP is seldom used in service systems viz., petroleum refineries, retailing systems, transportation firms and other non-manufacturing systems.

5A. 25 CHARACTERISTICS OF ‘MRP’ SYSTEM

The production systems suitable for MRP should have the following desirable.

CHARACTERISTICS:

1. An effective computer system.
2. Computerized BOM files and inventory status file for all end products and materials with the highest possible accuracy.
3. A production system that manufactures discrete products made up of raw materials, parts, sub-assemblies and major assemblies which are processed through several production steps or operations.
4. Production processes or operations requiring long processing times.
5. Short and reliable lead times for procurement of raw materials and components from vendors.
6. The time fence for the frozen MPS should be sufficient to procure materials without undue expediting effort.
7. Support and commitment of the top management.

MRP is more useful in process-focused systems that have long processing times and complex multi-stage production steps. It simplifies production and inventory planning in process-focused systems by its ability to offset planned order receipts to planned order releases to account for long lead times for in-house processed items or raw materials and components purchased from suppliers.

For MRP to be effective supplier lead times must be short and reliable and the MPS must be frozen before the start of actual production to the MPS. What is to be produce (i.e., the MPS) must be known with certainty and quantity and timing of receipts of raw materials and components must be dependable? MRP offers advantages in inventory planning when lot-sizes are small and demand is highly variable.

However, it should be remembered that MRP is not a panacea to solve all our inventory planning problems. Basically, MRP is a computerized information system for production and operations managers MRP will not be of much help when computer systems are ineffective, inventory status and BOM files are inaccurate and MPS are unrealistic. MRP is best applied when production systems are well managed and when a comprehensive production and inventory planning system is needed.

5A. 26 Manufacturing resource planning (MRP II)

Manufacturing Resource Planning (MRP II) has been developed by manufacturing managers to address the planning and controlling of a manufacturing process and all of its related support functions. It encompasses logically correct planning and control activities related to materials, capacity, finance, engineering, sales and marketing. MRP II is universally applicable to any manufacturing organization, regardless of its size, location, product or process.

MRP II is a management process for taking the business plan and breaking it down into specific, detailed tasks that people evaluate, agree upon and are held accountable for. It involves all departments viz., materials departments, engineering department that must maintain bill of materials, sales/marketing department that must keep sales plan up to date, purchasing and manufacturing departments that must meet due dates for bought-out items and in-house manufactured items respectively.

From MRP I to MRP II: Manufacturing resourced planning (MRP II) is a natural outgrowth of materials requirements planning (MRP I). Whereas, MRP I focuses upon priorities of materials, CRP is concerned with time. Both material and time requirement are integrated within the MRP system (i.e., MRP I). Beyond this, MRP II has been coined to ‘close the loop’ by integrating financial, accounting, personnel, engineering and marketing information along with the production planning and control activities of basic MRP systems. MRP II is the heart of the corporate management information system for many manufacturing firms.

5A. 27 Evolution of MRP II

The earlier resource requirement planning systems were quite simple and unsophisticated. The MRP technique was used for its most limited capability to determine what materials and components are needed, how many are needed and when they are needed and when they should be ordered so that, they are likely to be available when needed. In other words, MRP simply exploded the MPS into the required materials and was conceived as an inventory control tool or a requirements calculator. Later, the logic of MRP technique was extended to serve as the key component in an information system for planning and controlling production operation and purchasing. It was helpful to production and operations manage to determine the relative priorities of shop orders and purchase orders. As a manufacturing planning and control system, MRP laid the basic foundation for production activity control or shop-floor control.
Closed-Loop MRP: Later, during the 1970s, closing the loop in MRP systems was thought of by experts in manufacturing management. The term “closed-loop MRP” means ‘A system built around material requirement planning (MRP I) and also including additional planning functions such as master production scheduling and capacity requirement planning’. Once the planning phase is complete and plans have been accepted as realistic and attainable, execution functions such as shop-floor control function (viz., input-output measurement, detailed scheduling, dispatching, anticipated delay reports from shops and vendors, purchase follow-up and control etc.) same into the picture. The closed-loop MRP system implies that, not only the above elements included in the system, but also that there is feed back from the execution functions so that, planning can be kept valid at all times. Further to the closed – loop MRP systems, the MRP I was improved to manufacturing resource planning (MRP II).

Manufacturing resource planning is a broader resource co-ordination system. In this, the capabilities of closed-loop MRP are extended to provide information on financial resources, personnel and labour budgets. It provides a means of simulating to provide information on the use of various assured plans. Information about inventory investment levels, plant expansion needs and work force requirements is useful for coordinating marketing, finance, engineering and manufacturing efforts to achieve the overall business plan of the firm. MRP II is a direct outgrowth and extension of the closed – loop MRP.

5A. 28 INTEGRATED SYSTEM

MRP II is an integrated system for planning and control. In this process, a production plan is developed from a business plan to specify production levels for each months for each product line for the next one to five years. Once the production plan is accepted by all the functional departments, it becomes a commitment for all concerned i.e. the production department is expected to produce at he committed levels, the sales department to sell at these levels and the finance department to ensure adequate financial resources for these levels of production. Based on the production plan, the MPS specified the quantities of specific products to be produced every week. Rough-Cut capacity planning is done to determine whether the capacity available is roughly adequate to sustain the proposed MRP. The MPS is then used to generate material requirements and priority schedules for production. Then detailed capacity planning is done to determine whether the capacity is sufficient for producing specific components at each work centre, during the scheduled time periods. After a realistic capacity-feasible schedule is developed, the plan is executed. Purchase schedule and shop floor schedules are generated, based on which work centre loadings, shop floor control and vendor follow-up activities can be determined to ensure that the MPS is met.
5B. INVENTORY CONTROL

5B. 1 INVENTORY

Inventory is a detailed list of movable goods such as raw materials, work-in-progress, finished goods, spares tools, consumables, general supplies which are necessary to manufacture product and to maintain the plant and machinery in good working condition. The list includes the quantity and value of each and every item. Inventory is defined as an idle resource of any kind having an economic value since these resources are idle when kept in the stores.

5B. 2 TYPES OF INVENTORIES

The inventories most firms hold can be classified into one of the following types:

(i) Raw materials and purchased parts: These include, the raw materials directly used for production and the semi finished products – which are produced and supplied by another firm and sold as a raw materials by the firm under considerations.

(ii) In-process inventories (or) partially completed goods (or) goods in transit are the semi finished goods at various stages of the manufacturing cycle.

(iii) Finished goods inventories (manufacturing firms) or merchandise (retail stores) are the finished goods lying in the storage yards after the final inspection clearance and waiting dispatch.

(iv) Indirect inventories include lubricants, spares, tools, Consumables, component parts and general supplies needed for proper operation, repair and maintenance during the manufacturing cycle.

5B. 3 FUNCTIONS OF INVENTORY

Good inventory management is important to the successful operation of most organizations. Adequate inventory facilitates smooth production operations and help to assure customers for various goods and services offered by the company. On the other hand, carrying inventories ties up working capital on goods that are kept idle – not earning any return on investment. Hence the major problem of inventory management is to maintain adequate but not excessive levels of inventories. By holding the optimum inventory, the following functions can be realized.

(i) To meet the expected customer (immediate and seasonal) demands. A customer can be a person who walks in off the street to buy some cosmetics say, a tooth paste, and if a particular brand he/she is asking for is not available then they may switchover to some other brand. In this process, the company loses sale opportunity. In most cases, expected demand requirements are based on forecasts.

(ii) To smoothen production requirements and establish an efficient production flow, the organizations often build up inventories in anticipation of seasonal increase in demand, and take up the production to replenish the depleted inventory during the off-season periods.

(iii) To decouple internal operations: A buffer oil in-process inventory will be created at successive operations. If this is not created, a breakdown in any one operation will cause the entire system to come to a grinding halt.

(iv) Desired quantities are purchased to protect the firm against the effects of process changes and possible stock-outs. Delayed deliveries and unexpected increases in demand increase the risk of shortages. Delays can be due to weather conditions, supplier stock-outs, delivery of wrong and defective materials. The risk of shortage can often be reduced by holding stocks in excess.

(v) To take advantage of economic lot sizes in order to minimize frequent ordering costs, it is necessary to buy quantities that exceed the immediate usage requirements. This necessitates strong some or all of the purchased items for later use. Similarly, it is economical to produce items in batches which are generally in
large quantities. Here also, the excess finished goods must be stored for firm to buy and produce in economic lot sizes without having to try to match purchases or production with demand requirements in the short run.

(vi) To derive advantages against price increases: If the firm expects the prices of raw material or any other input material to go up due to price revision by the suppliers or due to changes of policy by the government, they procure these items in excess of their requirements. Similarly if they expect the demand (due to seasonality) or price of the firm’s finished good to go up, they produce the items in excess and stock them thereby increasing the firm’s profit.

(vii) Facilitate the production of different products using the same facilities: If two or more products can be manufactured using, the existing facilities of a firm, batch processing form of production may be adopted, thereby first produce on product in excess of the current demand and store it for future use. Then take up other product and adopt the same mode of production so that the firm will be able to produce more than one product and serve its clients in a better way.

5B. 4 REPLENISHMENT OF STOCK

A firm which is already in the process of manufacturing a particular product or products will have a certain type of inventories of required quality and in desired quantities. Adequate control has to be exercised on the stock. If the control becomes inadequate, it will result in either under stocking or overstocking of items. Under stocking results in missed deliveries, lost sales dissatisfied customers and production bottlenecks while overstocking unnecessarily ties up funds that might be used more productively elsewhere in the case of continuous process industry, under stocking will cease the production line.

Enormous effort and resources are required to re-start the production. in the case of overstocking, the major consideration has to be given to the cost of carrying the inventory. To achieve balance with stock replenishment decision-avoiding both under stocking and overstocking, fundamental decisions must be made relates to the timing and size of the orders (i.e. when to order and how much to order). This can be better decided by making forecasts on the material requirements.
Since inventories will be used to satisfy the demand requirements, it is essential to have reliable estimates of the amount and timing of demand requirements. Similarly, it is essential to know how long it will take for orders to be delivered. In addition, it is necessary to know the extent to which demand and lead times might vary: the more potential variability, the greater the need for additional stock to insure against as between deliveries. Thus, there is a crucial link between forecasting and inventory management.

5B. 6 TOOLS OF INVENTORY CONTROL

5B. 7 ABC ANALYSIS

This is one of the basic analytical management tool which enables top management to place the effort where the results will be greatest. This technique tries to analyze the distribution of an characteristic by money value of importance in order to determine its priority. The annual materials consumption analysis of an organisation would indicate that a handful of high value items—less than 10 percent of the total number will account for a substantial portion of about 70-75 percent of the total consumption value, and these few vital items are called ‘A’ items which needs careful attention of the materials manager.

Similarly, large number of bottom’ items over 70 percent of the total number called the trivial many – account for about 10 percent of the total consumption value, and are known as the ‘C’ class. The items that lie between he top and bottom are called the ‘B’ category items.
5B. 8 PROCEDURAL STEPS OF ‘ABC’ ANALYSIS

a) Identify all the items used by a company

b) List all the items as per their money value in the descending order. i.e. The high valued items will be listed first followed by the next valued item.

c) Count the number of high valued, medium valued and low valued items

d) Calculate the individual values of the high, medium and low valued items. This is arrived at first by multiplying the number of items as in step (a) and adding all the items in different categories high, medium and low.

e) Find the percentage of high, medium and low valued items. High valued items normally contribute for 70 percent or so of the total inventory cost and medium and low valued items 20 and 10 percent respectively.

f) A graph can be plotted between percent of items and percent of total inventory cost.

5B. 9 PURPOSE OF ABC ANALYSIS

The object of carrying out ABC analysis is to develop policy guidelines for selective control. After the analysis, broad policy guidelines can be established.

A. Items High Consumption Value

B. Items : Moderate Value

C. Items : Low Consumption Value

5B. 10 ADVANTAGES AND DISADVANTAGES OF ABC ANALYSIS

This approach helps the materials manager to exercise selective control and focus his attention only on a few items when he is confronted with lakhs of stores items. By concentrating on high valued ‘A’ items, the manager will be able to effectively control inventories and show the ‘visible’, results in a short span of time by reducing the overall working capital requirement and increasing the profit of the company. By this analysis obsolete stocks are automatically pin pointed. This results in better planning and improved inventory turnover.

The major limitation of the ABC analysis is that it takes into account the total consumption value of items but not their vitality. Some items, though negligible in monetary value, may be vital for running the plant or machines. For example, the connecting belts in case of motors, foundation bolts etc. the results of ABC analysis have to be reviewed periodically and updated. Low valued item in ‘C’ category, like diesel oil to ruin the generator, may become B for A category item during the power crises.

5B. 11 VED analysis

This analysis attempts to classify items into many categories depending upon the consequences of materials stock out when demanded. The cost of storage may vary depending upon the seriousness of such a situation. The items are classified into V (Vital), E (Essential) and D (Desirable) categories. Vital items are the most critical having extremely high opportunity cost of shortage and must be available in stock when demanded. Essential items are quite
critical with substantial cost associated with shortage and should be available in stock and by and large. Desirable group of items do not have very serious consequences if not available when demanded but can be stocked items.

Hence, the percentage risk of shortage with the 'vital' items has to be quite small, thus calling for high level of stock. With 'Essential category we can take a relatively high risk of shortage and for 'Desirable' category even higher. So, depending upon the seriousness of the requirement of the item they are classified.

5B. 12 FSN ANALYSIS

The items that are being used in a company are not required to be purchased at the same frequency. Some materials are quite regularly required, yet some others are required very occasionally and some materials may have become absolute and might not have been demanded for years together. This FSN analysis groups them into three categories as fast moving, Slow-moving and Non-moving items. Inventory policies and models for he three categories have to be different. Most spare parts come under the slow moving category which has to be managed on a different basis. For non-moving dead stock, we have to determine optimal stock disposal procedures and rules rather than inventory provisioning rules. Categorization of materials into three types on values, critically and usage enables us to adopt the right type of inventory policy to suit a particular situation.

5B. 13 ECONOMIC ORDER QUANTITY (EOQ)

Inventories are built to act as a cushion between supply and demand. The supply could be a one time supply (static) or a continuously repetitive one (dynamic). The demand could be totally known (certain), be known over a range of probable values (risks) or be totally unknown (uncertain). The goal of the basic EOQ model is to identify the order size that will minimize the sum of the annual costs of holding inventory and the annual cost of ordering inventory. The major elements of the inventory carrying cost are:

i. opportunity cost of the funds utilized for the purchase of items

ii. cost incurred in the storage of these items

iii) obsolescence and deterioration cost

iv) insurance cost when items are bought and stored in the company’s stores

The ideal inventory movement pattern for a given material a company can be drawn.
The inventory cycle begins with receipt of an order of Q units. These items are utilized for producing certain product at a constant rate over a period of time. When the quantity on hand is not sufficient to satisfy demand during the lead time (the time requirement between submitting an order and receiving that order), an order for Q units is submitted to the supplier. Because it is assumed that both the usage rate and the lead time do not vary, the order will be received at the precise instant that the inventory on hand falls to zero. Thus, orders are timed to avoid having excess stock on hand and to avoid stock outs.

The optimum order quantity reflects a trade off between inventory carrying costs and ordering costs. As order size varied one type of cost will increase while the other one decreases. The ideal solution will be an order size that causes neither a few large orders or many small orders but one that lies somewhere between those two extremes.

