PREFACE

In the curricular structure introduced by this University for students of Post-Graduate degree programme, the opportunity to pursue Post-Graduate course in Subject introduced by this University is equally available to all learners. Instead of being guided by any presumption about ability level, it would perhaps stand to reason if receptivity of a learner is judged in the course of the learning process. That would be entirely in keeping with the objectives of open education which does not believe in artificial differentiation.

Keeping this in view, study materials of the Post-Graduate level in different subjects are being prepared on the basis of a well laid-out syllabus. The course structure combines the best elements in the approved syllabi of Central and State Universities in respective subjects. It has been so designed as to be upgradable with the addition of new information as well as results of fresh thinking and analysis.

The accepted methodology of distance education has been followed in the preparation of these study materials. Co-operation in every form of experienced scholars is indispensable for a work of this kind. We, therefore, owe an enormous debt of gratitude to everyone whose tireless efforts went into the writing, editing and devising of proper layout of the meterials. Practically speaking, their role amounts to an involvement in invisible teaching. For, whoever makes use of these study materials would virtually derive the benefit of learning under their collective care without each being seen by the other.

The more a learner would seriously pursue these study materials the easier it will be for him or her to reach out to larger horizons of a subject. Care has also been taken to make the language lucid and presentation attractive so that it may be rated as quality self-learning materials. If anything remains still obscure or difficult to follow, arrangements are there to come to terms with them through the counselling sessions regularly available at the network of study centres set up by the University.

Needless to add, a great part of these efforts is still experimental–in fact, pioneering in certain areas. Naturally, there is every possibility of some lapse or deficiency here and there. However, these to admit of rectification and further improvement in due course. On the whole, therefore, these study materials are expected to evoke wider appreciation the more they receive serious attention of all concerned.

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Course Code : CP-207
Course : Operations Management

First Print : March, 2023

Printed in accordance with the regulations of the Distance Education Bureau of the University Grants Commission.

Netaji Subhas Open University
Post Graduate Degree Programme
Master of Business Administration (MBA)
Course Code : CP-207
Course : Operations Management

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Module 1

Module 2

Unit 1 □ Nature and Scope of Production and Operations Management

Structure

1.1 Introduction

The success of an organization could be clearly visible through the choice of products or services that people opt while meeting their needs. We have seen people's choice for Nokia (while purchasing mobile phones) for their cost-effective innovative products or Godrej storewell for their durable range of products. The belief that marketing hype alone can bring success to any product is not correct. Organizations have to deliver the products and services that they have promised to the customers. Hence ''Production'' and ''Operations'' are at the forefront of manufacturing goods and of service delivery. This is true for all types of organizations such as manufacturing companies, service providers, public and government services and so on.

Now-a-days, the role of operations has become increasingly important because the needs and wants of customers at a compressed time frame have increased. Ridderstale and Nordstrom in their book called Funky Business have described that the customers want both cheaper and better product/service, and they want it ''Yesterday''.

Thus the objective of effective production and operations management would be:

''To make available better and cheaper products/service and faster than before''.

1.2 Definition of Operations Management

The word operation signifies that it is what the organization does to meet the needs or a customer. It involves all spheres of activities that produce the organization's goods and services. In other words it can be defined as : Those set of activities concerned with acquisition of inputs (raw materials and other resources), their conversion into finished goods, and the delivery of that finished goods and services to the customer.

Operations Management describes the functional area responsible for designing, execution, managing, controlling and improving the operations that produce organization's goods and services. A key aspect of operations management is that it focuses on processes, i.e., the way we function.

Operations management also describes the study of the different operations practices followed by organizations. It helps in benchmarking the processes that lead to organizational success.

Operation managment describes the tools and techniques to analyze the operation of an organization, in order to manage and improve the operations. That is, to give the firm a competitive advantage over the other.

1.3 The 'Operations Mix'

The operations mix comprises of four Ps, namely, the Policy, Practices, Processes and Performance. These four elements describe the entire gamut of operations and production management .

1.3.1 The four P's of operations management are as follows

As stated earlier, operations management focuses on processes. These processes are managed via the four 'P's of operations: Policies, Practices, Processes and Performance. These four key elements and there relationships can ''no hyphen'' be described as follows:

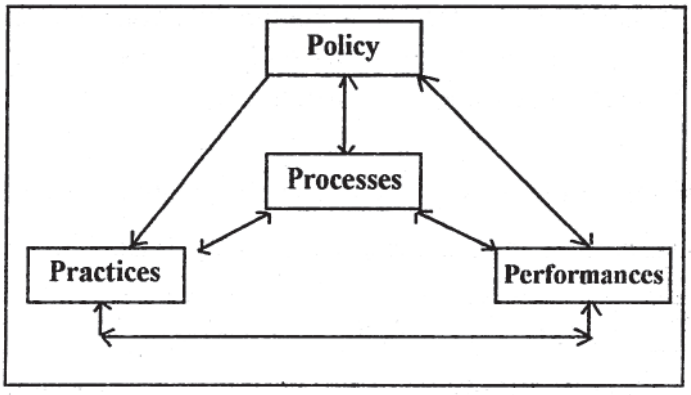


Figure 1.1 Relationship amongst Policies, Practices, Processes and Performance

Policies refer to the aim, objectives and strategies that the organization lay down and follow in order to achieve its mission. Thus the mission statement plays an important

role in articulating the organization's policies. It gives the aims and objectives. Strategy refers to the ways and means (how) the organization will meet its mission. Policies define the practices - the systems, procedures and technological capabilities that need to be followed and need to be in place within the firm, and, between the firm and its vendors (suppliers) and customers. Performance refers to the output measured in terms of time, cost, quality and quantity. It describes the deviations of organization's output from that of targeted levels of performance. The performance of an organization is dependent on practices and polices. Practices such as 'just-in-time' and policies such as 'anytime' customer care are likely to improve organization's performance. Process refer to bringing together the policies, practices and performance to transform the inputs to the desired outputs, that is, lead to value addition for satisfying customers' needs.

1.4 Production and Operations

Both of these refer to transformation of inputs into Outputs. Operation describes the transformation process in more generic terms, that is, 'Service' transformation as well as 'Manufacturing' transformation. Production generally refers to transformation of raw materials into finished manufactured goods.

Types of Operations

Service Operation	Manufacturing peration
- Intangible	- Tangible
- Cannot resold	- Can be resold
- Cannot stored	- Can be stored
- Generally not (but producers might be) transported.	- Can be transported
- Production: Buyer/Customer takes part.	- Seller/Manufacturer Only takes part in Production.
- Usually cannot (but delivery system often can) be exported.	- Can be exported.
- Quality cannot be checked before being delivered	- Can be inspected Prior to delivery.
- Production & Consumption generally coincide	- Production precedes consumption.

1.5 Questions

Short Type Questions

i) Define operations management

ii) What are 4P's in operations management?

iii) What is the relationship among Policies, Practices, Processes and Performance?

Descriptive Type Questions

i) Describe the four P's of operations management.

ii) Distinguish between service operation and manufacturing operation.

Unit 2 □ Types of Manufacturing Systems and Layouts

Structure

2.1 Introduction

Manufacturing systems or in more generic term, operation processes are responsible for transforming the inputs (raw-materials) into the value added outputs (finished goods and services). The organizational strategies (to meet its mission) are operationalised (converted into reality) and produce and deliver the product/service offerings required.

There are different types of processes (manufacturing systems) available for transformation of raw materials (inputs) into finished goods (outputs). Each type is associated with a particular combination of volume and variety. Volume refers to the quantity of products delivered while variety refers to the different types of products produced through a particular manufacturing system.

Different physical layouts describe the actual placement of machines/ equipment or people that are used for manufacturing goods or delivering services. The type of manufacturing system (or operations process) determines the physical layout required for the transformation process.