Annual carrying cost is computed by multiplying the average amount of inventory on hand by the cost to carry one unit for an year, even though any given unit would not be held for a year. The average inventory is one half of the order quantity, the amount on hand decreases steadily from the maximum of Q units to 0, for an average of (Q+O)/2 or Q/2. The average annual carrying cost per unit is expressed as C, the total annual carrying cost is calculated as:

\[ \text{Annual carrying cost} = \frac{Q}{2} C \]

On the other hand, annual ordering cost will decrease as order size increases, since for a given annual demand, the larger the order size, the fewer the number of orders needed. The hunger of orders per year will be \( \frac{D}{Q} \) where \( D \) = Annual and \( Q \) = order size. Unlike inventory carrying costs, ordering costs are relatively incentive to order size in that regardless of the amount of an order, there are certain activities which must be done, such as determine how much is needed, periodically evaluate sources of supply, and prepare the invoice. Annual ordering cost is a function of the number of orders per year and the ordering cost per order:

\[ \text{Annual ordering cost} = \frac{D}{Q} S \]

Where \( S \) = ordering cost.

Because the number of orders per year, \( \frac{D}{Q} \), decreases as \( Q \) increases, annual ordering cost is inversely related to order size.

The total annual cost associated with carrying and ordering inventory when Q@ units are ordered each time is:

\[ \text{TC} = \text{Annual carrying cost} + \text{Annual ordering cost} \]
\[ = \frac{Q}{2} C + \frac{D}{2} S \]

Where \( D \) = Demand in unit per year
\( Q \) = Order quantity in units
\( S \) = Order cost in rupees
\( C \) = Carrying cost in rupees per unit per year.

The total cost curve is U and that it reaches its minimum at the quantity where carrying and ordering costs are equal.

To minimize the total cost, differentiate \( \text{TC} \) with respect to \( Q \) and equating is to 0,

We will get:

Optimum Order Quantity: \( Q = \left( \sqrt{2DS} \right) / C \)
We can calculate the ordering cost per order and the annual carrying cost per unit, the optimum (economic) order quantity can be computed if the annual demand is given.

The minimum total cost is,

\[ TC_{\min} = \frac{Q}{2} \cdot C + \frac{D}{Q} \cdot S \]

5B. 14 INVENTORY CONTROL OF SPARES

The spares are required for the upkeep of various general and special purpose equipment and machineries in a company. The requirement of spares will emerge preventive or breakdown maintenance operations. The requirement of spares can be well planned in the case of items required during routine preventive operations irrespective of its cost, critically or its essentiality. In the case of breakdown of certain machineries, the requirement of spares becomes critical for the repair and rectification of the machinery. If the machine itself as an important special purpose machinery, then the requirement and availability of the spares at that point of time is very much vital irrespective of the cost of the spare. The required item may fall in any of the A,B,C category, but its availability is to be ensured by stocking certain expected items to the required numbers. The inventory control of spares items call for a trade-off between the cost of the spares stored and the breakdown or stoppage of production because of the non-availability of certain critical and vital spare parts.
5C. NETWORK

5C.1 INTRODUCTION

Operations managers must plan organize and control a variety of manufacturing and service operations. Some or they are one time activities and others are repetitive. Besides, some activities might be continuous or intermittent or job shop production required scheduling, loading and control techniques whereas continuous production requires line balancing techniques. The one-time activities are generally one-time projects such as construction of a hospital, research and development of a missile or manufacturing an aircraft or building a ship and the like. A different approach known as project approach is used to develop, manufacture and market new products and services.

5C. 2 WHAT IS A PROJECT

Project is a term which covers once-through and small –batch programmes. When attempting to determine the completion data for any task/project. Where it is

- Construction projects, building of a bridge etc.
- Research and development Projects
- Designing of a new pieces of equipment
- Erection and commission of Industrial Plants
- Preventive maintenance
- Trial manufacture.
- Heavy engineering
- Custom-engineered Products
- Market launching of new Products
- Finalization of annual accounts
- An inaugural
- A banquet
- A marriage programme
- Preparation for a dinner party
- A picnic party
- A picnic outing etc.

Or any other project it is necessary to time-table all the activities which make up the task or the project, that is to say, a plan must be prepared. The need for planning has always been present, but the complexity and competitiveness of modern undertaking now requires that this need should be met rather than just recognized.
5C. 3 PROJECT MANAGEMENT

A project is an organized endeavour to accomplish a specified non-routine or low volume task. Although projects are not repetitive, they take significant amount of time to complete and are large-scale or complex enough to be recognized and managed as separate undertakings.

Management of a project differs in several ways from management of a typical business.

Operations manager must often organize project team to plan and control projects. The objective of a project team is to accomplish its assigned mission and disband. The project teams must ordinarily work to tight time schedules, adhere to strict budgets, report to top management personnel of the organization and be temporarily removed from their regular jobs. While the project work is proceeding, the remainder of the organization must continue to produce the organization’s products. Because of the difficulty of simultaneously managing the projects and producing the products and services, operations managers have developed new approaches to managing and controlling projects. The type of techniques required to manage the projects depend on the complexity of the projects. For small projects, Gantt charts are adequate whereas for large and complex projects, the critical path method (CPM) or the program evaluation and review technique (PERT) would be more effective.

In this architect’s office, representatives from human resources and product management bring their skills together from their “home” departments to complete this facility expansion. Workmanship, pleasure from job flexibility, and pride in the team effort. All of these can be fostered and encouraged by project managers.

5C. 4 CONVERSION SYSTEM: PROGRESS REPORTING

Project management involves more than just planning, it also requires controlling, monitoring progress and taking corrective action when activities deviate from schedules or costs get out of line. Progress reporting helps managers control by showing cost variances (actual versus budgeted) and time variance (actual versus scheduled) during the projects.

5C. 5 MATRIX ORGANIZATION

The matrix organization is a team approach to special projects. When teams are established, the firm’s organization departs from the conventional functional basis for organization – departmentalization.

Today, project teams enjoy widespread acceptance in many of our major industries. They are especially effective in large companies that emphasize new product development and rapid launching of new products in the marketplace.

Several factors seem to have been responsible for this trend toward project teams. Rapid technological changes forced organizations to minimize development lead times, reduce costs, and avoid obsolescence. These pressures resulted in the need for a kind of organization that could cut across functional areas. The project matrix organization fills that need. Engineers, scientists, technicians, market specialists, and other skilled personnel can be effectively and efficiently loaned from their “home” unit to another unit for periods of time, thus avoiding duplicated skills and unnecessary costs.

5C. 6 BEHAVIORS IN A PROJECT ENVIRONMENT

Project managers must not only be competent technically but must also be skilled in analysis, interpersonal relations, and decision making. Let’s briefly examine a few key behaviours within project teams.

5C. 7 COMMUNICATION

Project leaders must be able to communicate freely with both team members and line employees who are not regular team members. Within the project team, communication is frequent and often involves intensive collaboration. Short daily meetings, written correspondence, and one-on-one problem-solving sessions are often necessary for the sort of tasks required of project teams. The non-routine, diverse, loosely structured tasks that project teams often engage in require flexible relationships and communications to avoid duplication of effort and costly project delays.
5C. 8 MOTIVATION

Project managers motivate team members in much the same way other managers motivate their staff. Motivation comes from either extrinsic or intrinsic rewards. One difficulty a project manager may face is that they may not have sufficient latitude to give monetary rewards. They may be able, however, to give monetary rewards in the form of incentives for cost control and completion time. Or they may rely on intrinsic rewards, such as satisfaction from tasks accomplished, pride in quality.

5C. 9 GROUP COHESIVENESS

As the size of the project team increases, group cohesiveness decreases. The higher a group ranks in organization status (measured by project importance, skills required, and job flexibility), the more cohesive the group tends to be. If group members’ social economic or psychological needs are met by a group, they tend to feel strong ties to the group. The more a project team fills these needs, the more cohesive the team. Finally, the closer group members work in close proximity to one another under stress conditions, the greater the groups cohesiveness.

Overall, the more cohesive the group, the better the chances a project can be completed on budget and on time. Because of both the diversity of team members and the one-shot nature of the project, group cohesiveness is difficult to achieve in project teams. But project teams that are cohesive increase their chance of achieving their primary goals.

5C. 10 PROJECT LIFE CYCLE

A project passes through a life cycle that may vary with the size and complexity of the project. Typically an project will pass through the following phases:

1. The Concept Phase: During this phase, the organization realizes that a project may be needed or the organisation is requested to propose a plan to perform a project for some customer.

2. Initial Planning of Feasibility phase: During this phase, the project manager plans the project to a level of detail, sufficient for initial scheduling and budgeting.

3. Detailed Planning Phase: If the project is approved, then detailed scheduling and budgeting is done in this phase.

4. Organisation Phase: During this phase, a detailed project definition such as the work breakdown structure (WBS) is examined. A WBS is a document similar to the bill of material and divides the total work into major packages to be accomplished.

   Personal and other resources necessary to accomplish the project are then made available for all or a portion of the projects duration through temporary assignments from other parts of the organisation or by leasing resources or subcontracting portions of the projects.

5. Execution Phase: During this phase the various activities planned are completed as per the schedule, utilizing the allotted resources.

6. Termination Phase: This is the phase, during which the project is terminated or disbanded after completion. The personnel who were working in the project are assigned back to their regular jobs or to other jobs in the organisation or to other projects in this phase.

5C. 11 PROJECT ORGANIZATION

Project organizations have been developed to ensure both continuity of the production system in its day to day activities and the successful completion of projects. A variety of organizational structure are used by enterprises to perform project work. The various considerations in forming a project organisation are:

(a) Proportion of the company’s work that is performed by projects
The scope and duration of the projects
The capabilities of the available personnel
The preferences of the decision makers

There are four options available in choosing an appropriate organization for project:

1. Functional organization: in functional organizations, functional departments are formed that specialize in a particular type of work such as production and sales. These functional departments often are broken into smaller units that focus on special areas within the function. Top management may divide project into work tasks and assign them to the appropriate functional units. The project is then budgeted and managed through the normal management hierarchy.

2. Project co-ordinator: A project may be handled through the organisation as described above, except some one is appointed to co-ordinate the project. The project is still funded through the normal organization and he functional managers retain responsibility and authority to their portion of the project work. The project co-ordinator meets with the functional managers and provides focus and impetus for the project and may report its status to the top management.

3. Project matrix: In a matrix organisation, a project manager is responsible for completion of the project and often assigned a budget. The project manager contracts with the functional managers for completion of specified parts of the project. The functional managers for completion of specified parts of the project. The functional managers assign work to employees and co-ordinate work within their areas. The project managers co-ordinates project efforts across the functional units.

4. Project Team: A particularly significant project that will have a long duration and require the full time efforts of a group may be run by a project team, specially constituted for that purpose. Personnel are assigned full-time to the project and are physically located with other team members. The project has its own management structure and budget as though it were a separate division of the company.

5C. 12 THE ROLE OF A PROJECT MANAGERS

The project manager’s job is important and challenging. He is responsible for getting work performed, but often has no direct, formal authority over must of the people who perform the work. He must often rely on broader knowledge of the project and skills at negotiation and persuasion to influence participants. He may have the assistance of a staff if the project is large.

5C. 13 PROJECT ORGANISATION : ADVANTAGES

Perhaps the one overriding advantage of project organization is that by grouping people and tasks, the organization can tackle unusual project opportunities on short notice. A key disadvantage, however, is that creating and dispersing project teams can be upsetting to the routine employees have developed. Furthermore, project managers often feel considerable constraints in having to accept responsibility for completing the project without being given line authority to control it.

5C. 14 BASIC FUNCTIONS OF PROJECT MANAGEMENT

1. Manage the project’s scope to define the goals and work to be done, in sufficient detail to facilitate understanding and correct performance by the participants.

2. Manage the human resources involved in the project

3. Manage-communications to see that, the appropriate parties are informed

4. Manage time by planning and meeting a schedule
5. Manage – quality so that, the project’s results are satisfactory

6. Manage-costs so that, the project is performed at the minimum practical cost and within budget if possible.

5C. 15 PROBLEMS IN MANAGING A PROJECT

1. Managing a project can be a complex and challenging assignment.

2. Since projects are one-of-a-kind endeavors, there may be little in the way of experience, normal working relationships or established procedures to guide participants.

3. A project managers may have to co-ordinate diverse efforts and activities to achieve the project goals.

4. Persons from various disciplines and from various parts of the organization who have never worked together may be assigned to the project for differing spans of time.

5. Sub-contractors who are unfamiliar with the organisation may be brought in to carry out major portions of the project.

6. The project may involve a large number of inter-related activities performed by persons employed by any one of several different sub-contractors.

For the above reasons, it is important that the project leaders have an effective means of identifying and communicating the planned activities and the way in which they are to be inter-related. An effective scheduling and monitoring method is absolutely essential for the management of a large project. Network scheduling methods such as, PERT and CPM have proven to be highly effective and valuable tools during both the planning and execution phases of projects.

5C. 16 HISTORY OR NET ANALYSIS

Before CPA coming on the scene probably the best-known method of trying to plan was by mean of a bar or Gantt chart. There were certain drawbacks and problems in it. In Great Britain the Operational Research Section of the Central Electricity Generating Board investigated the Problems concerned with the overhauls of Generating Plant – an area of considerably complexity which was increasing in importance as new higher Performance Plant was being brought into service. By 1957 the O.R. section had devised a technique which consisted essentially of identifying the “Longest irreducible sequence of events”, and using this technique they carried out in 1958 an experimental overhaul at a Power Station which reduced to overall time on 42% of the previous average time for the same work. Continuing to work upon these times the overhaul time was further reduced by 1960 to 32% of the previous average time. The name, “Longest irreducible by sequence of events” was soon replace by the name, “Major Sequence, and it was pointed out for example, that delay in the “major-sequence” would delay completion times., but the difficulties elsewhere need not necessarily involve extension in total time. This work of the O.R. group was not made public, although comprehensive reports were circulated internally elsewhere.

Similar development work was being undertaken elsewhere – for example in the U.S. Air force under the code name P.E.P. Also in 1958, the E.I. du pont de Nemours Company used a technique called the “Critical Path Method” “CPM” to schedule and control a very large project, and during the first complete year’s Use of CPM it was credited with saving the company $ 1 million. Subsequent use underlined the basic, simplicity and extraordinary usefulness of this method, and by 1959 Dr. Machly, who had worked on the Du Pont Project, set up an organisation to solve industrial problems using the Critical Path Method.

Since 1958 considerable work has been carried out, mainly in the United States of America, in consolidating and improving these techniques. Much of the effort has been expanded by the Computer Companies, who have devised special names to distinguish their own work.

Network analysis is synthesis of two techniques namely Programme Evaluation and Review Technique and Critical Path Method evolved independently during 1956-57. The two methods have many features in common and
are now combined and called Network Analysis. For large non-repetitive operations or projects CPM-PERT and other related network technique are usefully aids for project managers. A few of the features making the techniques are:

- A logical and disciplined basis for planning
- Simplicity
- Improves co-ordination and communication
- Pinpoints trouble spots and responsibility
- Better management of resources
- Versatile and application
- Scope for unseen changes

5C. 17 ORIGIN OF NETWORK PLANNING

The very nature of the one-time large project demands that what has to be done and the schedule for performance must be planned together. These factors are interdependent, and the planning of large projects involves planning for deployment of resources to the total project. To accomplish this, we must determine the activities required, the timing and interdependencies, the requirements of various possible schedules for manpower and other resources, and the relationship of all the foregoing to a project completion date. The project completion date most often is part of a contract that carries penalties for nonperformance. Therefore, the complexities and the one-time nature of the project require a coordinated plan that involves activities required, scheduling, and deployment of resources. The great complexity of such projects calls for special methods; network planning techniques have been developed to meet this need.

Network planning techniques go under a confusion of acronyms with variations. The two original names, PERT (Performance Evaluation and Review Technique) and CPM (Critical Path Methods), have been differentiated into a variety of brand names that essentially have been applied to the same basic methodology. Some of the alternative names used are: CPS (Critical Path Scheduling), LES (Least-cost Estimating and Scheduling), Micro-PERT, 1-Time-PERT, PERT/COST and PEP. The variety of names for PERT/CPM techniques are a measure of the degree of interest that has developed.

Network planning methods seem to have been developed by two different groups independently. As an internal project of the DuPont Company, critical path methods were developed to plan and control the maintenance of chemical plants; subsequently the were used widely by DuPont for many engineering functions. Parallel efforts were undertaken by the U.S. Navy at about the same time to develop method for planning and controlling the Polaris missile project. We can glimpse the magnitude of the task when we realize that approximately 3,000 separate contracting organization were involved. The result was the development of the PERT methodology. The immediate success of both the CPM and PERT methodologies may be gauged by the following facts. Do Pont's application of its technique to a Louisville maintenance project resulted in reducing down time for maintenance from 125 to 78 hours, the PERT technique was credited widely with helping to shorten by 2 years the time originally estimated for the completion of the Polaris missile engineering and development program.

PERT and CPM are based on substantially the same concepts, although there are some differences in details. First, as originally developed, the PERT methods were based on probabilistic estimates of activity times that resulted in a probabilistic path through a network of activities and a probabilistic project completion time. The CPM methods, however, assumed constant or deterministic activity times, and they now use the slightly simpler deterministic model is equally applicable to and usable by either technique. As a matter of fact, most present day applications of PERT methods have dropped the use of the probabilistic activity times estimates. The second difference between the two techniques is in the detail of how the arrow diagram is prepared. In the discussion that follows, we shall note more fully both the probabilistic – deterministic and the arrow diagram differences.
In the following sections, we shall develop PERT planning methods and then show the difference between PERT and CPM methods.

5B. 18 UTILITY OF NETWORKS

1. It aids the manager in planning, scheduling, controlling the activities.

2. In guiding and directing team efforts more effectively

3. It permits advance planning, indicates current progress wants of potential future trouble spots when there may still be time to avoid them.

4. It aids in handling uncertainties regarding time schedules, co-ordination of many activities and control of cost involved.

5. It shows its values most strikingly when a special projects of new kind is undertaken.

5C. 19 NETWORK TECHNIQUES OF PROGRAM MANAGEMENT

The need for management direction on a program or job depends upon two factors-its repetitiveness and complexity. Simple jobs that occur infrequently do not require any involved direction. The techniques for direction of project-type jobs are the new. However, there has recently been an explosive growth in the family of these technique a number of network techniques have been developed which are named below:

- (1) PERT : Programme Evaluation and Review Technique
- (2) CPM : Critical Path Method

5C. 20 PROJECT PLANNING AND CONTROL TECHNIQUES

PROJECT PLANNING: Project planning includes all activities that result in a course of action for a project. Planning begins with setting well defined objectives (such as implementing an new management information system). Also, planning involves decision making regarding resources to be committed, completion times, priorities of activities etc. Areas of responsibility must be identified and assigned. Time and resource requirements to perform the work activities must be forecasted and budgeted. Planning also involves establishing project boundaries and identifying controllable and uncontrollable variables that must be managed. Also, the performance criteria should be stated related to the project objectives and in measures of time, cost and quality characteristics.

PROJECT SCHEDULING: Project scheduling establishes times and sequences of the various phases of the project. In project scheduling, the project manager considers the various activities of an overall project and the tasks that must be accomplished and relates them coherently to one another over the projects time horizon.

Techniques for scheduling projects include Gantt charts and network techniques such as PERT and CPM. Gantt Charts do not reflect the inter-relationship among resources or the precedence relationships among project activities. Network technique overcome this shortcoming of Gantt charts by including precedence relationships.

5C. 21 DEVELOPMENT OF PERT

Project Managers increasingly noted that the technique of Frederick Taylor and Henry L. Gantt introduce during the early part of he century for large scale productions, were inapplicable for a large portion of the industrial effort. The work was being undertaken in the U.S.A. and in early 1958 the U.S. Navy Special Project. Office concerned with performance tends on large military development programs set up team of the management consulting firm of Booz-Allen and Hamilton; to devise a means of dealing with the planning and subsequent control of complex work. This investigation was known as the Programme Evaluation Research Task, which gave rise to (or possible derived from) the code name PERT. By February 1958, Dr. C.E. Clark, mathematical in the PERT team presented the early notions of arrow-diagramming, military drawing from his study of graphics. This early work of Dr. Clark was rapidly published and by July 1958, the firs report, PERT Summary Report, phase I, was published. By this
time the full title of the work had become “Programme Evaluation and Review Technique”, and the value of the technique seemed well established.

FIGURE: 5.8 “PERT” – A SAMPLE

By October, 1958, it was decided to apply PERT to the Fleet Ballistic Missiles Programmes where it was credited with saving two years in the development of Polaris Missile. Since that time PERT has spread rapidly through out the U.S. defence and Space industry Currently almost every major Government and military agency concerned with space Age Programs is utilizing the technique as large industrial contractor in this field. Small business wishing to participate in national defence programs has found it increasingly necessary to develop PERT capability.

In 1958 the U.S. Navy developed Program Evaluation and Review Technique (PERT) for planning and control of the Polaris nuclear submarine project. The results of using PERT in that application, in which some 3,000 contractors were involved, is generally reported to have reduced by two years the project completion time for the Polaris project in both government and industry today, PERT is still widely used. A similar modeling approach called the Critical Path Method (CPM) is also used by business and government.

5C. 22 Application of PERT

First we should clarify the conditions under which PERT may be appropriately used. If your situation lacks the following features, PERT will yield little benefit. First, the project must be one whose activities clearly are distinct and separable. Second, the project and activities must all have clear starting and ending dates. Third, the project must not be complicate by too many interrelated tasks. Fourth, the project must be one whose activities afford alternative sequencing and timing.

5C. 23 LANGUAGE OF ‘PERT’

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<thead>
<tr>
<th>Symbol</th>
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<td>Activity</td>
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FIGURE : 5.10 PERT – A GLOSSARY

The PERT language comprise simple symbols and terms. Key symbols are those for activity, dummy activity, event, and critical path of the network. Since the critical path requires the longest time through the network, management should watch it most closely to avoid unnecessary project delays.

5C. 24 HOW DOES PERT WORK

It works by following these steps:

- Clearly identify all activities in the project
- Identify the precedence requirements of the activities
- Diagram the precedence requirements as a sequence of activities
- Estimate the time each activity will take.
- Calculate the critical path and other project performance criteria, creating the schedule and plan for subsequent control.
- Reevaluate and revise as experience dictates.

Time estimates are obtained from either past data or from people experimented in a particular activity. Optimistic, pessimistic and most likely times must be estimated so that the expected (average) time can be calculated from the following equation.

5C. 25 ADVANTAGES OF PERT

- It provides clear objectives
- It provides an analytical approach to the achievements of an objective
- It enumerates detailed plans and important programmes and events
- It establishes sequence of activities and their inter-relationship.
- It focuses attention on important and critical activities and events.
- It provides a logical plan for formulating a realistic schedule of activities.
- It provides up-to-date status information of the project and enables quick revive of the progress at all stages
- It can point out improbabilities and may even predict before their occurrence and they help to remedy the situation.
- It can foretell the feasibility of a plan and can help in formulating new schedules if the one under consideration is found impracticable or wanting.
- It avoids slippage of plan and waste of time, energy and money
- It is an aid for allocating the available resources for optimum results.
- It brings about time and cost consciousness at all levels of management
5C. INTRODUCTION "PERT" INTO AN ORGANIZATION

As with any other new managerial tool, PERT will require to be introduced into an organisation with care. It is suggested that the following points should be observed.

1. PERT is not a universal tool – there are situations where it cannot be usefully employed. These situations are, in general those where activity is Continuous, for example, flow production. A PERT type situation is characteristically on which has a definable start and definable finish.

2. PERT is not a life saving drug, it does not cure all ills – Indeed, PERT in itself does not solve any problems, but it does expose situations in a way which will presuit effective examinations both of the problems and of the effect of possible solutions. How ever. The formulating and implementing of any solution will remain the responsibility of the appropriate manager.

3. PERT must not be made a mystery, known only to a chosen few. All levels require to appreciate the method and its limitations, an extensive educational programme will be necessary to ensure that knowledge is spread as widely as possible.

4. The person initiating PERT into an organisation must be of sufficient stature and maturity to be able to influence both senior and junior personnel.

5. Wherever possible, the early applications for PERT should be to simple situations. If PERT is first employed on a very difficult task, it may fail, not because of the difficulty of PERT but because of the difficulty of the task itself.

However, the failure is likely to be attributed to PERT and the technique will be discredited.

6. PERT will involve committal to, and the acceptance of, responsibilities expressed in qualitative terms. Many supervisors find this difficult to accept, and will often try to escape by creating unreal problems, it is vital to make it quite clear that PERT is not a punitive device; it is a tool to assist, not a weapon to assault.

7. Difficulties in using PERT are almost always symptoms of same Managerial Weakness.

5C. 27 PERT PLANNING METHODS

The essence of PERT planning is based on the development of a network representation of the required activities. Here, the arrows represent the required activities coded by the letters with estimated performance time shown near the arrows. In network planning, the length of the arrows ordinarily has no significance. The numbered circles define the beginning and end points of activities and are called events or nodes. The direction of arrows indicate flow.

5C. 28 STEPS IN 'PERT' PLANNING

- Define clearly the end objectives.
- Determine the major events that must be completed prior to reaching the end objectives.
- Analyses and record the work to be done in between events.
- The project is broken down into different activities systematically.
- Arrange the events and activities in the order of sequence of their occurrence.
- The network diagram is drawn. Events and activities are numbered and make sure no activity is left over.
- Layout and finalize the network in a neat form. May be more than one attempt is needed.
• Event numbers should be given with the starting event as 1, and progressing successively to the right in the order in which they occur.

• Any dummy activity should be shown by dotted arrow time on the network.

5C. 29 ORGANIZING THE CONVERSION SYSTEM

The Gantt charts were also valuable for the company representative, a recent business school graduate. The process of constructing the chart provided an understanding of project activities, their precedence relationships, and how in real time the project would be completed by the target date. The charts were a critical model for subsequent project control.

5C. 30 NETWORK MODE

Network modeling allows us to address project scheduling a little more, formally than we can with the Gantt chart. Although network models are based on rigorous theory and precise definitions, we discuss only a few terms and concepts here.

Each activity is symbolized by an arc, an arrowed line segment (or, simply, an arrow). Both the beginning and the ending of each activity are symbolized by a node, a circle at the beginning or ending of the arrow. The precedence relationships of the activities are represented by joint nodes. An arc whose ending node is the beginning node of a second arc represents an activity that must precede the second activity.

5C. 31 TRADE-OFF

Time / Cost Tradeoffs Managers often want to reduce critical path times, even if it cost extra money to make the reductions. Although we won't discuss these formal methods here, we consider basic time / cost tradeoff concepts.

FIGURE 5.11 CRASHING

Time – related costs: Indirect project costs include overhead, facilities, and the opportunity cost associated with resource being used than can be eliminated if the project is shortened. Overhead costs of maintaining a house trailer at a construction site, for example, might be Rs. 10,000 per month for heat, light, telephone, clerical help, and other indirect construction costs. A second kind of cost is the activity direct cost of expediting (speeding up) the project. These expediting costs include overtime or extra labor, retaining an expeditor, and leasing more equipment.

The essence of the time/cost tradeoff is allocating resources (spending money) to reduce project time only so far as further direct costs do not exceed indirect project cost savings. Beyond this point, the cost of expediting exceeds the benefit of reduced indirect project costs.
5C. 32 PROCEDURES FOR ANALYZING TIME/COST TRADEOFFS

1. Estimate costs: For each activity, determine indirect project costs and expediting costs per time period.

2. Estimate crash times. For each activity, determine the shorted possible activity time.

3. Identify activities on the critical path.

4. Evaluate the PERT network. Reduce the critical path (CP) activity times by observing these restrictions: Expedite the CP activity that has the least expediting cost, continuing to the second least costly, and so on to the most costly, or until one of the following occurs:
   (a) The target expedited time has been reached
   (b) The resources for expediting (Rs.) have been exhausted
   (c) The indirect project costs are less than the expediting costs for each activity on the critical path.

In this procedure, you must be careful to keep an eye on the critical path. As the path time of the original CP is reduced, other paths may become critical. Should two or more paths have to be expedited simultaneously, the procedure may become too costly.

5C. 33 ORGANIZING THE CONVERSATION SYSTEM

Unlike routine, repetitive functions, project management present some special challenges that require somewhat different talents and a unique management style. Getting the project launched and overseeing its completion have both technical and behavioral dimensions, as we see next.

5C. 34 CONVERSION OF THE PROJECT

Major projects pose real challenges in their planning and control: Two methodologies, work breakdown structures and progress reporting, can help.

5C. 35 WORK BREAKDOWN STRUCTURE

The work breakdown structure (WBS) is a methodology for converting a large-scale project into detailed schedules for its thousands of activities. The WBS is a level-by-level breakdown of project modules. The overall project is subdivided into major subcomponents that, in turn, are further subdivided into another, lower level of more detailed subcomponent activities, and so on.

Eventually, all the tasks for every activity are identified, commonalities re discovered, and unnecessary duplication can be eliminated.

After the WBS is developed, it can be used to create segments of the network structure which, ultimately, are combined into the PERT network for the project. Let’s examine the WBS methodology by continuing the Long – Term Care example.

5C. 36 CRITICAL PATH SCHEDULING

With a property constructed arrow diagram, it is a simple matter to develop the important schedule data for each activity, and for the project as a whole. The data that interest us are the earliest and latest start and finish-times, available slack for all activities, and the critical path through the network.

EARLIEST START-AND FINISH – TIMES

If we take zero as the starting time for the project, then for each activity there is an earlier starting – time (ES) relative to the project starting-time, which in the earliest possible time that the activity can begin, assuming that all the predecessors also are started at their ES. Then, for that activity, its earlier finish (EF) is simply ES + activity time.
LATEST START – AND FINISH – TIMES

Now let us assume that we have a target time for completing the project, which, for the house construction example, is three days after the EF time, or thirty-seven days. This is called the Latest finish-time (LF) of the project and of the final activity x. the latest start-time (LS) is the latest time at which an activity can start.

5C. 37 PROBABILISTIC NETWORK METHODS

The network methods that we have discussed so far may be termed deterministic, since estimated activity times are assumed to be the expected values. But deterministic methods do not recognize the fact that the mean or expected activity time is the mean of a distribution of possible values that could occur. Rather, these methods assume that the expected time is actually the time taken.

Probabilistic network methods assumes the reverse, more realistic, situation, in which activity times are presented by a probability distribution. With such a basic model of the network of activities it is possible to develop additional data that are important to managerial decisions. Such data help managers assess planning decisions that might revolve around such questions as What is the probability that the completion of activity A will be later than January 10? What is the probability that the activity will become critical and affect the project completion date? What is the probability of meeting a given target completion date for the project? What is the risk of incurring cost penalties for not meeting the contract date?