2.2 Types of Manufacturing Systems (Process Types)

There are five generic process types, namely, projects, job, batch, line and continuous. As stated earlier, each of these types distinguish themselves in-terms of volume and variety of goods that are produced. The broad differences of these types in terms of volume and variety are as follows :

	Volume	Variety
Project	Very Low	High (Usually Unique)
Job	Low	Moderate
Batch	Moderate	Low
Line	High	Very low
Continuous	Very High	Minimal

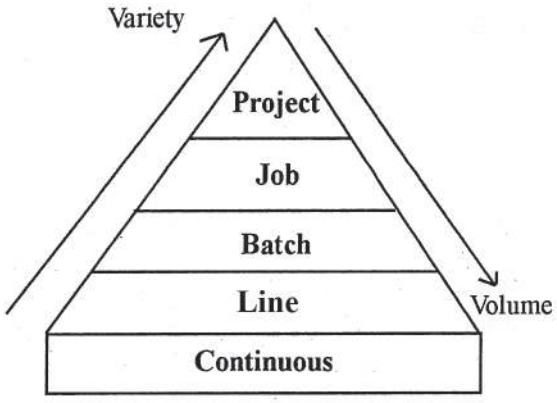


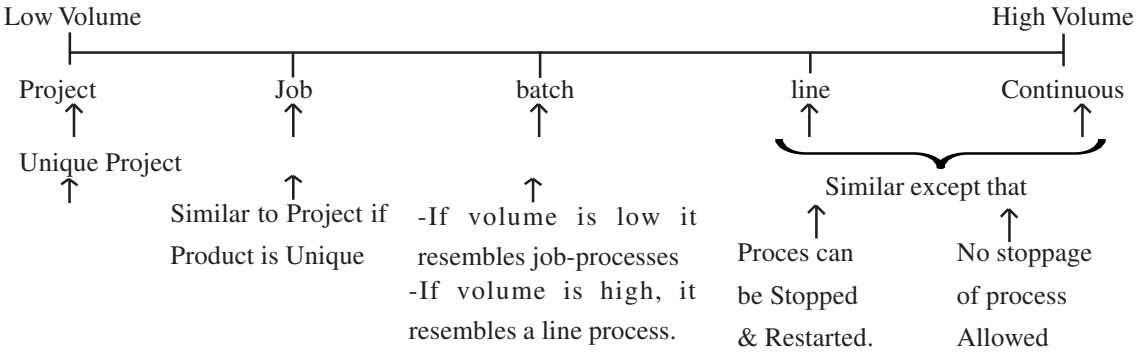
Figure 2.1 Different Process in terms of Volume and Variety

As we go up the hierarchy, the specialization of the product increases. Unique products customized to meet particular specialized requirement are met through project type manufacturing systems. Voluminous production of goods with very less differentiation among the goods is the features of continuous - manufacturing systems.

Manufacturing (Process) types	Characteristics
Project	Highly flexed. Best suited for individualized outputs. High unit cost. Mobile and flexible resources viz. men, material and machines required quality is dependent on individual customer requirements. High set up cost.
Job	Volume generally higher than Project-type. Significant flexibility to meet particular job requirement, required. Some repetition in the system and some common elements exist. High unit costs relative to higher volume processes, but low set up cost.
Batch	Batch production describes a process that require some flexibility to meet the differences between batches. Some investment is required for set-up to each batch. Higher levels of specialization is required for machines as well as men.

Line	It describes high volume production of goods and services with comparatively low variety (standardized products). It is dedicated to single product and causes difficulty in introducing new products using the existing line layout. Highly specialized men and machines are required, and products are of Low Unit Cost Systems have limited flexibility and the quantity levels are usually consistent.
Continuous	Process are set up to run without stopping-running all through the day, round the year. It is applicable for products that are totally standardized, power generation, steel production etc. It requires high investment/ capital cost. It is different from line production and can be stopped at a particular stage of production and the production process can be restored again without affecting the product. In continuous production, a process if stopped causes losses & difficulty for restarting. It has limited flexibility and are highly automated.

2.3 The Process Type Linkage



2.4 Examples of different types of processes

1. Projects :

– Hooghly River Bridge Construction.
– Damodar Valley Dam.
– Konkan Railway Project.

2. Job :

– Metro Rail System in Calcutta and New Delhi.
– Ship building.
– Book editor providing editing services to publishers.

3. Batch :

– Printing of a similar document many times (in a discrete mode)

– Wine production (Annual batch production of wine from grapes)

4. Line :

– Manufacturing of automobiles.

– Manufacturing of Computers.

– Preparation of fast foods.

5. Continuous :

– Power generation.

– Steel production.

– Chemical refining.

2.5 Flexible Manufacturing Systems (FMS)

Manufacturing systems that are controlled and operated through the use of computers, enabling flexibility in manufacturing are referred to as Flexible Manufacturing Systems. A number of workstations, such as Computer Numerically Controlled machines are programmed for production of a product. A comprehensive Computer Control System coordinates all activities such as Control of Workstations, distribution of instructions to workstations, production and tool control, traffic control and system performance monitoring. The benefits of FMS are as follows :

(i) Speed
(ii) Flexibility } in terms of rapid changes to products

Machines are grouped in to FMS cells and these FMS cells are arranged around a group of products where some variety of the product is required even though volume is high. If the volume is high and product variability is low, then a line process would be most applicable.

2.6 Manufacturing Systems and Layouts.

There is a close link between the type of manufacturing systems and layout. Layout refers to the arrangement of equipment, machinery and tools such that the flow of materials from one processing unit to another is not inhibited and at the same time the space and storage

requirement are optimized to produce goods within the standard time to complete each operation. Layout also takes into account the environmental and ergonomical factors for smooth operation. The different linkages between manufacturing systems and layout can be summarized as follows :

- Apart from the choice of manufacturing systems, the layout is dependent on other factors of operation strategy, process characteristics, existing processes and suppliers.
- Project and jobbing processes are primarily deployed in case of wide variety of products or designs, which can be customized for individual customers. Volumes are small or products may even be unique. In order to provide customized products/ solutions, product improvement may be required on a continuous basis. The organization obtains competitive advantage based on flexibility, including design and innovation.
- On the other hand, Line and Continuous processes are associated with supply of high volume of narrow range of standard products. Making changes or introducing innovation takes longer than in project and job products, because the process is dedicated to specific products. The most common manufacturing process is batch. Firms focus on finding the optimum batch size, instead of taking care of customer service. New techniques such as Mass Customization and Agile Manufacturing offer a way of imitating the features of either jobbing or high volume process choices to batch production.

2. 7 Questions

Short Type Questions

i) What are the different. types of manufacturing systems?

ii) How are manufacturing systems different in terms of volume and variety of production?

iii) What is the linkage between manufacturing systems and layout?

Descriptive Type Questions

i) Describe the characteristics of the different manufacturing systems.

ii) Explain flexible manufacturing system.

iii) Explain the process type linkages.

Unit 3 □ Layouts Planning and Analysis

Structure

3.1 Introduction

The manufacturing process describes the nature of tasks that needs to be performed. For example, will these be batch or project activities. The layout determines where and in what sequence activities that make up a process are located. In the following sections the four basic layout types - Fixed, Process, Product and Hybrid or Cell layouts would be discussed. The basic objectives behind any layout are the following :

- To Minimize material handling to avoid wastage, damage, cost and time overrun.
- To reduce steady work flow with no stakeouts & low inventory.
- To shorter the turn round time of production.

In this type of layout the product involved in the production remains in one place whilst operations take place around it. Work persons come to the product (or to the production location) instead of the products moving between workers and/or job centres, and these workers carry out single or multiple activities to add value to a product or provide a service until completion.

Fixed position layout are used in manufacturing of heavy and bulky products, fragile products such as ship and airplaries and most construction projects take place with the people and machines moving around the 'product'.

Fixed position layouts are associated primarily with lower volume production but sometimes are also applicable in jobbing process (specialized contractors in construction) and batch processes (e.g. production of aircrafts, construction of multiple types of the

same house on a housing development project).

3.2 Process Layout

In this type of layout, specific types of operations are grouped together with the manufacturing or service facility. The workflow is not pre-specified. The products move from one operational point to another depending upon the requirements as shown below.