The nature of the planning decisions based on such questions might involve the allocation or reallocations of manpower or other resources to the various activities in order to derive a more satisfactory plan. Thus, a “crash” schedule with extra resources might be justified to ensure the on-time completion of certain activities. The extra resources needed are drawn from non-critical activities or activities in which the critical probability is small.

The discussions that follows can be applied equally to either the PERT or CPM basic format, although the probabilistic methods originally were developed as part of PERT. The probability distribution of activity times is based on three time estimates for each activity.

OPTIMISTIC TIME

Optimistic time, a, is the shortest possible time is which to complete the activity if all goes well. It is based on the assumption that there is no more than one chance in a hundred of completing the activity in less than the optimistic time.

PESSIMISTIC TIME

Pessimistic time, b, is the longest time in which to complete an activity under adverse conditions but barring acts of nature. It is based on the assumption that there is no more than one chance in a hundred of completing the activity in a time greater than b.

MOST LIKELY TIME

Most likely time, m, is the modal value of the activity-time distribution.

The computational algorithm reduced these three time estimates to a single average or expected value, which actually is used in the computing procedures. The expected value is also the one used in computing schedule statistic for the deterministic model. Actually, the time distributions could be symmetrical or skewed either to the right or the left.

With a probabilistic model, we can see the probability that seemingly non-critical activities may become critical. This could happen either if a long performance time occurs for the activity in question, or if short performance time occur for activities that already are on the critical path. This is a signal that the schedule plans that have been developed are likely to change. As actual data on the progress of operations come in, we may have to make changes is the allocation of resources in order to cope with the latest set of critical activities.
5C. 38 DEPLOYMENT OF RESOURCES

Given the activity network, the critical path, and the computed schedule statistics, we have a plan for the project. But is it a good plan? We can abstract from our data some additional data on the demand for resources of the early-start schedule. By using the schedule flexibility available through slack in certain activities and/or slack in the project completion date, we can generate alternative schedules and compare the use of important resources with the objectives of load leveling.

Another way to look at the initial or raw plan is in terms of activity costs. The initial activity duration estimates are based on an assumed level of resource allocation. Is it possible to alter activity times by pouring in more or fewer resources? Activity times for some activities can be affected directly in this way. For example, adding carpenters usually will shorten the time it takes to frame a house (this was a critical activity in our house construction example). Would it be worthwhile to pour in more manpower on the critical framing and allocate less to the non-critical brickwork, which has eleven days of slack? Would the alternative plan be more or less expensive? Would shorting the critical path be advantageous? Least costing considerations are worth examining.

Finally, in some situations we may be faced with a demand for some critical resource that is limited in supply. The raw plan may not be feasible if it implies the use of the only available power shovel in two places at the same time. The raw plan must be examined with the objective of the feasible scheduling of limited resources, again using available slack time where possible, or even lengthening the project in order to generate a feasible plan.

5C. 38 COST CONCEPT OF PERT

PERT tells us to achieve the committed objectives in best possible manner and also in the least possible cost and time.

To effect this central, the management must know that:

(i) what is required to be done?
(ii) Schedule time required?
(iii) The estimated cost.

PERT provides a dynamic total for the execution of a program and for developing a technique to control time and cost of achievement.

The following functions are required to be carried out:

1. To make a budget of expenditure for given time schedule.
2. To assess the increase or decrease of cost in relation to decrease or increase in time.
3. To arrive at optimum cost.
4. To draw expenditure plan against time.
5. To review the progress in terms of expenditure incurred and time spent.

This cost or expenses to be incurred in the performance of any activity is divided into two sub-heads:

1. DIRECT COST: The cost incurred in compressing the activity completion time. Each of the activity in network can be performed in a shorter time than early expected time by providing additional resources. The resources can be evaluated in terms of money or cost. Direct cost has the tendency to increase with decrease in time.
2. INDIRECT COST: All overheads such as interest on capital, rent for various equipments. Cost of supervision, cost of storing materials etc. comes under indirect cost. It has the tendency reduce with the reduction in time of an activity. Direct cost to indirect cost cannot be zero at any time.

3. TOTAL COST: It is the sum of direct and indirect costs and it can also be plotted against activity time.

The project duration time X, both direct and indirect costs are equal to Y and, therefore, the total cost of project is 2Y which may or may not be minimum cost.

If an activity span is reduced, the direct cost increases. If we plot cost verses duration on a graph we will find a point where the further crushing of activity is not possible irrespective of the amount of resources applied. This cost is known as crash cost and denoted by Ce.

5C. 39 CRASH DURATION

It is the minimum possible duration of an activity which can not be reduced any more irrespective of resources applied. The crash cost is the minimum cost incurred for crash duration.

5C. 40 FACTORS SHOULD BE CONSIDERED BEFORE IMPLEMENTING PERT

Engineering department often gets committed to release job on a specific date and must release it regardless of the need for total release by the manufacturing groups. PERT planning has greatly increased understanding between engineering and manufacturing. As long as the manufacturing people understand the overall sequence of release, it does not bother them. They no longer scream for engineering to release unless we are really at fault. Better understanding and better relations with manufacturer save money and keep the inventory low.

1. Top Management Support
2. Adopt PERT to local requirements
3. Replan When necessary
4. Leave room for expansion
5. Establish PERT on a permanent basis
6. Do not force formal reporting
7. Don't use Inaccurate Estimates
8. Don't add estimates first
9. Don't plan with overtime
10. Don’t plan with overtime
11. Don't standardize event titles
12. Resource Allocation Program

5C. 41 “CPM” AND ITS ADVANTAGES

Critical Path Method is a technique employed to schedule and control project. CPM is applicable to both large and small projects. It is widely recognized, most versatile and important management planning.

Some of the important advantages are given below

1. It helps in ascertaining time schedule
2. With its help control by the Management becomes easy
3. It makes better and detailed planning possible.
4. It encourages discipline
5. To provides a standard method for communicating project plans, schedules, time and cost performance.
6. It identifies most critical elements and thus more attention can be paid on these activities

Those techniques require a greater planning than required otherwise. Thus these methods increase the Planning cost, but this Cost is easily justified by concentrating attention Critical Paths only and avoiding unnecessary expenses on the strict supervision over whole programme.

5C. 42 DIFFERENCE BETWEEN “PERT” AND “CPM”

CPM is a technique used for the Planning and Controlling the most logical and economic sequence of operations for accomplishing a project. The project is analysed into different activities whose relationships, as in PERT, are shown on the network diagram. The network is then utilized for optimizing the use of resources, progress an control. PERT is a technique used for scheduling and controlling the projects, whose activities are subject to considerable degree of uncertainty in the performance time. The method of start-finish critical path and project time PERT, and CPM are similar. CPM is an activity oriented technique, while PERT is the event oriented technique. Event means the beginning or exceeding of one or more activities. CPM has one time estimate, while PERT has three time estimates.

5C. 43 STEPS IN “CPM” TECHNIQUE

CPM employs the following steps for accomplishing a project planning:

1. Break down the project into various activities systematically
2. Label all activities
3. Arrange all the activities in Logical sequence.
4. Construct the arrow diagram
5. Number all the nodes and activities
6. Find the time for each activity
7. Mark the activity times on the arrow diagram
8. Calculate early and late, start and finishing time
9. Tabulate various times and mark EST and LFT on the arrow diagram
10. Calculate the total float for each activity
11. Identify the critical activities and mark the Critical Path on the arrow diagram
12. Calculate the total project duration
13. If it is intended to reduce the total Project duration, crash the critical activities of the network
14. Optimize the cost
15. Update the network
16. Smooth the network

5C. 44 PROBLEMS IN CRITICAL PATH ANALYSIS

Ordinarily critical path scheduling techniques to not take explicit account of job resources requirements or of possible limitations on resource availability. Implicitly, it is assumed that only constraints on the start time of a job are technological, i.e., a job can be started as soon as its predecessors have been completed. The schedules for early start time and latest start time are established and any job on non-path can be delayed up to its total slack period without delaying the finish date of the project.

Slack in a Limited Resource Schedule:

1. The slack concept, though modified, may still be used and retain its utility as a measure of flexibility in a project schedule.

2. Slack is dependent upon both orders and resource availability.

3. In general, resource limitations reduce the amount of slack in a schedule.

4. Since, in general, the early and late start schedules are not unique, the set of slack valves for a project is not unique. Slack is conditional upon the scheduling rules for creating early start and late start schedules.

5. While a critical path of technologically connected jobs does not always exist in a limited resource schedule, under certain conditions a critical sequence of slackless jobs which span the length of the project can be identified. The job are continuous in time, if not in predecessor successor relationship.

******
6A. MAINTENANCE

6A. 1 PLANT

A plant is a place, where men, materials, money, equipment, machinery, etc., are brought together for manufacturing products.

6A. 2 MAINTENANCE

Today, in modern industry, equipment and machinery are a very important part of the total productive effort than was the case years ago. Moreover, with the development of special purpose and sophisticated machines, equipment and machinery cost a lot more money and therefore their idle or downtime becomes much more expensive. For this reason, it is vitally important that the plant machinery should be properly maintained.

In the preceding chapter, we have discussed the need for capacity requirement planning (CRP), shop – floor planning and control and quality assurance in detail. To ensure effective implementation of all these activities, it is of paramount importance that production facilities such as machinery, plant and equipment tools, materials handling equipments, metrology items such as inspection gauges and measuring instruments, will have to be maintained properly and kept in good working condition. The maintenance function acts in a supporting role to keep equipments and machines, operating effectively to carry out the required production processes and to maintain quality, quantity and cost standards.

6A. 3 MEANING AND DEFINITION

In simple words, maintenance may be understood as a set of activities which help keep plant, machinery and other facilities in good condition. A formal definition of maintenance is that function of manufacturing management that is concerned with the day-to-day problem of keeping the physical plant in good operating condition. It is an essential activity in every manufacturing establishment, because it is necessary to insure the availability of the machines buildings and services needed by other parts of the organisation for the performance of their functions at an optimum return on the investment, whether this investment is in machinery, materials or employees.

Viewed from this, it maybe stated that maintenance is not just repairs. Maintenance is much wider in its scope unlike repairs.

Maintenance is one function which has not been rendered obsolete by advanced technology, has not faded away with the passage of time and has not lost its stature in the industry, though other functions have witnessed fluctuating fortunes from time to time.

6A. 4 SCOPE OF MAINTENANCE

Every manufacturing organisation needs maintenance because, machines break down, parts wear out and building deteriorate over a period of time of use. All segments of a factory – buildings, machinery, equipments, tools, cranes, jigs and fixtures, heating and generating equipments, waste disposal systems, air-conditioning equipments, wash rooms, dispensaries and so on, need attention.

Maintenance covers two broad categories of functions as outlined below

(a) Primary functions

i. Maintenance of existing plant and equipments

ii. Maintenance of existing plant buildings and grounds

iii. Equipment inspection and lubrication
iv. Utilities generation and distribution

v. Alterations to existing equipments and buildings.

vi. New installations of equipments and buildings.

(b) Secondary functions

i. Storekeeping (keeping stock of spare parts)

ii. Plant protection including fire protection

iii. Waste disposal

iv. Salvage

v. Insurance administration (against fire, theft, etc)

vi. Sanitary services.

vii. Property accounting

viii. Pollution and noise abatement or control

ix. Any other service delegated towards maintenance by the plant management.

6A. 5 OBJECTIVES OF MAINTENANCE

The objective of maintenance is to facilitate the optimal use of capital equipment through actions such as replacement, repair, service and modification of the modification of the components or machinery so that these will continue to operate at a specified availability for as long as it is beneficial to do so. Maintenance encompasses keeping the "availability" of the entire production / operations system of the organisation.

Total time for which the plant is out of operation either because it is being given maintenance, service or waiting for it.

Total availability of the plant can be improved by various means such as:

(i) Diagnosing the faults or failures as early as possible and taking quick decisions regarding the same.

(ii) Reducing main breakdown or crisis situations with the help of appropriately organized preventive maintenance programmes

(iii) Designing and installing the equipment in such a way that the failures of the equipment will be low over its life time or in other words, increasing what I known as the “reliability” of the plant, machinery and equipment in the design stage itself.

(iv) Having proper replacement policies of equipment and their component parts in such a way that the total reliability and availability of the system is enhanced at optimal costs.

(v) Having standard Items and standard procedures in maintenance as much as possible so as to gain good control over maintenance operations and also to provide adequate incentives and motivation for maintenance personnel.

The objectives also include:

(i) The objective of plant maintenance is to achieve minimum breakdown and to keep the plant in good working condition at the lowest possible cost.
(ii) Machines and other facilities should be kept in such a condition which permits them to be used at their optimum (profit making) capacity without any interruption or hindrance.

(iii) Maintenance division of the factory ensures the availability of the machines, buildings and services required by other sections of the factory for the performance of their functions at optimum return on investment whether this investment be in material, machinery or personnel.

The development of special purpose and automated machineries requires a lot of capital tied up in the factory. If these machineries or equipments are kept idle because of breakdown or mal functioning, the company’s overall profitability gets affected. Moreover, if the equipment is on the critical path in the manufacturing cycle, the total production also comes down which may result in the deterioration of goodwill earned by the organization with its’ clients. It calls for proper maintenance so as to keep the downtime at the minimum or nil level.

Generally, in most of the organization’s maintenance management I one of the most neglected aspect. In, some places it is treated as a repair work. In most industries, minimum attention is paid to the proper stocking of spare parts, to maintain proper policies and procedures. Because of the low importance given to maintenance there are long shut-downs with consequent losses to the organisation in turn to the country’s economy. For example, most of our agricultural pump sets operate at a very low efficiency resulting in high energy consumption.

The reasons for the lack of management input in maintenance are:

(i) Machine failures occur at random and are un predictable

(ii) Each maintenance is different from the other and hence cannot be standardized.

(iii) Different types of equipments are imported at different times, resulting in a heterogeneous stock of equipments, this makes it difficult to provide proper skilled manpower and facilities for maintenance and repair.

Obtaining spares parts from foreign countries is difficult: making them within the Country is not economical since the quantity required of each item is small. It is difficult to apply management principles and generate economies in such circumstances.

6A. 6 OBJECTIVES OF MAINTENANCE MANAGEMENT

The following are some of the objectives of maintenance management.

a. Minimizing the loss of productive time because of equipment failure (i.e., minimizing idle time of equipment due to break down).

b. Minimizing the repair time and repair cost.

c. Minimizing the loss due to production stoppages.

d. Efficient use of maintenance personnel and equipments

e. Prolonging the life of capital assets by minimizing the rate of wear and tear.

f. To keep all productive assets in good working condition

g. To maximize efficiency and economy in production through optimum use of facilities

h. To minimize accidents through regular inspection and repair of safety devices.

i. To minimize the total maintenance cost which includes the cost of repair, cost of preventive maintenance and inventory carrying costs, due to spare parts inventory.

j. To improve the quality of products and to improve productivity.
6A. 7 MAINTENANCE POLICIES

Maintenance of facilities and equipment in good working order is essential to achieve specified levels of quality and reliability, and efficient working – the best equipment will not work satisfactorily unless it is cared for, and the cost of a breakdown in the system can be very high, not only in financial terms but also in poor staff morale and bad relations with customers. The workforce and the materials must also be ‘maintained’, through training, motivation, health care and even entertainment for the people, and proper storage and handling of materials.

6A. 8 IMPORTANCE OF MAINTENANCE

(i) The importance of plant maintenance varies with the type of plant and its production.

(ii) Equipment breakdown leads to an inevitable loss of production.

- If a piece of equipment goes out of order in a flow production factory, the whole line will soon come to a halt. Other production lines may also stop unless the initial fault is cleared.

- This results in an immediate loss in productivity and a diminution of several thousand rupees per hour of output.

(iii) An improperly maintained or neglected plant will sooner or later require expensive and frequent repairs, because with the passage of time all machines or other facilities (such as transportation facilities) building, etc., wear out and need to be maintained to function properly.

(iv) Plant maintenance plays a prominent role in production management because plant breakdown creates problems such as:

- Loss in production time
- Rescheduling of production
- Spoilt materials (because of sudden stoppage of process, demand in-progress materials).
- Failure to recover overheads (because of loss in production hours)
- Need for over-time
- Need for subcontracting work
- Temporary work shortages – workers require alternative work

Other important features:

(a) Equipment break-down leads to inevitable loss of production.

(b) An improperly maintained plant will require expensive and frequent repairs

(c) Plant break-down creates problems like

- Loss of production time
- Rescheduling of various tasks
- Wastage of materials
- Failure to recover overheads due to loss of production time.
- Need for overtime (or) operating the plant on additional shift.
• Need to resort to sub-contracting
• Redeployment of workforce during the rectification time.

6A. 9 IMPORTANCE OF MAINTENANCE MANAGEMENT

1. Dependability of service is one of the performance measures by which a company can distinguish itself from others. To establish competitive edge and to provide good customer service, companies must have reliable equipments that will respond to customer demands when needed. Equipments must be kept in reliable condition without costly work stoppage and down time due to repair, if the company is to remain productive and competitive.

2. Maintenance is an important factor in quality assurance, when is another basis for the successful competitive edge. Inconsistencies in equipments lead to variability in product characteristics and result in defective parts that fail to meet the established specifications. Beyond just preventing break down, it is necessary to keep equipments operating within specifications (i.e., process capability) that will produce high level quality.

3. Many manufacturing organization, particularly those with JIT (Just-In-Time) programmes are operating with inventories so low that, they offer no protection in the event of a lengthy equipment failure. Beyond the cost of idle equipment, idle labour and lost sales that can result from a breakdown, there is a danger of permanently losing market shares to companies that are more reliable. Maintenance function can help prevent such an occurrence.

4. Good maintenance management is important for the company’s cost control. As companies go in for automation to become more competitive, they increasingly rely on equipments to produce a greater percentage of their output. It becomes more important that, equipments operate reliably within specifications. The cost of idle time is higher as equipment becomes more high-tech and expensive. E.g. NCICNC machines and robots.

5. Organizations like airlines and oil refineries have huge investments in the equipment. Equipment failure will be disastrous for such companies. they need proper maintenance to keep the equipment in good condition.

6A. 10 IMPACT OF POOR MAINTENANCE

   Maintenance operations include all efforts to keep production facilities and equipments in an acceptable operating condition. Failure or mal-functioning of machines and equipments in manufacturing and service industries have a direct impact on the following:

1. Production capacity: Machines idled by breakdowns cannot produce, thus the capacity of the system is reduced.

2. Production costs: Labour costs per unit rise because of idle labour due to machine breakdowns. When machine malfunctions result in scrap, unit labour and materials costs increase. Besides, cost of maintenance which includes such costs as costs of providing repair facilities, repair crews, preventive maintenance inspections, spare parts and stand-by machines will increase as machines break down frequently.

3. Product and service quality: Poorly maintained equipments produce low quality products. Equipments that have not been properly maintained have frequent break downs and cannot provide adequate service to customer. For example, air craft fleets of the airline, railway and road transport services not maintained well can result in poor service to customer.

4. Employee or customer safety: Worn-out equipment is likely to fail an any moment and these failures can cause injuries to the workers, working on those equipments. Products such as two wheelers and automobiles, if not serviced periodically, can break down suddenly and cause injuries to the users.
5. Customer satisfaction: When production equipments break down products often can not be produced according to the master production schedules, due to work stoppages. This will lead to delayed deliveries of products to the customers.

6A. 11 AREAS OF MAINTENANCE

The major areas of maintenance are:

1. Civil Maintenance: Building construction and maintenance, maintaining service facilities such as water, gas, steam, compressed air, heating and ventilating, air conditioning, painting, plumbing and carpentry work. Also included in civil maintenance are janitor, service, house-keeping, scrap disposal, fencing, landscaping, gardening and maintaining drainage, lawns and fire fighting equipments.

2. Planned approach to maintenance reduces the machine or equipment down time, reduced the cost of maintenance and increases productivity as compared to haphazard or unplanned maintenance.

6A. 12 MAINTENANCE POLICY

Maintenance of facilities and equipment in good working order is essential to achieve specified levels of quality and reliability, and efficient working – the best equipment will not work satisfactorily unless it is cared for, and the cost of a breakdown in the system can be very high, not only in financial terms but also in poor staff morale and bad relations with customers. The workforce and the materials must also be 'maintained', through training, motivations, health care and even entertainment for the people, and proper storage and handling of materials.

Primarily, maintenance policy must answer the questions of the extent of activities and the size of the maintenance department. With regard to the extent of activities, practices vary across companies. small plants, for example, use the maintenance department for simple repair and replacement. A major non-production engineering job in these plants, such as an addition to the building, is handled through outside specialists with only token aid from in-house maintenance department. Large companies, on the other hand, with more their maintenance departments. In some companies, responsibility for planning and suggesting building construction changes is placed with the maintenance department, but the actual construction is let to outside contractors.

With regard to equipment maintenance, two practices vary. One practice is to have a well-planned and organized maintenance programme designed to secure maximum life and utilization of machinery. Other practice is to adopt a policy of minimum maintenance and maximum wear. This policy is more economical because, the equipment is usually superseded before it wears out With regard to size of the maintenance crews large enough, so that, every job can be done on a moment's notice. What should happen to the maintenance staff, when there is no overhauling work, is not the concern of the maintenance managers. For the management it amounts to a trade off between large maintenance crew (and corresponding cost) and prompt service and skeleton staff (with lower cost) and delayed maintenance services.

The other issues which deserve consideration in establishing the maintenance policy are:

1. Contract out some work during peak periods to avoid getting too far behind and also to avoid hiring temporary extra help.

2. Defer some maintenance work until slack periods so as to keep the workforce intact during such periods. Overhaul work and painting projects are often handled on this basis.

3. Replace machine and equipment at the optimum time. This time is difficult to determine, but many machine tool manufacturers are willing and able to assist in such determination.

The point is to replace machines before they get too old and require too much repair work. These and similar items are policy matters, pertaining to the maintenance department and should be decided by the top management. It is necessary that once a policy is formulated, everyone is informed of the decision. In addition, the limits of
responsibility and authority of the maintenance department needs to be carefully defined and everyone informed as to which jobs are maintenance jobs, who is to do them and when they are to be done.

6A. 13 FOCUS OF MAINTENANCE POLICIES

- Reduces frequency of break-downs
- Reduces severity of break-downs
- Emphasizes preventive maintenance
- Provide extra machines, reduce utilization to reduce wear and tear.
- Replace parts to reduce number of break downs.
- Train operators and involve them in machine care.
- Train operators and involve them in machine repair.
- Over design machines for durability and redundancy, so that likelihood of break downs is reduced.
- Design machines for maintainability, emphasizing modular designs, quick change parts and accessibility, so that repairs can be made faster.
- Enhance maintenance department’s capability, new size, capability of repair facilities, cross training for personnel, flexibility etc.
- Increase supply of spare parts so that repairs can be made faster.
- Increase supply of stand-by or back up machines, devise alternative product routings or arrange parallel production lines, so that lost production is avoided in case of break-downs.
- Increase in-process inventories.

6A. 14 ORGANISATION OF MAINTENANCE DEPARTMENT

1. The building, plant and services are called by the accountant fixed assets and in many companies they from at least 50% of the money invested.
   In any company, small or big, it is therefore essential that some part of the main organization should be responsible for maintaining these important assets.

2. The section or department which preserves and looks after the upkeep of equipment, building etc., is called maintenance department.

3. To work satisfactorily, the maintenance department has an organization structure.

4. A few basic concepts of good organizations that should be kept in mind in developing an organization are:
   - A reasonably clear division of authority with little or no overlap.
   - Vertical lines of authority and responsibility should be kept as short as possible. In other words, a level which simply transmits information up and instructions down should be eliminated.
   - Keep optimum number of persons (3 to 6 is the average value) reporting to an individual.
   - Fit the organization to the personalities involved. This means that the organization structure should be flexible and it may be revised periodically to fit changing personnel and conditions.
5. The basic organisation structure of maintenance department depends upon.

(i) Types of maintenance activities to be looked after: The wider the maintenance field to be covered, the bigger is the organization.

(ii) Continuity of operations: The size of the maintenance force and therefore the structure of maintenance organization depends upon.
- Whether it is a four, five or six working days week, and
- Whether the plant runs in one, two or three shifts.

(iii) Size of the plant: The organization structure of the maintenance department varies with the size of plant. The larger the plant the more the number of persons in the maintenance force.

(iv) Compact or dispersed plant: A plant spread in a wider area (like ECII, Hyderabad) needs decentralization and may require parallel maintenance organizations. A compact plant may need only one such organization. The following shops within the maintenance department can be created, but depending upon the requirements, it will exist.
- Maintenance
- Repair
- Lubrication
- Construction
- Steam
- Power
- Water
- Air

(v) Nature of industry, i.e., whether it is primarily an electrical, electronics, chemical or a mechanical industry.

(vi) State of training and reliability of work force.

(vii) In establishing a maintenance organization, it is essential to recognize that
- The plant is to be maintained at a level consistent with low cost and high productivity;
- Supervisors should be appointed according to the duties and responsibilities involved, and modern age indicates greater need of newer engineering techniques and skills.

6A. 15 FUNCTIONS AND RESPONSIBILITIES OF DEPARTMENT

(i) Depending upon the size of the maintenance department, it has a wide variety of duties or functions to perform.

The work is under the control of plant engineer or maintenance engineer who normally reports to the Works Manager.

(ii) The different duties, functions and responsibilities of the maintenance department are as follows:

   (A) Inspection
• Inspection is concerned with the routine schedule checks of the plant facilities to examine their condition and to check for needed repairs.
• Inspections ensure the safe and efficient operation of equipment and machinery.
• Frequency of inspections depends upon the intensity of the use of the equipment. For example, belts in a machine may be checked every week; furnace equipment every month; in over-head bridge crane every four months and so on.
• Inspection selection makes certain that every working equipment receives proper attention.
• Items removed during maintenance and overhaul operations are inspected to determine the feasibility of repairs.
• Maintenance items received from vendors are inspected for their fitness
  
  (B) Engineering
  
  Engineering involves alternations and improvements in existing equipments and building to minimize breakdowns.
• Maintenance department also undertakes engineering and supervision of constructional projects that will eventually become part of the plant.
• Engineering and consulting services to production supervision are also the responsibilities of maintenance department.

  (C) Maintenance (including Preventive Maintenance)

  • Maintenance of existing plant equipment.
• Maintenance of existing plant buildings, and other service facilities such as yards, central stores, roadways, sewers etc.
• Engineering and execution of planned maintenance, minor installations of equipment, building and replacements
• Preventive maintenance i.e. preventing breakdown (before it occurs) by well – conceived plans of inspection, lubrications, adjustments, repair and overhaul.

  (D) Repair

  • Maintenance department carries out corrective repairs to alleviate unsatisfactory conditions found during preventive maintenance inspection.
• Such a repair is an unscheduled work often of the emergency nature, and is necessary to correct breakdowns and it includes trouble calls.

  (E) Overhaul

  • Overhaul is a planned, scheduled reconditioning of plant facilities such as machinery etc.
• Overhaul involves replacement, reconditioning, reassembly etc.

  (F) Construction
In some organizations, maintenance department is provided with equipment and personnel and it takes up construction jobs also.

Maintenance department handles construction of wood, brick and steel structures, cement and asphalt paving, electrical installations, etc.

(G) Salvage

Maintenance department may also handle disposition of scrap or surplus materials. This function involves:

- Segregation, reclamation and disposition of production scrap
- The collection and disposition of surplus equipments, materials and supplies.

(H) Clearical Jobs

(I) Maintenance department keeps records

- Of costs.
- Of time progress on jobs

- Pertaining to important features of buildings and production equipments, electrical installation, water, steam, air and oil lines, transportation facilities (such as elevators, conveyors powered trucks cranes, etc.

(J) Administration and supervision of labour force (of maintenance department)

(K) Providing plant protection, including fire protection

(L) Insurance administration

(M) Establishing and maintaining a suitable store of maintenance materials

(N) Janitorial services

(O) Housekeeping

- Good housekeeping involved unkeep and clearing of equipments, building, toilets, wash-room etc.

(P) Pollution and noise abatement

5A. 16 THE MAINTENANCE UNIT DUTIES

Many of the activities associated with effective preventive maintenance requires particular knowledge and training, meaning that maintenance is a specialized service. In order to take advantage of the benefits of specialization, all direct maintenance should be carried out by one unit under a maintenance manager, who may be responsible for duties other than the maintenance of equipment. Since the production operations unit employees the bulk of the physical assets of an organization, it will be found to be most satisfactory if the maintenance department is part of the production / operations manager’s responsibility. Separation between POM and maintenance inevitably leads to frustration and dysfunctions.

The duties of the maintenance unit include the care of plant, building and equipment, the installation of new equipment, and the supervision of new building. Typical sections of the maintenance departments are:

1. The equipment fitters, who install, maintain and repair all mechanical equipment.

2. The electricians, who install, maintain and repair all electrical equipment, including power plants and all communications equipment. A vital sub-section is the group of electronic specialists who look after the
increasingly important control systems so prevalent in today’s automated world. Although the actual maintenance of some of these may be in the hands of the owners of the equipment – for example, the telephone company or the local suppliers of electricity – all dealings with the owners should be through the maintenance department, so that individual complaints or should be made first to the appropriate maintenance supervisor(s)

3. The buildings, which include any carpenters, bricklayers, plumbers or painters. Included in the responsibility of this section may be the provision and unkeep of all fire-fighting equipment (hoses, extinguishers, sprays, sprinklers), unless a separate department exists only for this purpose, and the care and control of the heating and ventilating plant.

4. General laborers, who will carry out the moving of materials and equipments. These will usually include a ‘heavy gang’ equipment for and capable of manhandling bulky and heavy loads.

5. Cleaners, who will be responsible for all cleaning and sweeping, including the care of toilets and wash-places.

6. Sub-contractors, who are necessary to maintain specialist equipment, e.g. telephones, computer and office equipments.

Rules governing maintenance work in order that there should be some control over the work of maintenance, three rules should be enforced.

1. All request for formal maintenance work must be made (preferably in writing) to one central control point. No work should be carried out without the knowledge and approval of the maintenance supervision at that point. Lack of strict adherence to this rule will result in a wasteful use of skilled staff and an inability to keep to any schedule of essential work.

2. Maintenance stores must be as carefully controlled as any other of the company’s stores, as the absence of a vital part can lead to an expensive plant shut-down. On the other hand, excessive stocks can tie up valuable capital.

3. Records of all work carried out, including a statement of materials required, should be kept, as these may assist in setting rational maintenance, replacement and depreciation policies.

6A. 17 INFORMATION SYSTEM FOR MAINTENANCE MANAGEMENT

Maintenance management is a continuous function in any organization. It is highly essential to computerize the whole function for its effective operation mainly because of the following reasons.