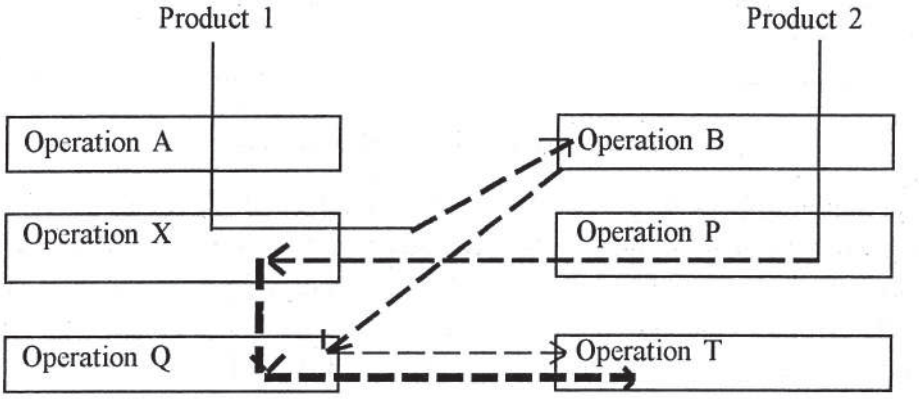


Figure 3.1 Process Layout in a Functional Approach

This layout type is generally deployed in precision engineering, production of furniture, high fashion clothing and jewellery. Process layouts are associated generally with jobbing production, where low volumes of products are manufactured to individual requirements. The layout may also be used in case of low volume batch production.

Process layouts involve flexible equipment and works, so that stoppage or break down of a single operation does not lead to stoppage of whole process. As evident from the fiture above, even with two products the manageability ofworkflow becomes difficult. This approach is, therefore, not the fastest at handling throughput and often requires people to pursue the progress of work at every stage, as the product may have to queue before an operational point or may be accorded lower priority compared to another product.

3.3 Product Layout

In this type of layout, peopl (and machines are dedicated to a single product or a very small range of similar products. The workstations are laid out in a sequence that matches the stage-wise requirements of the product. Each stage is separate from the next stage as :

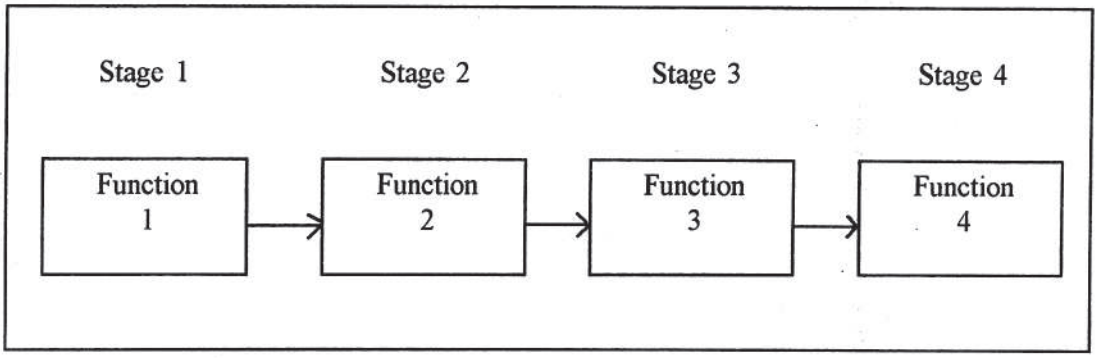


Figure 3.2 Product Layout

The output of one stage serves as input to the next stage. As such activity in one stage cannot be started unless the previous activity has already been completed. Product layout is generally associated with manufacturing process such as automobile assembly and other high volume applications. The overall layout could be in a straight line, or U or S shaped. The distance between the workstations is optimized in order to reduce material handling, and control follow of materials from one point to another. This ensures less wastage / damage, steady flow of work without any stock-outs and low work-in-Progress (WIP). The tum round time of production is dependent on the workstation with the lowest capacity. Moreover, stoppage of work at one workstation would lead to stoppage of the entire process.

3.4 The hybrid process/product cell

In large and/or complex operations, the layouts described above, i.e., neither the process nor product layout can meet the requirements satisfactorily. The workstations are designed to accommodate a range of products and not a particular family. This leads to generalization of process characteristics resulting in lack of specialization in many compronies. The limitation has been overcome by adoption of cell manufacturing system. In this system, cells are designed to meet the needs of limited range of products. This ensures more focus on needs of customers rather than trying to meet a much wider range. The machines are grouped together in a cell to support the product of a single product family.

In the figure below, U-Shaped cell layout with number of features is described. This layout allows one operator to carry out more than one function and to maintain all operations within sight of each other. This facilitates communication and control. Here

the operators are required to be multi-skilled and as such provides more flexibility than product layout. An important characteristic of a cell layout is that, firms benefits from team work where a small group of people work together with greater autonomy. Autonomy includes· simplification of work procedures and schedules. In addition, it has been also observed that work moves faster through cells than in the case of tradition product layout, thus achieving short lead times.

Cell manufacturing is associated with high-tech environments, where high volume and moderate variety can be achieved simultaneously.

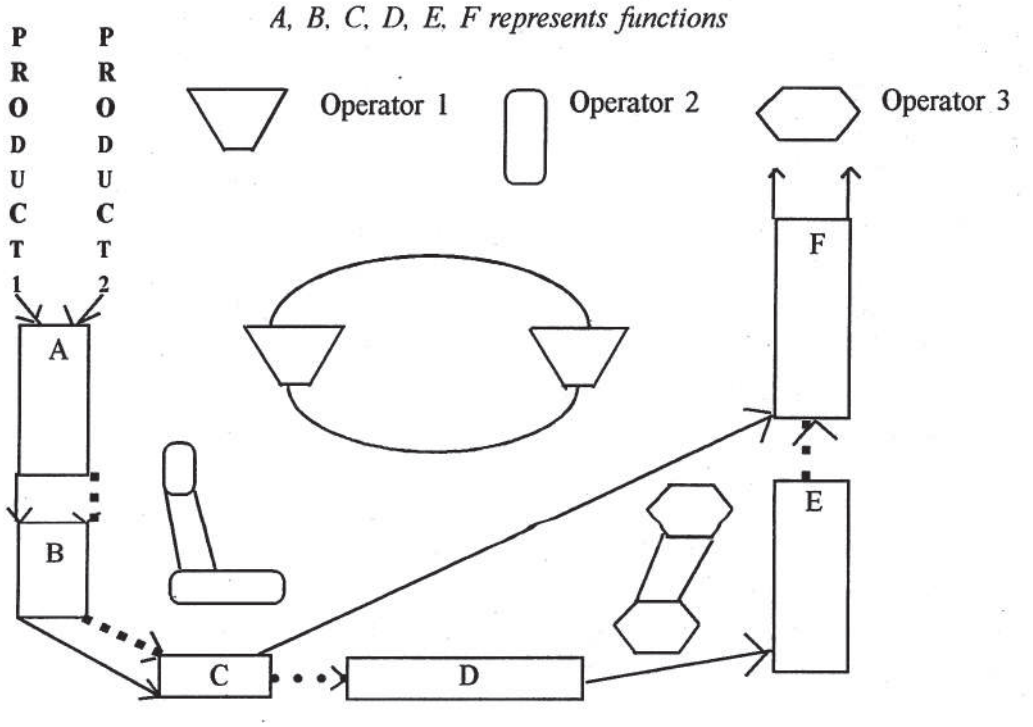


Figure 3.3 Cell Layout

3.5 Factors of Choice for Process Types

There are basically two criteria for selecting a process type (Described by T. Hill, 1995).

- Order Qualifying Criteria
- Order Wining Criteria

The mapping of criteria of these two criteria may be described as follows

Process Type/Criteria	Order Wining	Qualifying Criteria
Project	Quality, Delivery and Customisation	Price
Job	-do-	Price
Batch		
Line	Price	Quality, Delivery and Customisation
Continuous	Price	-do-

Order Wining Criteria refers to those criteria by which one can ensure the customer orders. Order Qualifying, criteria describes the 'necessary' (but not sufficient) conditions to participants in a tender.