6A. 42 PREVENTIVE MAINTENANCE RECORDS

It is very necessary to keep records because they are the only reliable guides for measuring the effectiveness of the preventive maintenance programme. Only records tell us, what is the situation at present and where it is going.

Good updated records, proper filing equipment and adequate clerical help are the backbone of PM programme. Record keeping is also necessary.
(i) When budgeting for major overhauls.
(ii) When budgeting for general maintenance costs
(iii) For finding equipment reliability
(iv) For determining frequency of inspections
(v) For preparing maintenance schedules.
(vi) For predicting equipment life
(vii) For designing maintenance cost control system
(viii) For equipment replacement analysis
(ix) For carrying out cost reduction studies (e.g. value analysis)

Guidelines to good PM records

- Minimize the number of forms and entries
- Integrate PM system with other manufacture paper work system in order to reduce administrative cost
- Account for costs of all primary PM inspections in order to show what exact costs are and how far the PM programme is justified.

Arrange for a periodic control report (weekly or monthly) to check on PM performance.

Records should show

(i) Type of equipment and its description
(ii) Whether it is a key item?
(iii) Name of the manufacturer
(iv) Cost and date of purchase of the equipment
(v) Location of the equipment in the factory
(vi) Equipment identification (e.g chassis) number
(vii) Inspection of job specification reference number
(viii) Estimated cost of inspection and the cost and data planned repairs
(ix) Breakdowns, their dates and reasons
(x) Cost of breakdowns and other associated implications

What spare parts to keep and how much to keep depends upon:

- The past experience
- Advice from plant manufacturers
- The cost of buying and storing the spares
- The cost of having idle plant waiting for spare parts in case of a breakdown or at the time of need.
The ease or difficulty with which the spare parts can be made available when required.

Whether spare parts are standard or not.

Spare parts once procured should be stored adequately in order to locate them immediately at the time of need. For this,

(i) Spare parts should have stamped code number

(ii) The stock card may be identified by this number

(iii) The bin or rack, in which the part is lying, should have its location reference number recorded on the stock card.

(iv) Spare parts for an equipment may be grouped together and referred to by their plant number

(v) For locating a part, the storekeeper would first check the stock card bearing the plant number and take down the bin (or storage rack) reference number. Then, by the code number of the part, he will identify the required spare part from the many parts lying in that bin.

A PM programme be coordinated and must remain under control at all times.

To maintain control of the PM programme, the following measures should be taken:

(i) Periodic review of PM programme with the operating department

(ii) Review of monthly reports of PM inspections

(iii) Analytical approach to the evaluation of PM

6A. 43 Advantages of PM

1. Reduced breakdowns and connected down-time

2. Lesser odd-time repairs and reduced overtime to the maintenance work-force.

3. Greater safety for workers

4. Fewer large-scale and repetitive repairs

5. Low maintenance and repair costs

6. Less stand-by or reserve equipment, and spare parts.

7. Identification of equipments requiring high maintenance costs

8. Lower unit cost of manufacture

9. Better product quality and fewer product rejects

10. Increased equipment life

11. Better industrial relations because production workers do not face involuntary lay-offs or loss of incentive bonus because of breakdowns
6A. 44 PREDICTIVE MAINTENANCE

It is comparatively a newer maintenance technique

It makes use of human senses or other sensitive instruments such as Audio gauges, Vibration analyzers, Amplitude meters, Pressure, temperature and resistance strain gauges, etc. to predict troubles before the equipment fails.

Unusual sounds coming out of rotating equipment predict a (coming) trouble; an electric cable excessively hot at one point predicts a trouble.

Simple hand touch can point out many unusual (equipment) conditions and thus predict a trouble.

In predictive maintenance, equipment conditions are measured periodically or on a continuous basis and this enable maintenance men to take a timely action such as equipment adjustments, repair or overhaul.

Predictive maintenance extends the service life of equipment without fear of failure.

A.45 PLANT MAINTENANCE SCHEDULE

Maintenance scheduling follows a similar procedure to that outlined for production. it is required to know that how long a job will take, when it should be done and if resources are available.

As explained earlier, scheduling means determining calendar inspection dates that will fulfill the frequency requirements in the most efficient way.

6A. 46 SCHEDULING

- System should be clear, precise and easy to operate,
- Should be based upon accurately determined time standards
- Should be finalized in consultaont with prductoin department so that the equipments for maintenance purposes can be spared.
- Should aim at creating a balanced work load on each trade section in the department, that is, each section should be evenly loaded.
- Maintenance scheduled should be flexible

Maintenance schedule should

1. Be such that, the maintenance work can be carried out during lunch hours, between shifts or at week ends etc.
2. Take advantage of planned machine stoppages such as tool changes, loading and unloading of job etc.
3. Plan major repairs and overheads during holidays,
4. Make use of reserve plant if the need arises

6A. 47 MAINTENANCE SCHEDULE PROCEDURE

The scheduling of maintenance work involves essentially two steps:

1. Preparation of master maintenance schedule
2. Preparation of Detailed weekly or daily schedule
Master maintenance schedule indicates the nature and magnitude of each repair and construction task segment of maintenance for a specified time span.

Considering, total man hours needed for each task segment and the manpower available, the distribution of jobs (that will have reasonable man loadings, and can be accomplished) is done. A master schedule is flexible and a cushion always exists to accommodate, unanticipated tasks and jobs which are lagging behind schedule.

Detailed schedules are prepared by breaking overall time spans allocated under master schedule.

Detailed weekly work schedule provides information to each craft and shop regarding the task to be carried on each job for each day in the coming week.

Detailed scheduling requires records of work capacity of each section of the maintenance department and of the maintenance department as a whole.

List master schedule, the detailed schedule should also be flexible and able to accommodate emergency jobs.

Detailed schedule may be issued to concerned persons every day or near the week-end.

Maintenance schedule of each machine may be prepared and it will indicate the list of works which must be carried out (together with the frequency) and will contain servicing, adjustments, lubrication details and particulars of replacement work. Fig. 13.3 shows the schedule of maintenance.

6A. 48 SCHEDULING TOOLS

They are classed as

- Visual charts
- Scheduling boards
- Individual cards

6A. 49 STANDARD DATA MAINTENANCE

No maintenance programme can be accurately developed and maintained without various standards such as:

(i) Time standards which indicate the time to complete a maintenance job

(ii) Lubrication standards which mark the interval between lubrications, etc.

6A. 50 uses of maintenance standards

- Planning and scheduling maintenance work
- Providing fair number of maintenance – men
- Measuring the output or effectiveness of performance of maintenance – men
- Providing incentive earnings for maintenance – men
- Setting and using Standard Data

Owing to the variable, non-repetitive nature of maintenance work, a great deal of technical study is required before the standard data assembled represents sufficient coverage of the work to do effective planning.

Standard data derived from the studies is probably the most widely used system for applying sophisticated labour control to maintenance departments.
For individual concern, to collect standard data, would require many engineering hours and thus make it prohibitive because of initial cost. However, there are management consulting firms who have assembled standard data (for maintenance) and have established programmes that are available to clients for installation of maintenance controls.

6A. 51 ORGANISATION FOR MAINTENANCE

Organisation structures for maintenance vary across companies, the deciding factors on a particular type being the nature of industry (electrical, chemical, or mechanical); size of the plant; and the scope of activities to be performed.

The maintenance department is headed by the plant engineer. Other titles in use include maintenance superintendent, superintendent of maintenance and the manager of maintenance.

One interesting feature of the organisation structure for maintenance is the presence of craftsmen, electricians, plumbers, mechanics, painters, helpers, pipe fitters, and the like are seen rubbing shoulders among themselves, and carrying ropes, wires, spanners, oil and cotton waste in their hands. This is in contrast to other department in a plant. The presence of craftsmen is justified by the nature of the job involved.

Job and cost control as a part of maintenance department. Why is this section important? This section is responsible for Production and Operations Management scheduling work for the maintenance staff and for maintaining cost, figures on all jobs. It makes possible the efficient utilization of the craftsmen.

The maintenance department is primarily a service department and as such, is a part of the plant's staff. Generally, the maintenance department is attached to the production function. The head of the department reports to the works manager.

6A. 52 CONTROL OF MAINTENANCE

Maintenance involves cost, and the cost is quite high. Hence the need for control. Control is facilitated by the following measures:

(a) Maintenance work must commence only after it has been authorized by a responsible official.

(b) Maintenance schedule must be prepared stipulating the timing of maintenance and number of staff required.

(c) Materials such as bearing must be issued by the storekeeper against proper authorization from the maintenance department.

(d) Maintenance budgets must be prepared and used to determine whether the actual expenses are within estimates.

(e) Equipment records must be maintained. Information from the records will be useful when ordering parts or when seeking clarification form the equipment supplier.
FIGURE: 6.1 MAINTENANCE COSTS

Management should give serious thought to certain issues – issues which have bearing on maintenance costs. The questions are:

(i) How much maintenance is needed?
(ii) What size maintenance crews should be used?
(iii) Can maintenance be sub-contracted?
(iv) Should maintenance staff be covered by wage incentive schemes?
(v) Can effective use be made of computers for analyzing and scheduling activities?

6A. 54 TRENDS IN MAINTENANCE

Several trends are taking place in the maintenance field. Increasing attention is being paid to the design of buildings, facilities, and processes to eliminate as much maintenance as possible. There is greater emphasis on manufacturing system reliability and procurement of equipment with a prescribed level of quality assurance. Maintenance engineers will be using statistical tools to pinpoint problem areas, so as to justify the need for equipment replacement periodically. Maintenance staff too need to be upgraded to cope with the challenges of complex manufacturing systems.

Special training programmes have sprung up to give maintenance workers, the skills necessary to service and repair today’s specialized equipment.

Sub-contracting service companies have developed to supply specialized maintenance services. Computers, automobiles, office machines and other products are increasingly serviced by outside sub-contracting companies.

Other technologies are developing that promise to reduce the cost of maintenance, while improving the performance of production machines. An example is the network of computerized temperature sensing probes connected to key bearings in a machine system. When bearings begin to fail, they overheat and vibrate, causing these sensing systems to indicate that a failure is imminent. The massive damage to machine that can happen when bearing fail – snapped shafts, stripped gears, and so on – can thus be avoided.

Computers have entered the maintenance functions in a big way. Five general areas in maintenance commonly use computer assistance today. They are:

1. Scheduling maintenance projects;
2. Maintenance cost reports by production department, cost category and other classifications;
3. Inventory status reports for maintenance part and supplies;
4. Part failure data and

5. Operations analysis studies which may include computer simulation, waiting lines and other analytical programmes.

Information from these uses of computers can provide maintenance staff with necessary failure patterns, cost data and other details fundamental to the key maintenance decisions. Computers, robots and high tech-machines cannot replace people in the maintenance function. One important trend is the involvement of production workers in repairing their own machines and performing preventive maintenance on their own machines.

Maintenance today in production management is more than simply maintaining the machines of production. Maintenance function is expected to sub serve the overall objectives of the organisation – better customer services, higher return on investment, increased product quality and improved employee welfare.

6A. 55 PLANNING THE PROGRAMME

A routine maintenance programme can be set up as follows:

1. List all work which is required to be carried out I external authorities:

   (a) The washing and/or the painting of all inside walls, partitions, ceilings and staircases.

   (b) The thorough examination, followed if necessary by an overhaul and accompanied by a written report issued by a competent person, of all lifts, lifting equipment, cranes, hoists, boilers, weighing machines, large computers, postal and insurance franking machines etc.

2. List, with the frequency required, all work deemed desirable by the appropriate manager. This will include the overhaul and servicing of all machines and items of plant, including office equipment, computers and any company cars or other transport. The frequency of maintenance may need to be set initially by the ‘best’ guess or manufacturer’s recommendations but thereafter it should be verified against records kept of performance and breakdown.

3. Prepare standard documentations and instructions covering the maintenance required on each item listed. These instructions should be in detail and should avoid the ‘overhaul as necessary’ type of instruction. The purpose to which the equipment is put should be considered when deciding the scale to which the maintenance required, as identical pieces of plant being used for different purposes may well need entirely different levels of maintenance. In setting up these standard instructions, CPA can be invaluable in examining and determining the methods and in instructing the staff on all type of maintenance, from short-duration overhauls, with individual activities of only a few minutes, to very lengthy plant shut-downs.

4. Prepare a plan of work covering at least 12 months, in such a way that no maintenance section is in any way overloaded. This is very conveniently done on a Gantt chart, or one of the equivalent computerized planning programs or the control of maintenance work which are commercially available.

5. From the plan, issue instructions to the appropriate staff when necessary, requiring them to carry out work, and record on the plan when the work has been done.

6. Carry out post-maintenance audits to verify the times allowed for various tasks and to provide information for future policy making.

To ensure that all items of equipment are included. It is desirable to number them and then to make a plant register. At the outset, this must be prepared from a physical inventory which is then checked against the organization’s asset register. Thereafter it should be kept up-to-date by an information system that reports every piece of equipment purchased, replaced or removed.
The effectiveness of a maintenance policy and programme should be judged not on the vigor with which emergency repairs are carried out but on the freedom from such emergencies.

6A. 56 MAINTENANCE IN OPERATION

Maintenance staff will need to make decisions about whether to repair or replace items, components or parts of equipment and when to carry out scheduled maintenance. Reliability data can be a useful aid, and may clues will come from the bath-tub shaped curve. The above situation implied that failure brings with it penalties so large that replacement must be carried out upon or before failure. In some situations the costs incurred by failure are such that inactivity, both of equipment and of the maintenance department, can be tolerated until some convenient time has elapsed, for example until a specific number of items are not working or until a shift has ended.

In this case, it is necessary to balance the costs due to inaction against the costs of replacement. Here again, it is necessary that information concerning failure frequency rates and replacement costs are available, as well as the costs due to inactivity. The necessary criterion then is that the cost attribute to inactivity during time $T$ must be less than the cost of replacement at time $T$.

Knowing the various failure parameters, the above conditions enable the optimum replacement time to be calculated.

6A. 57 REPLACEMENT DUE TO DETERIORATION

Inevitably, all equipment deteriorates with time, although in some cases the time span may be extremely long. To decide whether equipment should be replaced is a problem similar to that considered under the heading ‘Capital expenditure budgets – depreciation and DCF. Here one of the pieces of equipment being considered is the existing plant, and it is this which is compared with the alternative equipment/plant available. Clearly the various factors refer to the values applicable at the time when the appraisal is being made, not the initial values which were relevant when the plant or equipment was first installed.

6A. 58 MAINTENANCE AUDIT

Under this stage, a thorough review of existing systems and practices in the maintenance department including documentation flows, assets coding, work patterns job resourcing, job costing, feedback, stock control, information systems, etc is done.

6A. 59 STRATEGY DEVELOPMENT

Guidelines provided by the maintenance audit assist the development of the strategy of implementing and using the computer system. Existing documentation and procedures may be modified, or the computer programmes may require modifications to match existing systems. Decisions on full-scale or stage-by-stage implementation must be made. The effects on existing staff, and the possible training requirements must be considered. A timetable must be prepared and any additional resources (programming, consultancy, document printing) are arranged.

6A. 60 INPUT DATA AND RECORDS

The existing records, schedules, manuals, instructions, stock books, specifications, service contracts, etc must be examined, and arrangements are to be made for the transfer of the relevant data to the machine. The assets register, preventive maintenance schedules, statutory maintenance tasks, service contracts and stock records are usually the first to be processed.