3.6 Trends in Process Design

Traditionally, industries resorted to mass production for organizing the production of high volumes of standardized products. In recent times, because of many market competitors or customers, there has been change in approaches to process design. These changes have been made possible through new technology, especially, application of computer and communication technology in manufacturing. The important two alternatives to traditional mass production are as follows

- Mass customization.
- Agile manufacturing.

3.6.1 Mass Customization

This approache enables mass production of goods as per the choice made by a customer from among a finite number of alternatives. The operation can create and delivers goods according to customer's choice without incurring additional costs to change the output's design or appearance. The idea of this approach is to produce exactly what the customers wants in the quantity that he or she desires, for example, cellular phone, and computers. This process, therefore, combines the benefits of higher variety to customers, while retaining the benefits, in terms of costs, of mass production.

3.6.2 Agile Manufacturing

It is an alternative approach to mass production or mass customization. This method tries to respond quickly and effectively to change in customer's demand, and also to be proactive in developing and retaining markets in the face of competitive forces.

Mass customization aims at meeting the customer's demand while retaining the benefits of mass production. On the other hand, although agile. manufacturing also aims at meeting market demand, it is being able to respond quickly to the changes. That is, in the today's world of rapid change in customer needs, agile manufacturing is better approach than mass customization. It is not only adoption of specific technology to meet the market demand; it involves deployment of agile strategy, processes linkages and people. Agile strategy describes the process for understanding the firm's position within its sector, committing to the required strategy, aligning it a fast moving market, and communicating and deploying it effectively. That is, it proposes a holistic approach towards mass production. Agile processes refer to the provision of facilities and processes that enables agile functioning of the firm. Agile linkages include dose working with and learning from the customers and vendors. Agile people comprises flexible and multi-skilled workforce that work in an environment that allow creativity and initiative.

3.7 Questions

Short Type Questions

i) What are the criteria for selecting a process?

ii) What is a hybrid process?

iii) What is the basic objectives behind any layout?

Descriptive Type Questions

i) Describe the process and product layout.

ii) Explain what is meant by mass customization.

iii) What are the benefits of cell layout? Describe in brief the cell layout.

Unit 4 □ Material Handling

Structure

4.1 Introduction

Material handling serves as a tool for cutting cost arising out of irregular pattern of arrival, congestion at receiving point, in efficient storage and fragmented quantities. Thus, the objectives of material handling are as follows :-

- Reduced Cost
- Reduce labour
- Increase safety
- Increase capacity
- Reduce waste
- Improve services
- Enhance productivity

4.2 Elements of Material Handling (MH)

The material handling equation is as follows

Why	= What	+ Where	+ When	+ How	+ Who
Why MH is required	Type of material to be handled	Place (where it is to be moved)	Time of movement	Method of MH to be used	Person responsible

That is, material handling is required to move a particular type of material to a particular place at the right time by using the right handling methods by the right persons. Hence the elements of material handling are as follows :

1. Material
2. Distance and movement
3. Time
4. Handling Methods
5. Human

4.3 Symptoms of inefficient material handling

i. Back tracking in material flow path.
ii. Built in hindrances to flow of materials.
iii. Clustered aisles
iv. Confusion at transportation points (e.g. docks)
v. Disorganized storage
vi. Excess scrap
vii. Excessive handling of individual pieces
viii. Excessive manual effort
ix. Excessive walking
x Failure to use gravity
xi. Fragmented operations
xii. High indirect labour cost
xiii. Idle machines (Low utilization of machines)
xiv. Inefficient use of skilled labour
xv. Lack of parts and supplies
xvi. long hauls
xvii. Material piled up on the floor
xviii. No standardization
xix. Over crowding
xx. Poor house keeping & inventory control
xxi. Product damage
xxii. Repetitive handling

4.4 Basic concept of material handling

The three primary components of material handling include material, moves and method. The key input data required to describe these three components, are as follows:-

- Product (what)
- Quantity (how much)
- Routing (where)
- Support (with what back up)
- Time (when and how long)

The 5 (five) physical characteristics that affect movement of material (transportation) are as follows :- ·

- Size
- Weight / Density
- Shape
- Risk of damage
- Condition

Every move involves the following :

- Pick up
- Transport
- Set down

Or, in other words, it involves load-move-unload.

Cost of material handling can be grouped under two categories:-

- Fixed (investment) cost
- Variable (Operational) cost

The greater the amount of goods moved, less is the cost per unit moved. The greater the variety of product or material, the greater is the cost per unit moved.

The type of material, distances moved, terminal activities and the time of the movement quantity influence the cost of material handling. The cost of moving special type of material is highest while transporting uniform type of materials is the less. The cost per unit decreases with quantity. The cost decreases if the movement of goods are planned and scheduled, and the cost is maximum when the movement is made in an immediate or urgent basis without pre-scheduling.

4.5 The Principles of Material Handling

Planning Principle : Material handling like any other subject requires planning. Planning is a process of deciding on the course of action to meet the desired goal.

System Principles : A systematic approach to material handling leads to integration of all activities in the supply chain.

Material flow principles : An organized flow of materials minimizes back tracking. Simplification Principles : Simplification of procedures and processes lead to effective material handling.

Space utilization Principles : The flow of materials should not be inhibited with storage of materials while at the same time the utilization of space should be optimum.

Unit Size Principle : Unit size of a material determines the time, cost and effectiveness of material handling. Irregular and non-uniform size leads to delayed and costly movement of materials.

Mechanization Principles : Mechanization of movement of materials reduces the cost and time of movement and also reduces the risk of damage of materials.

Gravity Principles : Movement of materials through use of gravity reduces time, cost of operation. Maximum benefit of gravity should be taken in moving materials.

Equipment Selection Principles : Material-handling equipment differs with the type of materials. Selecting the right kind of equipment makes the handling effective.

Standardization Principles : Standardization of material packaging and processes leads to effective material handling.

Utilization Principles : Selection-of equipment and method of handling should be such that the utilisation of resources (men, material, machine and money) is optimum.

Dead Weight Principles : Material handling should aim at reducing idle movement of equipment.

Safety Principles : Material handling should follow principles of safety to reduce loss of life and damage to goods. Besides, other principles of material handling include maintenance, control, capacity, adaptability, performances and obsolescence principles.

4.6 Material Handling Equipment

Material handling equipment can be classified as follows :-

- Fixed path moving equipment
- Variable path moving equipment
- Fixed at a point equipment

Another way of classifying material handling equipment is on the basic cost of using equipment. Some equipment are economical for shorter distances, limited movement while some are economical for longer distances. Some equipment have low fixed cost but high variable cost while some have high fixed cost and low variable cost.

In view of factors such as distance and intensity of flow of materials the equipment can be classified as follows :-

Simple handling equipment: These are suitable for short distances and low intensity (e.g.2 wheel Hand Truck).

Complex handling equipment : These type of equipment are suitable for short distances and high intensity (e.g. Fort Lift Trucks, Top Lift Trucks).

Simple Travel Equipment : These are suitable for long distances and low intensity (Trucks).

Complex Travel Equipment : These are suitable for long distances and high intensity (e.g., Electronic Controlled Tractor-Trailer).

4.7 Questions

Short Type Questions

i) What are the symptoms of inefficient material handling?

ii) What do you understand by:
   a) Material flow principle
   b) Space utilization principle.

iii) What is the- different types ·of material handling equipment? .

iv) What are the elements of material handling?

Descriptive Type Questions

i) Explain the three primary components of material handling.