6A. 61 OUTPUT REPORTS

Some of the outputs to be obtained from the database are as follows:

- Costs
Utilization
Stock control
Maintainability and reliability
Management ratios
Asset statistics Costs

The different costs reports which are to be generate are as follows:
- Costs for each machine
- Costs for each building
- Costs for areas or locations
- Costs for each type of maintenance
- Costs for each person
- Asset renewal costs

6A. 62 UTILIZATION

The different utilization reports which are to be generated are downtime, hours, downtime costs, loss of production, consequential loss, maintenance costs, downtime trends, manpower utilization, spare parts stocks, and maintenance standards.

Stock control: Under this category, report on spare parts used, materials used, stock level changes, and strategic spare parts are generated.

Maintainability and reliability: Under this category, report on access problems, shutdown plans, liaison with users, excess maintenance, design problems, defect statistics and failure patterns are to be generated.

Management ratios: under this category, report on maintenance planned / achieved, maintenance / asset costs, preventive / corrective ratios, emergency / corrective ratios, budget variations, downtime / uptime ratios, spares used / spares stock ratios and manpower utilizations are to be generated.

6A. 63 ECONOMIES OF MAINTENANCE

Maintenance is a costly activity. It is one of the sizeable indirect costs that enter into manufacturing and hence it should be given considerable attention by the operations managers.

Total cost decreases up to point M under preventive maintenance and beyond this point, an increasingly higher level of preventive maintenance is not economically justified. The level or degree of maintenance at point M, which gives the minimum total maintenance cost is known as the optimal level of maintenance activity or ideal level of maintenance. At the optimal level of maintenance activity of maintenance, preventive maintenance cost equals the break-down maintenance cost.

Optimal level of maintenance activity is easily identified theoretically, in practice this necessitates knowing a good deal about the various costs associated with both preventive and break-down maintenance activities. This includes knowledge of both the probability of break-down and the amount of repair time needed.
Deciding on the size of maintenance crew is a specified application of the concept of minimizing the total of preventive and break-down maintenance costs. When the crew size is increased, the down-time costs tend to be decreased but the cost of hiring the maintenance crew increases.

The crew costs are part of the overall preventive maintenance cost and the down-time costs constitute a part of the breakdown maintenance costs.

The maintenance models described in the next section illustrate how the preventive and break-down maintenance costs can be estimated and compared in order to minimize the total maintenance costs.

6A. 64 TOTAL PREVENTIVE MAINTENANCE (TPM)

Well – designed preventive maintenance plans can reduce the incidence of emergency maintenance. In the production of standardized product design along flow lines, where there is little if any work-in-progress between adjacent operations, an equipment break-down at one operation will quickly cause all other downstream operations to come to a standstill. This situation can arise just as easily in the supply of cheeseburgers in a ‘burger-bar’ and the preparation of letters of credit in a bank as in the assembly of motor cars. An extensive preventive maintenance programme is essential to reduce the frequency and severity of work flow interruption in these situations.

In automated production environments, again not restricted to manufacturing, preventive maintenance programmes must be part of the POM policy. Where automated equipment operates continuously, without the need for operatives, human intervention will be required in the form of a maintenance unit to keep the equipment lubricated, adjusted and generally operating in good condition. As automation increases throughout various types of operation, there will be a need to move to smaller production workforces and larger maintenance crews. Hence, some of the production operatives replaced by robotics and computer-aided systems will require retraining to provide the necessary increase in maintenance staff.

Because of the increasing introduction of just (JIT) methods, in which in-process stocks and batch sizes are reduced to vary low levels, the near – absence of work-in-progress will focus attention on equipment and system failure. JIT demands perfect equipment maintenance, since breakdowns cannot be tolerated. It is not sufficient to speed up repairs to minimize down-time breakdowns must be eliminated through an effective prevention strategy.

Where operatives are employed in productions, this strategy requires their total involvement. They must be given the responsibility for preventing equipment failure by conducting checks, inspecting, lubricating and adjusting their own equipment with meticulous attention to detail. Just as in the achievement of quality of conformance, operators must be given the tools to do this, and this means providing the appropriate training to be able to detect, find and eliminate potential causes of trouble before they manifest themselves in a system failure.

6A. 65 ASPECTS OF MODERN MAINTENANCE

Technology is increasingly complex, with electronics, robotics and computer control now influencing every walk of life. These have clearly led to many changes in maintenance activities. Special and continuous training programmes are required to provide the necessary knowledge, understanding and skills to service the increasingly specialized equipment and to keep up with the developments in the field. Specialist organisation have developed to provide maintenance services on a sub-contract basis, and transport vehicles, computers, office equipment and medical support system are often serviced by outside companies. the specialized technical knowledge and skills are frequently more economical to acquire on a call-in fee basis than an in-house team.

The advances in technology have enabled the development of systems which reduce the cost of maintenance while imporving operational performance. These are usually computer-based devices which enable the detection of faults before serve difficulties, and even damage, occur. For example, sensing devices may be installed to monitor factors such as vibration, local temperatures, pressures, consumption of lubricants, changes in electrical resistance, composition of products from a chemical plant, etc. Chaners in such factors often indicate changes in the condition of equipment and can give timely warning of approaching, failure. This approach has been called predictive
maintenance and can usefully be coupled to a preventive maintenance policy. Computers can of course, be used in the actual maintenance for:

(a) Planning maintenance;

(b) Financial control of maintenance;

(c) Spare part inventory control;

(d) Reliability and failure data collection and analysis

(e) Operational research models applied to maintenance, e.g. queuing theory and simulation.

Model maintenance management is far more than repairing and servicing equipment. The perspective of maintenance must be broadened to the long-range performance aspects of the complete customer service system. Failure of any component in that system can cause total disaster, and the viability of the whole organisation is dependent on effective maintenance policies and operations.
6B. QUALITY CONTROL

6B. 1 QUALITY

Quality is that characteristic or a combination of characteristics that distinguishes one article from the other or goods of one manufacturer from that of competitors or one grade of product from another when both are the outcome of the same factory. Quality of a product is one of the most important assets which a manufacturing concern should try to acquire to win the confidence of the people using it.

Quality of a product is defined as its fitness for the purpose for which it is made. Many characteristics of the product like its shape, colour, surface, finish etc. determine the quality of the product.

6B. 2 CONTROL

Control may be defined as the comparison of the actual with the pre-determined standards and specifications. Control locates the deviations and tries to remove them.

6B. 3 MEANING

Quality of a product depends upon the interaction of materials, men, machines and manufacturing processes. The systematic control of these factors is the quality. The quality of these factors varies greatly due to these for example, a skilled worker will produce products of better quality and a less skilled worker will produce poor quality products. Similarly, better machines and better materials with satisfactory manufacturing conditions produce a better quality product. So, if we want to control the quality of the product, it is necessary that we should control the factors responsible for quality.

6B. 4 DEFINITION

Afford and Beatty define Quality control as follows:

Quality control may be defined as that industrial management technique or group of techniques by means of which products of uniform acceptable quality are manufactured’.

Another definition by Better, Atwater and Stackman states the term as follows: “Quality control refers to the systematic control of these variable in a manufacturing process which affects the excellence of the end product. Such results very from the application materials, men, machines – manufacturing conditions”.

6B. 5 OBJECTIVES OF QUALITY CONTROL

The following are the main objectives of quality control.

- To decide about the standard of quality of a product which is easily acceptable to the customer.
- If the quality of product is falling down manufacturing, then to determine the different steps to check this deviation.
- To verify whether the product conforms to the predetermined standards.
- To take necessary steps so that the products which are below the standard do not reach to the customers.
- To take different measures to improve the standard of quality of product.
- To develop quality consciousness in the various sections of the manufacturing unit.
To reduce the wastage of raw materials, men and machines during the process of production.

In certain big concerns, a separate department known as Quality control department is established. Now, let us see some of the functions of the Quality Control Department.

6B. 6 FUNCTIONS OF THE QUALITY CONTROL DEPARTMENT

Quality Control department has the following important functions to perform:

- To ensure that only the products of uniform and standard quality are allowed to be sold to consumers.
- To suggest methods and ways to prevent the manufacturing difficulties.
- To reject the defective goods, so that the products of poor quality may not reach to the consumers.
- To find out the points where the control is breaking down and investigate the cause of it.
- To correct the rejected goods, if it is possible. This procedure is known as Rehabilitation of defective goods.
- To help increase the sales of the product so, in short, we can say that Quality Control is a technique followed in industries to improve industrial efficiency concentrating on better standards of quality.

So far, we have discussed about the quality control. Now, let us discuss the various aspect related to Inspection.

6B. 7 INSPECTION

Inspection is the function to judge the quality of a product. It also means checking the acceptability of the manufactured products. Dr. W.R. Sprigal says that “Inspection is the process of measuring the quality of a product or service in terms of established standards.

According to Alford and Beatty “Inspection is the are of applying tests, preferably by the aid of measuring appliances to observe whether a given item of product is within the specified limit of variability”

6B. 8 OBJECTIVES OF INSPECTION

a. Inspection separates defective components from non-defective ones and thus ensures the adequate quality of products.

b. Inspection locates defects in raw materials and flows in processes which otherwise cause problems a the final stage.

c. Inspection prevents further work being done on semi-finished products and thus checks the work of designers.

d. It also helps to establish and increase the reputation by protecting consumers from receiving poor quality

So, far achieving these objectives there is inspection in every organisation and its cost has to be borne by the employer but if there is no inspection the products of poor quality may reach to the consumers. Material wastage and
spoilage will be more. In order to avoid all these problems, it is imperative that every firm should have an Inspection Department.

6B. 9 QUALIFICATION OF INSPECTORS

In order to carry out the responsibilities the Inspector should possess certain special qualifications. The various qualities required of an Inspector are as follows:

- He should know his job thoroughly. For this, he should possess a sound technical background.
- He should be brilliant, and should possess a sound grasping power.
- He should be thorough with the Statistical Quality Control (SQC) Programme.
- He should have the working knowledge of the general quality standard.

6B. 10 PRINCIPLES OF INSPECTION

While carrying out the Inspection work, certain principles have to be followed. The two most important principles of Inspection are:

a) The Inspection function must be independent but should coordinate with the function of functions of production, planning and sales departments.

b) Improvement in quality performance is achieved as a result of changes in Engineering specifications or manufacturing procedures and not by inspection techniques.

6B. 11 INSPECTION STANDARDS

To meet the requirements of quality control certain standards have to be set. Standards are important for the following.

a) Inspection standards for raw materials
b) Inspection standards for work in process
c) Inspection standards for finished products
d) Inspection standards of the completed mechanism

6B. 12 KINDS OR TYPES OF INSPECTION

Because of the various varieties of the manufactured products, and the wide differences in comparative qualities, the following types of Inspection are recommended for various concerns. Special Inspection techniques may also be adopted in certain individual cases according to local requirements.

The Inspection Types are:

- Tool Inspection
- First piece Inspection
Now, let us discuss the above Inspection methods in detail:

1. Tool Inspection: Under this method, tools, fixtures, jigs and gauges are inspected in advance to the work of production.

2. First piece Inspection: In the case of automatic machines, first 2 or 3 products are inspected. And, if they are found to be satisfactory, it is assumed that the work has begun correctly and the output will be satisfactory. Further production is continued after this inspection.

3. Periodic Inspection: Under this Inspection, Inspection is undertaken at definite intervals to make sure that they are being produced after following the required standards.

4. Sample Inspection: In this, certain percentage of finished products are drawi from a lot and inspected and the entire lot is judged by the result of these samples.

5. Operation Inspection: Inspection is done as the completion of operation before the work in process passes to another operation or machine or department.

6. Working Inspection: In this type, articles are inspected when they are completely manufactured before sending them to store.

7. Pilot piece Inspection: This method is used in product layout. The product is passes through is entire sequence of operations on a series of machines, installed for producing that product. After one piece is manufactured, each tool, each machine is tested so that all detective tools are replaced and all incorrect adjustments are made alright, when a good product starts coming. The production line is allowed for actual production.

8. Key operation Inspection: Certain operations in a manufacturing cycle may be difficult. Such operations are known as key operations. Inspection is done prior to and immediately after the completion of each of these operations.

9. Functional Inspection: This Inspection is carried out after the completion of the assembly to assure it will function as required.

10. Endurance Inspection: This Inspection is carried out to estimate, how much time an assembly will withstand its use and to determine weakness for correction.

6B. 13 CLASSIFICATION OF INSPECTION

The above classification is based on methods. Apart from this, Inspection is classified on the basis of the location of the work spot. Classification based on it is given below:
a) Floor or Decentralized Inspection

b) Centralized Inspection

6B. 14 FLOOR OR DECENTRALIZED INSPECTION

Floor or Decentralized Inspection means inspection on the point of production. It requires the inspector fully equipped with all their devices or equipment to go to the point of work and visit the machines and check the materials coming out from the machine on the spot.

ADVANTAGES OF FLOOR INSPECTION:

a. Materials movements are avoided because after production, inspectors visit the spot where the finished products are kept and inspect them. This saves time considerably.

b. Errors are rectified on time

c. Delay at Inspection room is avoided and it results in time saving and reducing the indirect labour cost.

d. The work of routing, and scheduling can be eliminated

e. Work flow is maintained

DISADVANTAGES

- Under this method, inspectors have to move from one area to another and his time is wasted.
- Keeping a track of good or bad products is slightly difficult.
- The Inspectors have to carry with them their Inspector kit.
- Some time work may pile up at work stations. Even after completing their work, workers sometimes have to wait for inspection.
- Presence of large quantities of work on the floor complicates to keep work moving.
- There may be delay in deciding doubtful cases
- Highly qualified and skilled workers have to be employed. And,
- There are chances that some Inspectors may favour some workers.

6B. 15 CENTRALIZED INSPECTION

Centralized Inspection is quite opposite to floor Inspection. In this kinds, Inspection is carried out in Inspection rooms. Under this type, there will be one Inspection room for the entire factory or a number of Inspection sections maintained on different locations of the plant. The parts or products to be checked are moved to the Inspection rooms where various measuring devices are located. After inspection, the necessary materials are returned to the respective departments with necessary instructions. The main idea in this type of Inspection is to separate Inspection from manufacturing. Centralized Inspection provides better conditions for inspection such as required temperature, and dust-free environment etc.
6B. 16 ADVANTAGES OF CENTRALIZED INSPECTION

The various advantages of the centralized inspection are as follows:

a. Centralized inspection can be carried even with the help of less skilled inspectors.

b. Interference is less and supervision of inspection work is better.

c. With the aid of fixed and automatic inspection devices, mass inspection at lower costs is possible.

d. Because of better working conditions and less interferences, inspectors can check the products with higher speed.

e. Accurate inspection with delicate instruments can be done under controlled atmosphere.

f. Less number of gauges and instruments are required.

g. Decisions of doubtful cases can be taken at once by authority.

h. The shops mostly remain neat and clean as there is no accumulation of finished parts.

6B. 17 DISADVANTAGES

- Material handling is more
- Delay at inspection room causes wastage of time
- Workers will come to know their weak points much after the completion of jobs.
- Routing, scheduling and dispatching includes the Inspection Room, so the work of production control increases.
- Due to non-detection of machine errors in time, there may be more spoilage of work.

6B. 18 STATISTICAL QUALITY CONTROL (SQC)

One of the tools of Inspection is Statistical Quality Control, popularly known as SQC. Let us, now, discuss at length various aspects pertaining to SQC.

Statistical Quality Control (SQC) is the application of statistical tools and techniques to determine how far the product conforms to the standards of quality and precision and to what extent its quality deviates from the standard quality. The purpose of statistical quality control is to discover and correct only those forces which are responsible for variations outside the stable pattern. The standard quality is pre-determined through careful research and investigation.

While manufacturing the commodities, it is impossible to ensure 100% perfection in output. So, deviations are bound to occur. Under these inevitable conditions, certain deviations are allowed or tolerated. They are referred to as tolerances. If the products are within the tolerance limits, the product is considered to be of good and standard quality. SQC brings to light the deviations outside these limits.

6B. 19 TECHNIQUES OF STATISTICAL QUALITY CONTROL

The techniques of Statistical Quality Control can be divided into two major parts.
Control chart is a technique of SQC and is a graphical presentation of the collected information. A control chart detects variations in the processing and warns, if there is any departure from the specified tolerance limits. The central line shows the average size. The other two lines one below the Central line and the other above the Central line indicate LIL limits of tolerances. Deviations are permitted within the tolerance limits. Those measurements values which fall outside the tolerance limits are considered to be out of control points. According to the deviation, the manufacturer will initiate corrective actions to maintain the quality.

6B. 2 TYPES OF CONTROL CHARS IN SQC

There are may types of Control Charts, Important among them are:

1. X and R chart for process control
2. P chart, for analysis of fraction detectives
3. C chart, for control of number of defects per unit.

6B. 22 X – CHART AND R – CHART

This chart is used for the quality characteristics which specified as variables i.e., on the basis of actual readings. The purpose of these charts are:

- To establish whether the process is in Statistical Continuum or not.
- To determine whether the process capability compatible with the specifications.
- To detect trends in the process so as to assist in planning adjustment and resetting of the process.
- To show when the process is likely to be out of Control.
6B. 23 C CHARTS

C charts are prepared where defective items are taken out by the number of defects in one item. Items which are according to specifications are termed as standard items. Items which have one or more defects, it means they do not fulfill one or more of the given specifications. All defects are not of the same value. so, we may like to control the defects per unit.

The number of defects in a piece is expressed as:

- Total no. of defects found in the sample
- Total no. of pieces in the samples inspected.

The quality characteristics in such cases are the number of defects per unit. C Chart is an improvement over P chart.

1. It is the control chart in which number of defects in a piece or a sample is plotted.
2. It controls number of defects observed per unit or per sample
3. Sample size is constant.
4. The chart is used where average number of defects are much less than the number of defects which would occur otherwise if everything possible goes wrong.
5. Where P chart considers the number of defective pieces in a given sample C chart takes into account the number of defects in each defective piece or in a given sample. A defective piece may contain more than one defect, for example, a case pert may have blow holes and surface cracks at the same time.
6. The C chart is preferred for large and complex parts But, the sue of C chart is limited. Ten castings were inspected in order to locate defects in them. Every casting was found to contain certain number of defects as given below, it is required to plot a C – Chart and draw the conclusions.

Since all the values of C lie within the control limits, the process is under control. (Lower control limit is negative and thus has been taken as being zero)

6B. 24 APPLICATION OF CONTROL CHART

Control charts finds applications in controlling the quality characteristics of the followings:

1. Final Assemblies (Attribute charts)
2. Bullets and shells (Attribute charts)
3. Soldered Joints (Attribute charts)
4. Punch press works, forming (Attribute charts) and spot welding etc.
5. Castings and cloth lengths (Attribute, C charts)
6. Defects in components (C charts) made of glass
7. Large and complex products (C charts) like bomber engines, turbines etc.
8. Manufactured components like Shafts, spindles, ballpens, holes, slots etc. (Variable charts)
9. For studying tool wear (Variable charts)
10.Incoming material (Attribute or variable charts)

6B. 25 ACCEPTANCE SAMPLING

The previous chapters centred around Control charts. In the following paragraphs, we shall discuss about the other technique of the Statistical Quality Control known as ‘A Sampling’.

Sampling is a tool or technique of statistical Quality Control. Webster defines it as: 'A samples as a product to represent the quality of the whole lot.' For example, if we purchase a bag of brinjals, only a few brinjals can be observed from the whole bag. But, we draw an inference about the whole bag only by inspection a few.

If these brinjals are good, it is assumed that all the brinjals in that bag will be alright. In the same way acceptance sampling is verifying the quality of the product, that has already been produced. Under this, sampling technique, a sample is selected at random to examine whether it conforms to the pre determined standards or not. It is also assumed that a certain percentage of goods will not conform to the standards. So, a certain percentage of defective products in a lot may be specified.

The basic concept of sampling lies in testing the samples for acceptance or rejection. Some products such as electric bulbs, radio values, razor blades, bolts etc., require to be subjected to destructive test so as to ascertain their life. A cent percent inspection and testing for the above products is not possible and at times the cost of inspection is also very high. So, for these products acceptance sampling is widely used. Under this method, samples are collected at regular intervals and subjected for inspection.

6B. 26 BASIS OF SAMPLING INSPECTION

The basis of sampling inspection can be divided into two:

- Variable basis
- Attribute basis

VARIABLE BASIS
Under this type, inspection of samples, is conducted on measurement (variable basis). i.e. on the basis of actual readings taken:

Examples of variables are dimensions in mm, hardness in units, operating temperature in Fahrenheit; percentage of a particular item in a chemical compound, life in hours of an electric bulb etc. variables are dealt in X and R control charts.

ATTRIBUTE BASIS

In this, inspection of samples is conducted on ‘Go’ and NOT ‘Go’ basis i.e. determining whether or not the product in the sample conforms to the specified tolerances. Many requirements are necessarily stated in terms of attributes rather than variables. For example, whether the glass cover of a pressure gauge is cracked or not, the surface finish of the top of dining table presents a satisfactory appearance or not. This acceptance sampling has all the limitations of sampling technique. There are two limiting levels of quality in an acceptance sampling plan. They are:

- It is determined for each defect characteristic and denote in terms of percent defective i.e. percent of defective units to the number of units inspected.
- It also represents the lowest percentage of defectives which a buyer is expected to accept seller is expected to supply. So, it involves production risk.

6B. 27 THE LOT TOLERANCE PERCENTAGE DEFECTIVE (LTPD)

LTPD represent a limit at which the buyer wants to be certain that the lot will not be passed. LTPD is related to ‘consumer’s risk. It also determines that before he removal of any rejects whether or not the product is being manufactured under satisfactory control.

6B. 28 ADVANTAGES OF SQC

So far, we have discussed the two techniques used by the ASQC. Now, we shall discuss the advantages of ASQC.

1. Improved in the quality of product. This is achieved by maintaining quality of the incoming materials the manufacturing process and the finished product.
2. Reduction of scrap and rework: SQC uses sampling inspection method to check the incoming material. Only good quality material enters the production line. Quality of the product at different stages of production is controlled using control charts. This prevents production of defective products.
3. Uniform in quality: Using Control charts, the quality of the product maintained within the limits (upper and lower limits).
4. Time and cost of Inspection reduced. Since only sampling method, is used, the cost inspection is very less.
5. Consumer satisfaction: SQC satisfies production department as well as the customer.
6. Develops Quality consciousness: SQC detects the defects as and when they occur in the production process. The results are analyzed and the responsibility is fixed. So, the works will be quality minded.
7. Ensures standard price: SOC maintains the standards of the products, through rigorous tests and it does not allow the standards to fall. Owing to this, the producer is able to secure the standard price for his products. So, indirectly it increases the profitability of concern.

6B. 29 TOTAL QUALITY MANAGEMENT

British Quality Association (1989) defined TQM as follows: “TQM is a corporate business management philosophy which recognizes that customer needs and business goals are inspirable. It is appropriate within both industry and commerce”.

TQM ensures maximum effectiveness and efficiency within a business and secures commercial leadership by putting in place process and systems which will promote excellence and prevent errors. It ensures that every aspect of the business is aligned to the customer needs and the advancement of business goals without duplication or waste of efforts.

The commitment to TQM originates at the chief executive level in a business and is promoted in all human activities. The accomplishment of quality is thus achieved by personal involvement and accountability, devoted to a continuous improvement process, with measurable level of performance by all concerned. It involves every department, function, and process in a business and the active commitment of all employees to meeting customer needs. In this regard the customers of each employee are separately and individually identified.

Indian Statistical Institute, Hyderabad in its training document defined TQM as follows:

“TQM is an integrated organizational approach in delighting customers (both internal and external) by meeting their expectations on a continuous basis through everyone involved with the organisation working on continuous improvement in all products, services, and processes along with proper problem-solving methodology.”

Confederation of Indian Industry (CII) in its introductory document Total Quality Management – an Introduction, defined TQM as follows:

“Meeting the requirements of the internal and external customers consistently by continuous improvement in the quality of work of all employees. TQM can be conceptualized into the following three processes:

(a) Quality process for understanding who the customer is, what are his/her needs and taking steps to completely satisfy the needs of this customer.

(b) Management process of continuous improvement. The term manage merit refers to managing continuous improvement and does not address any specific organizational level. The process comprise the PDCA cycle and its continuously evolving policies, objectives and methods to achieve goals, education and training, implementation, checking causes, checking effects taking appropriate action, and preventing recurrence.

Management process address continuous improvements to keep pace with are:

(i) Changing requirements

(ii) Competitive environments

(iii) Technological advance

(c) People process – it is initiating and maintaining the TQM. It is carried out through involvement of all employees on the basis of all three values, namely intellectual honesty, self-control and respect for others.

6B. 30 FUNDAMENTALS OF TQM
TQM principles can be better explained by examining those companies which have been successful. Some Indian companies which have won the Golden Peacock National Quality Awards from Quality Council of India (QCI) and Institute of Director (IOD) are Telco, Philips, Bharat Electronics, Kirloskar, SAIL, and EIL. For this purpose, we may as well examine the Malcolm Baldrige Award winners in the USA like Motorola; the Deming Prize winners like Toyota; and The European Quality Award winners like Corning. On examining these companies, we find that the following fundamentals of TQM are common in each of these award winning international companies.

1. **PUTTING THE CUSTOMER FIRST**: Achieving customer satisfaction is at the heart of total quality management. This principle supports the traditional view that the "customer is king". If a company cannot satisfy its customers, another company will. Processes and products must be designed with one thing in mind – satisfying the customer. Companies in India must move from a "product-out" mentality (i.e. pushing a product or service-out) to a "customer-in" attitude (i.e., providing the product or service that customers expect, or better yet, beyond what they expect). These days the emphasis has shifted from the customer satisfaction to delighting the customer. The Indian companies in order to succeed in global competition are to adapt to this latest version of customer focus.

2. **MANAGEMENT BY FACT**: The second principle which TQM companies world over the adopting these days is management by fact. This principle is difficult to institutionalize, because every employee in an organization has opinions, views and notions about how things should be done. They may tell you what the root cause of a problem is but may not give you the facts for solving the problem. This ways people may become the part of the problem itself rather than solvers. Facts are far better than opinions, although opinions, views and ideas cannot be ignored.

In Indian organizations striving for TQM, senior and middle management, supervisors and employees should all be taught basic statistical techniques nd the importance of facts in solving problems. In most Indian organizations, a poor decision making process exists and thus it produces poor decisions. If every employee is trained in basic statistical techniques, it will dramatically improve decision making. Decision making must be based on facts that are data. Japanese industry vehemently used simple tools of statistics to solve not only their day-to-day but also major problems. Thus, they could achieve excellence.

3. **PRINCIPLE OF PDCA CYCLE**: The plan-do-check-Act (PDCA) principle is another essential tool for implementing a TQM programme successfully in Indian organizations. The PDCA also referred to as the "Deming Wheel" is the principle of continuous improvement. Most Indian companies do not have practices in place that force continuous improvement. Following the PDCA principle would force the organizations in India to examine their business processes. Check is the most important step in processes against a standard and stated business objective. Practice of the PDCA cycle generates numerous opportunities for further improvement. A systematic process for examining how to improve things is necessary successful application of TQM. Because condition are never as good as they might be in any business. Managers should never be satisfied with the status quo. Becoming complacent will allow competitors to win; but by following the PDCA principle they can guard against this complacency. Thus all Indian business organizations implementing TQM must follow the principle of PDCA for their future success. Japanese companies have the PDCA principle as their main forte for improvement.

4. **Focus on Prevention**: Indian Companies like Telco, Philips, etc, which have mastered TQM realized that solving problems is the first step in making improvement. These Indian companies realized that until methods are instituted to prevent the recurrence of problems, long-lasting results can not be achieved. Most companies in India do not understand this fundamental principle and generally end up solving the same problem over and over again. That is they keep on inventing the wheel again and again. The companies must ensure that problems are solved once for all and recurrence of these problems is prevented.

5. **PRINCIPLE OF EMPLOYEES INVOLVEMENT**: Surrounding the above four fundamental principles are two others that relate to how people should work together. Sometimes, this principle is referred to as respect for people. In some Indian business organizations, still the workers and employees are treated as persons with brawn only and not with brain. This was the traditional way of exploiting the workers. For becoming TQM
Company, we have to respect and optimally use employees' brainpower along with their technical skills and physical power. Most employees have very good minds and can contribute creatively if recognized. The companies must start aping employees' innovative and exciting ideas. Employees know about problems within the business much better and can help solve them. Successful TQM companies world over recognize that workers’ energy, enthusiasm, and value to the company can be limitless given the proper forum where their ideas can be expressed, and given the proper respect for their abilities. Thus Indian business organisation must start applying this TQM principle for increasing their effectiveness.

6. Principle of cross-functional management: Cross-functional management recognizes that no organizational unit can by itself control every aspect of the business operation to ensure that the customer's requirements are met. Cross-functional management is a method of cooperating across functional organizational boundaries – interacting with each other to make sure that the product or service meets the quality standards that are set. Indian organisations may take sometime to fully appreciate the power of this foundational principles of TQM, Because there may be a feeling that each managers in his/her department is functioning well. Generally, there may be every person for him/herself focus. They are interested in getting their jobs done and don’t bother about others. With the application of this principle and more decentralized approach, managers will be able to control the resources necessary to satisfy customers. Thus there would be improvement in customer satisfaction and cos savings. Slowly on implementation of TQM, Indian managers will understand and realize the meaning and application of cross-functional management. Communication among departments will improve. Cross-functional management techniques would reduce design time, improve product and service quality and build a sense of mission among company employees. this principle is very powerful as it aligns the vectors so that everyone and everything is going in the same direction. In the absence of this principle, no other approach for TQM can be successful.
MODEL QUESTION PAPER
PAPER 2.6: PRODUCTION AND OPERATIONS MANAGEMENT

Time: 3 hours
Maximum Marks : 100

PART – A
(5 x 8 = 40 marks)

Answer any Five questions

1. Describe the relationship of POM with other functions by management.
2. Explain capacity measurement process is different for manufacturing and service industries.
3. Detail with examples, the procedure for arriving at standard time.
4. Illustrate REL chart.
5. Describe the rules of network system.
6. Compare preventive and breakdown maintenance.
7. What is ‘acceptance sampling’?
8. Write a note on Reverse Engineering.

PART – B
(4 x 15 = 60 marks)

Answer any Four questions

Question No. 15 is compulsory

9. Describe with examples, the effect of time element on POM elements.
10. Illustrate locational break even analysis.
11. Elaborate the process from selection process with PLC phases.
12. Illustrate ‘assembly line balancing’.
13. Explain the scope and steps involved in MRP.
14. Detail how TQM is helpful to the managers.
15. A case let testing the methodology/ techniques of POM.