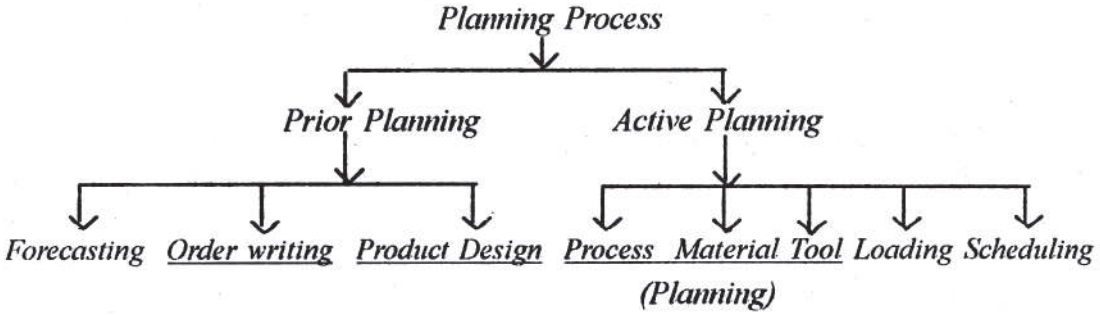
ii) Explain the principles of material handling.

Unit 5 □ Production Planning and Control

Structure

5.1 Introduction

Planning refers to future course of action in order to achieve the desired goal. It aims at identifying the targets, constraints and the strategies and programmes to carry out production process and operations. Planning could be for shorter, (less than one year), medium (one to three years) or longer (more than three years or so) duration. The production planning process could be described as follows :



Forecasting : It refers to prediction of future requirements namely, type, quantity, and quality of product. This in turn would lead to forecasting of production· process.

Order writing : It means assigning authority to one or more persons to undertake a particular job.

Product design : It refers to deciding on the layout of the product and arrangement of production process. The deliverables of this stage include plan and drawings, bill of materials and specifications.

Process planning (and routing) : It involves determination of the most economical method of performing an operation or activity.

Material planning : The planning of material requirement that are directly or indirectly used in the production process. Several techniques such as, MRP, MRP II, JIT etc. are used for the purpose.

Tool Planning : It refers to determination of tool requirement for the proposed production process.
Loading : It means assignment of job to manpower and other resources.
Scheduling : It refers to sequencing and timing of the jobs. It involves programming of the entire work so as to complete the job in the right time.

5.2 Continuous and intermittent production

Continuous production involves a continuous or almost continuous flow of materials and outputs. As discussed earlier, this mode of production is suitable and applied in manufacture of standardized items in large quantities. It makes use of special purpose machines. Manufacture of nuts and bolts, standard spare parts and components, cigarettes, cement, and chemicals are examples of continuous production. Continuous production system can be divided into two categories. These are as follows :

i) Mass and flow line production
ii) Continuous or process production

Mass and flow line production

Ford was first to introduce mass production in recent times. The idea was first developed in Venice several hundred years earlier, where ships were mass-produced using pre-manufactured parts, and assembly lines. The Venice Arsenal apparently produced nearly one ship every day, in what effectively the world's first factory that, at its height, employed 16,000 people.

Mass production refers to production of standardized items in large quantities using specialized machines. The manufacture involves one or more operations on the raw material on one machine (a special purpose machine). Manufacture of nuts and bolts and plastic products are some of the examples of mass production. Flow production, on the other hand, refers to continuous production of standardized items in large quantities in stages involving more than one machine. Examples of flow production are, manufacture of TV, motorcycles etc.

The economics of mass production come from several sources. The primary cause is a reduction of nonproductive effort of all types. In mass production, since special purpose machines are used, and that each worker repeats one or a few related tasks that use the same tool to perform identical or almost identical operations on a stream of products. The exact tool and parts are always at hand. The worker spends no time in going and getting them.

The salient characteristics of Mass and flow line production are as follows :

- The machines are arranged as per sequence of production.
- Mass production systems are usually organized in assembly lines. The assemblies pass by on a conveyor, or if they are heavy, hung from an overhead monorail.
- In a production centre for a complex product, there may be many auxiliary assembly lines feeding sub-assemblies (i.e. car engines or seats) to a backbone ''main'' assembly line.
- The flow of work is balanced and the time to reset machines are minimum.
- Material handling is optimized.
- Work in progress is small compared to intermittent production
- Work cycles are short and repetitive
- Factory can purchase very large amount of materials. This reduces the overhead costs (shipping, purchasing negotiations, paperwork, etc.) associated with purchasing the parts.
- The cost of production per unit is lowest.
- Division of labour and application of time study is possible.

Continuous or process production

Continuous or process production involves production of products that has continuous demand. This is due to the fact that most of the jobs are routine enough and can be easily automized. Continuous production is a method used to produce or process any product continuously. There is no discrete rate to which goods are produced, as opposed to a batch production process, or a one-time production. Examples of continuous production are the production processes for electricity, chemicals, pens, paper, cars and computers etc. The salient characteristics of *Continuous or process production are as follows* :

- Plant layout is as per the production process.
- Most of the operation including handling is automated. By employing certain PLC controls and automated controls, we can reduce the chances of error (thereby delays/ downtime) due to human intervention. So there is a lot of scope for conveyors, elevators, feeders etc for transporting raw materials, inprocess materials etc in continuous process industries.
- Maintenance of machinery, which is a very important factor in any manufacturing industry, in case of continuous process plants calls for online maintenance which requires very high alertness and response time from the concerned technicians.

- Both types of workers, namely, semi-skilled and skilled are employed.

5.3 Intermittent Production

An intermittent production involves intermittent flow of materials. It makes use of general purpose machines and produces varied components/products in small quantities. Intermittent production system can be divided into two categories :

i) Batch production, and

ii) Job production.

Batch production

Batch production is a method used to produce or process any product in groups that are called batches. Example of batch production are manufacture of drugs, clothes, paints, inks, adhesive and can be found in a bakery. There are inefficiencies associated with batch production. The production equipment must be stopped, re-cogfigured, and its output tested, before the next batch can be produced.

The salient characteristics of batch production are as follows :

- Plant layout is of process type
- Products are manufactured in batches as per order
- Process and product planning is done for each batch
- Flow of material is intermittent
- Makes use of general purpose machines
- Production is done in small quantities
- Batch production reduces initial capital outlay because a single production line can be used to produce several products.
- Batch production can be useful for small businesses who cannot afford to run continuous production lines.
- Orgnisations can use batch production as a trial run. If a retailer buys a batch of a product and people don't buy them then the producer can cease production without having to sustain huge losses.

Job order production

This is a type of intermittent production. Each job order is different from the previous order with regard to type, specifications, quality and quantity. The examples of job

order are manufacture of a large turbo-generator, special electronic equipment, special type material handling equipment, etc. The salient characteristics of job order production are as follows :

- Flow of material is intermittent
- Division of labour is not economical.
- Product design is made as per order and takes time.
- Prior planning is difficult. Scheduling is done for each component of the product.
- General-purpose machinery and flexible layout are preferred
- Skilled workers and factory made special attachment or accessories provide flexibility.
- High degree of control is required.
- Batch size is small.

Job shop

A job shop consists of a number of machine centers, each of these work centers Performs different activities. A job shop can produce a variety of jobs in small batches as per job orders. The flow of material is as per job, and not sequential or in any fixed path. The work-in-progress follows different processing patterns in batches through the shop facilities. The machines are of general-purpose type with provisions to use special tools, fixtures and gadgets to meet the production requirement. Thus, different jobs can be performed with the same basic machinery. A job shop also employs highly skilled workers.

A Closed Job Shop

A closed job shop is one that is closed to job orders from outside the organisation. That is, it produces products of standard design that have demand in the market. The same items are manufactured repetitively in cycles. For example, manufacture of automobile parts or computer components that are of standard design.

An Open Job Shop

An open job shop is one that makes to order. The orders may not be repeated. An open job shop produces as per requirements of the customer. There may be even one

product of larger dimension similar to a project. (for example, manufacture of a special heat treatment furnace).

5.4 Questions

Short Type Questions

i) What do you understand by forecasting? What is its usefulness?

ii) Under what conditions job shop production is suitable?

iii) What are closed job shop and open job shop?

iv) What type of layout is used in batch production and why?

v) Distinguish between continuous and intermittent production.

vi) Explain the meaning of loading and scheduling.

Descriptive Type Questions

i) Describe the production planning process.

ii) Describe the characteristics of mass production.

iii) Compare the characteristics of batch and continuous process production.

iv) Describe a job shop.

Unit 6 □ Capacity Planning

Structure

6.1 Introduction

Like other policy decisions, capacity decisions are one of the key policy decision area for operation. This involves making trade-offs between investing in resources for production and making the optimal use of these resource. Good capacity management ensures that the firm does not make promises to the customers that it cannot deliver. On the one hand, investment on facilities, technology and people are expensive and requires time to acquire or create, on the other hand, these resources, may be idle and wasted if they are not in demand and at the same time sales may be lost if goods are not variable when needed by the customers.

6.2 Defining Capacity

Capacity may be described as the level of output that the firm can attain over a specified period of time. Capacity can be defined in following ways:-

- **Theoretical Capacity**

It is the maximum level of output that can be achieved if the resources are used fully. That is utilising the resources in 24×7 basis (24 hrs. for all 7 days in a week throughout the year). This is the theoretical capacity, which is unrealistic.

- **Design Capacity**

This is the level of output that the operation was designed to have. It takes into consideration the pre and post operation time, time for preventive maintenance and includes other allowances for planned non-productive time. But it does not account for unplanned productive time such as stoppages in operation due to shortages of men to material, weather condition, equipment breakdown or transportation disruption.

- **Actual Capacity**

This is the level of output that can be actually achieved after considering the planned and unplanned productive time.

6.3 Measuring Capacity

In manufacturing operations capacity is generally measured in terms of the maximum number of physical units of goods that can be produced during a given period of time. In service operations, capacity is measured in terms of potential to provide services to the customers in a given period of time. It is defined as the potential, because the firm has to wait for the customers to arrive (and hence cannot pre-perform operations to keep services ready to deliver on arrival of customers) and they often operate below capacity. For example, hotels might measure their capacity in terms of number of rooms, since they cannot be sure that customers will turn up to fill them. So if there are, say, 200 rooms, the hotel has the potential to provide services to 200 customers. In non-profit organisations, e.g. Universities, Libraries etc., capacity is measured in terms of the level of outputs relative to the level in inputs. The level of inputs serve as the limit to the output the organisations can produce or the services it can provide e.g. the capacity of Library may be measured in terms of number of books it holds, rather than the number of members it can serve. equally, the duration of Library Hours indicates the timing capacity that is available to the readers. Thus, number of books and opening hours are level of inputs which determines the number of readers (Output), hence the capacity of the Library.

Inputs to capacity :-

The capacity of an Organisation is dependent on the following factors

- Facilities
- Technology
- Workforce
- Financial and other resources

Facilities : The tacilities of an Organisation are dependent on the following factors.

Facility Location :

Centralised facility has the advantage of ease of managing, but may be limited to the capacity. Instead, decentralised production of service facility enhance the capacity of the firm e.g. a centralised bank with no branches and ATMs as against a bank with multiple branches and ATMs. The decision of a firm to centralise its operations in a single large facility or to invest in multiple facilities, will depend on the market, the firms want to serve and the resources available to the firm.

Size of Facility :

Firms often try to achieve the economies of scale in order to minimise the average cost

per unit of output. But at the same time, the size of the facility is also dependent on the level of the market demand. Thus, if the capacity is based on the economies of scale while the demand less than the designed capacity there would be under utilisation of capacity.

Facility layout :

The layout of facility also determines capacity of the organisation.

Technology :

The capacity of a firm is dependent on the technology it uses. It includes the investments in machines, equipment, information technology and technological know-how.

Workforce :

The size and capabilities of the workforce is one of the major determinants of a firm's capacity. Highly skilled and trained workforce results it enhanced capacity. Deploying workforce on overtime or outsourcing the work to outside agencies may increase capacity. The capacity of the workforce in an organization can be measured by the technique called 'Work-Study'. Work-Study comprises method study and work measurement.

Financial and other resources :

Availability of financial resources determines the organisation's ability to acquire inputs and distribute output. Thus, it is a determinant of the organisation's capacity. Financial Resources are required for purchasing inputs, equipment and facilities and for hiring workforce and hence its availability may limit capacity. Other inputs in themselves, may be limited, e.g. a firm may require funds to set up a diamond processing plant; on the one hand, the availability of financial resources may limit the capacity of the firm, while on the other hand, the amount of (diamond) raw materials may also be limited. These factor limit the capacity of the firm to produce finished diamonds.

6.4 Questions

Short Type Questions

i) Define capacity.

ii) What is the significance of workforce in capacity planning?

iii) How does technology affect capacity?

Descriptive Type Questions

i) What are inputs to capacity? Describe in brief

ii) Describe the capacity planning process.

Unit 7 □ Process Planning, Scheduling and Work Study

Structure

7.1 Introduction

Planning describes the activities that take place in order for the transformation process to occur. It involves determination of the most economical method of performing an operation or activity. The stages in process planning are as follows:

1. *Process choice* : As described in earlier section the different types of processes are namely, project, job, batch, line and continuous process. These processes have different characteristics and as such require separate approaches in process planning. The choice of process depends upon the following factors :

a) Ongoing jobs and production commitments
b) Delivery date
c) Quantity of production
d) Customization and quality standards

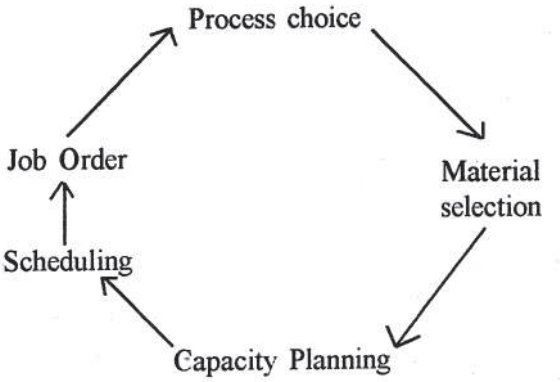
2. *Material selection* : The right type and quantity of material should be selected to meet the customer's demand and optimize material consumption.

3. *Capacity planning* : Capacity required to produce finished goods within a specified time is determined. Capacity planning involves selection and acquisition of right kind of equipment. The selection should be such that it ensures higher production rate, lower production cost, and enable production of desired type of product.

4. *Work scheduling* : Scheduling refers to when and in what sequence the work will

be done. It involves programming of the entire work so as to complete the job in the right time.,

Thus the planning cycle can be represented as follows :



7.2 Scheduling

It is concerned with sequencing and timing of activities. It is the operational level planning and control that can be used for the following :

- Schedule the timing and sequencing of activities.
- Prepare the worker deployment plan, i.e., which workers perform these activities, and when
- Arrange for delivery of inputs
- Arrange for delivery of finished goods and/or services.

Scheduling involves the following three activites :

(i) Loading - determining and assigning the amount of work to be assigned in each stage of the process, whether to production centers, or staff groups. There are two types of loading, namely, finite loading and infinite loading. Finite loading refers to assigning work to a job centre with a finite capacity limit, e.g., machines equipment with a maximum processing time rate. Infinite loading is related to assigning work centre or activity where there is no maximum capacity limit, e.g., queue at a ATM (cash withdrawal machine), that can be of any length.

(ii) Sequencing - deciding on the order of initiating and processing of jobs at each stage.

(iii) Scheduling - fixing start and finishing times to each work at each stage.

7.2.1 Schedule tools

The Gantt Chart : It is a simple tool and easy to understand, for scheduling activities. It

is a type of bar chart that indicates what work is scheduled for a given period of time. The activities are shown on y-axis (vertical axis) and the time frame shown on the x-axis (horizontal axis).An example is shown in the figure below :

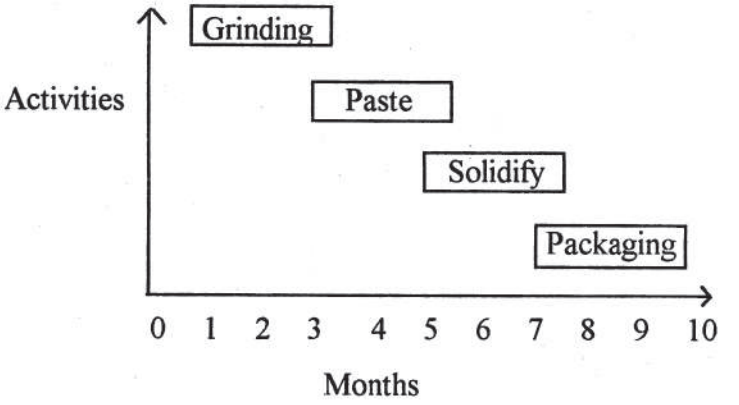


Figure 7.3 Gantt Chart

7.2.2 Factors affecting scheduling

The factors that affect production scheduling are as follows :

(i) External factors

- (a) Demand
- (b) Delivery rate and dates
- (c) Inventory of finished goods with dealers, wholesales and retailers

(ii) Internal factors

- (a) Inventory of finished goods with the firm
- (b) Production cycle time
- (c) Availability of materials and equipment (capacity)

7.2.3 Dispatching

Planning and scheduling lays down the plan of work. Dispatching ensures that the plans are properly implemented. It refers to orders and instructions in accordance with the plan of activities. A dispatcher coordinates the production activities and serves as link between production and sales. Dispatching involves issuance of the following orders :

- ◆ Store Issue order – for issue of materials (inputs)

- Tool order – for release of equipment and machinery
- Job order – for start of operation
- Inspection order – for inspecting goods at various stages of production
- Move order – for movement of materials and components from one facility to another.

7.3 Work Study

One of the major determinant of an operation's capacity is the size and capabilities of the workforce. Unlike equipment and machines, workers cannot be programmed to work at uniform pace. Their performance vary in both qualitative and quantitative terms with respect to several factors such as, motivation, working conditions, method of operation etc. People need time off and their performance has high variability. Because of this inherent variability in people's work-pace, special set of tools and techniques have been developed to measure what work levels, people can achieve under normal circumstances. The time taken to do a work may also depend on the method of operations. Unnecessary operations may lead to more time to carry out an operation. Method study aims to eliminate unnecessary operations and wastage.

Work-study, comprising method study and work measurement, can help in improving operations in many ways. It enables reduction of cost, improvement in productivity and ensures high motivation of the work force.

7.3.1 Method study

Method study involves the systematic recording of the existing and proposed ways of doing work. It aims at critically analysing the processes in order to improve performance. It relates to activities and represents modifications and additions to the present procedures so as to make what is done more logical and more systematic. Method study consists of a basic procedure, embodying certain formalized techniques, which are employed in a particular way and for a specific purpose. The steps constituting the basic procedure are as follows :

1. **Select** the job to be studied in terms of the precise boundaries of the investigation. Impose any necessary constraints and determine the objectives of the study.
2. **Record** all the relevant information which will assist in the solution of the problem, making sure that the level of detail is appropriate to the level of the activity selected.
3. **Examine** the recorded facts or proposals critically and impartially and produce

alternative courses of action, together with the implications of these alternatives.

4. **Develop** a better approach or process.
5. **Install** the new method as a standard of excellence.
6. **Maintain** this new standard as the minimum, at the same time actively seeking for further improvement on a continuous basis.

The above approach is termed as SREDIM, which is widely used for method study. The activity studied for the purpose of improvement is represented with symbols. The five symbols used in method study are as follows :

❍	Operation	∇	Controlled storage
D	Delay	⇨	Transport
□	Inspection		

The study of the method would reveal the delays and unnecessary operations. The aim is to have as much pure 'operation' activity as possible as this is the only activity that adds value, while the other are, though may be essential, non-productivity 'cost' factors and will reduce utilisation of the capacity. Method study serves as tool for continuous improvement and helps in following areas :

- layout
- Material handling
- Tool design
- Product design
- Quality standards
- Process design

7.3.2 Work measurement

Any job when studied and analyzed broadly breaks up into following three categories :

1. Basic work content
2. In-effective work content
3. In-effective time

The aim should be to eliminate or, reduce the last two components. Method study on the one hand tries to eliminate or reduce ineffective work content while work measurement is primarily concerned with investigation, reduction and subsequent elimination of

ineffective time, be it within the control of the management of the worker. According to ILO (International Labour Organisation) the definition of work measurement is as follows:

"Work measurement is the application of technique designed to establish the work content of a specified task by determining the time required for carrying it out at defined standard of performance by a qualified operator".

Work measurement, thus, provides managment with means of measuring the time of performance of a job and doing so, also, separates the ineffective time from effective· time.

In general the following are the objectives of work measurement :

1. To investigate, reduce and subsequently eliminate ineffective time.
2. To assist method study.
3. To set consistent and equitable standards of performance.
4. To furnish reliable date for use in compiling charts a formula.
5. To complete standardization of a given job.

The important uses of work measurement are as follows :

a) To compare the efficiency of alternate methods
b) To determine assignments for balancing the work load
c) To control machine utilization and labour performance
d) To set standard data ·
e) To provide information on :
   (i) Planning and scheduling
   (ii) Estimates for tenders and quotations, selling prices and delivery promises
   (iii) Incentive schemes
   (iv) Labour cost control

Work measurement techniques : The following are the principal techniques by which work measurement is carried out

(a) Time study
(b) Production study
(c) Work sampling
(d) Synthesis from standard data
(e) Pre determined Motion Time Standard (PMTS)

(f) Analytical Estimating

Other than work sampling and analytical estimating, all other techniques either derive from time study or are variants of it. These techniques are applicable in different situations.

- **Factors affecting the time**

There are several factors affecting the time which a worker would take to accomplish a given job. These are as follows :

(a) Method of working

(b) Place at which work is performed

(c) Delays and interruptions

(d) Time taken for compensating fatigue and attending personal needs.

Therefore, the time required to do a job can be specified only when the factors affecting the time have been standardized. In other words, it can only be said that a given job performed according to specified method, and when involving a specified amount of delay would require a certain fixed time for completion by a worker working at normal pace and taking a specified normal amount of time for rest and personal needs. The amount of time as described above is termed as Standard Time.

- **Time Study**

It is a technique for determining as accurately as possible from a limited number of observations the time necessary to carry out a given activity at a defined standard of performance (ILO).

Thy steps in Time Study include:

(i) Selecting the job. to be studied

(ii) Breaking down the job into elements

(iii) Measuring with a timing device (usually a stop watch) and recording the time taken by the operator to perform each ‘‘element’’ of the operation.

(iv) At the same time assessing the effective speed of the working of the o.perator relative to a pre-determined ‘‘normal’’ speed.

(v) Converting the observed times to ‘‘normal times’’.

(vi) Determining the allowances to be made over and above the normal time for the operation.

(vii) Determining the 'allowed time' for the operation.

Types of elements

There are different types of elements and they may be classified as follows :

(i) Regularements are those which recur in every cycle of a job.

(ii) Constant elements are those elements that are identical in specification and time, and occur in two or more operations.

(iii) Variable elements are those elements in which the time of performance varies with characteristic of the product, equipment, a process (e.g. dimension such as weight of an object to be moved).

(iv) Occasional elements are those elements which do not occur in every cycle of the task but which may occur occasionally.

(v) Foreign elements-are those observed during study, which are not a necessary of the operation or activity studied.

Computation of Standard Time

Observed time *Rating = Normal Time

Normal time +Allowance = Standard Time

where,

- Observed time is the time observed (with a stop watch)
- Rating (also known a performance rating) is the mental comparison by a work study man of the performance of an operator under observations with his own idea of a standard performance for a given method.
- Allowances are given over and above normal time to compensate for the fatigue so that the operator is able to work throughout the shift. It is also included to compensate for all lost time which is beyond the control the work.

Thus, standard time of operation of any given job should include the following.

1. The effective normal time for the continuous performance of the cycle.
2. The time for rest to compensate for the accumulated fatigue.
3. All other loss time per cycle that can be termed as unavoidable delays that is inherent for a given situation beyond the control of the worker.

In a practical work situation the worker while performing a job does it at a certain pace, takes rest when he needs it and also looses time due to maintenance, inspection, talking to foreman, change of setup etc.

The first step before giving any allowance is to examine carefully all the inflectual time

and decide whether or not it can be eliminated. Thus, allowance should include ineffectual time beyond control and indirect activities necessary for the proper performance of the work. The different types of allowance are :

1. Process Allowance : It is an allowance of time given to compensate for enforced idleness on the part of an operators due to the character of the process or operation on which he is employed (ILO).
2. Rest and Personal Allowance : It is an addition to the normal time (usually calculated as a percentage) intended to provide the worker with an opportunity to recover from the physiological and psychological effects of expending energy in the performance of specified work under specified conditions and to allow attention to personal needs (I.L.O).
3. Constant Allowances : It is made up of the personal allowance and an allowance to cover the using up of energy over where no work is being done. This allowance varies with sex and working conditions.
4. Variable allowance : These are given or factors which vary from job to job, such as standing in abnormal position, use of force or energy, bad light, atmospheric condition, noise level, mental strain, monotony, tediousness etc.
5. Special Allowances : It is given for any activities not normally part of the operation cycle but essentially to the satisfactory performance of the work, they fall under two broad categories namely,
    (a) Periodic activity allowance (e.g. periodic inspection etc.)
    (b) Interference allowance (e.g. operator working with several machines, each of which is liable to either cyclic or random stoppages; these are prominent in jute, textile and similar industries)
6. Policy Allowances: Any allowance given at the discretion of the anagement over and above allowances given due to features inherent to tle work under consideration (ILO).

Temporary allowances, which are also a form of policy allowance, may be made for abnormal conditions, such as poor quality material or the imperfect functioning for a particular piece of plant etc.

7.3.3 Work Sampling

Work Sampling is a measurement technique for the quantitative analysis, in terms of time, of the activity of men, machines, or of any observable state condition of operation. It is an extremely useful device with which to make an inexpensive overall survey of

office, workshop, or service activity. Work Sampling is preferred above time study as it is convenient, possesses known for reliability. It can be applied without the use of stop watch or to subjective judgement of performance rating.

A Work Sampling study consists of a large number of observations taken at random intervals in taking the observations the state or condition of the object of study is noted, and this state is classified into predifined categories of activity pertinent to the particular work situation. Inferences are drawn concerning the total activity from the proportions of observations in each category.

The underlying theory of work sampling is that the percentage of observations recorded a man for machine as idle or working, or in any other condition, reflect to a known degree of accuracy of the average percentage of time actually spent in that state or condition. If observations are randomly distributed over a sufficiently long period of time, this theory is held to be true and correct, regardless of the nature of observed activity. Work Sampling utilises the well-established principle of drawing inferences and establishing frames of reference from a random sample of the whole. It is a practical compromise between the extremes of purely subjective opinion of continuous observation and a detailed study. The reliability of work sampling is enhanced with increase in number of observations.

Steps in Work Sampling.

The steps in work sampling are as follows :

A Preparing for work sampling :

1. Deciding on the objectives of study.
2. Establishing and recording quantitative measure of production with which work sampling results may be correlated.
3. Selection and training of personnel.
4. Announcement of the study.

B. Performing work sampling :

1. Classifying into categories the activity to be studied.
2. Designing the necessary forms.
3. Developing properly randomized times of observation.
4. Observing activity and recording data.

7.4 Questions

Short Type Questions

i) What factors affect scheduling?

ii) What is the role of dispatching?

iii) How does work-study help us in improving the productivity?

iv) What is the importance of method study?

v) How does time study helps a production manager?

vi) How is standard time computed?

Descriptive Type Questions

i) Describe the process planning cycle .

ii) Explain what is work-study.

iii) Describe work sampling.

Unit 8 □ Work Environment

Structure

8.1 Introduction

This is one of the most important factors in any organization, as it helps in improving productivity and reducing loss to life and property. The need for safety management was realized in early part of 20 century. The first co-operative safety congress was held in 1912 and an organization of the National Safety Council was formed in USA. In India different acts such as Factories, Office, Shops, Railway premises acts etc have been introduced to ensure implementation of safety measures in the industries.

8.1.1 Need for Safety

Safety in industry helps in the following ways:

(i) Increase the rate of production
(ii) Reduces production cost
(iii) Reduces damage to property (Equipment, machinery, building etc.)
(iv) Prevents loss of life.
(v) Reduces injury and disablement of work force
(vi) Boosts morale of employees
(vii) Reduces legal hassles and loss due to work men's compensation

8.1.2 Safety Management

Safety Management involves planning, implementation and control of safety measures in organization.

Planning for safety

The aspect of safety should be borne in mind at the time of deciding on location and layout of operation. These are important factors, as decision taken and implemented on these aspects are very difficult to change. The investment made are sunken cost and almost irreversible. As a result most of the operations continue in spite of the occurrence of accident at the production site (primarily because of wrong location and for layout). The next important factor for safety planning is the choice of tools and equipment etc. Some machinery is accident-prone and hence, adequate training to the work force should precede use of this equipment. Planning for safety should involve implementation of best practices and measures as per statutory requirements. Thus, safety planning should include educating and training workers and supervisors regarding safe practices on the shop floor.

8.1.3 Implementation of Safety measures

The first step to implementation of safety measures is to identify the person in-charge of safety measures. The responsibilities of this official are the following :

(i) Identification of safety needs

(ii) Enforce safety measures

(iii) Review safety measures

(iv) Record and maintain data on accidents, deaths, injuries, damage to property and related aspects.

(v) Recommend training, and conduct work-shops and seminars.

(vi) Circulate and display safety rules, and modifications and amendments of the rules and safe practices.

(vii) Carry out inspections and visit to check implementation of safety measures.

(viii) Report the status to higher authority and· regulatory bodies periodically.

8.1.4 Safety Programs

Safety programs are held to assess review and educate work force on safety aspects in an organization. It analyses the cause and effect of accidents and suggests ways and means of reducing such accidents. It is a continuous process and aims at continuous improvement in work practices. A safety program, thus, includes 4 'e' as described below:

(i) **Engineering :** Consideration of safety aspects at the time of layout, design and installation of machinery.

(ii) **Education :** Training and creating awareness of safe practices among employees.

(iii) **Enlistment :** It refers to the interest and attitude of employees and management towards safety programs and it purpose. Safety programs also aim at arousing the interest of employees in safe practices and safety consciousness.

(iv) **Enforcement :** Enforcement and adherence to safety rules and safe practices.

8.2 Accidents

An industrial accident may be defined as unexpected event that cause injury, disability or death of a person and damage to property.

Although accidents are stated to be unexpected events, there lie distinct causes.

The causes of accidents are as follows :

(i) Human cause

(ii) Technical cause

Human causes are unsafe acts by persons resulting in accidents. These unsafe acts include ignorance, forgetfulness, carelessness, defiance to safety rules and safe practices etc. Accidents may also happen because of personal factors.

Technical causes are unsafe conditions that reflect deficiencies in design, layout, equipment, tools, material handling system, work environment etc.

8.2.1 Environmental Factors

Environmental factors refer to physical and atmospheric surroundings of work that affect operations. It includes

(i) Temperature

(ii) Illumination

(iii) Sound

(iv) Humidity

(v) Work Load

(vi) Working hours

(vii) Odour and other disturbances

(viii) House keeping

8.2.2 Prevention of Accidents

The working environment should have the right temperature and illumination, low humidity, and human bearable noise and disturbances. The work place should be hygienic and free from bad odour. There should be well-defined scientifically designed (may be through

work study) workload and working hours. There should be provision for appropriate breaks and recess for rest. Adequate health measures should be taken to ensure proper physical and mental condition of workers.

The equipment, tools and machinery should be property maintained. Preventive maintenance should be carried out at periodic intervals. The workload and working hours of equipment, material and tools should be properly monitored. Effective spare parts management to replace old and worn out components should be in place. Old and fragile equipment should be replaced at the right time.

Material handling should be done with right handling equipment and using the right method. Working should put on protective devices such as helmets, gloves, eye goggles, mask, safety shoes, apron etc wherever required. Handling of inflammable materials should be done with care. Electrical connections and insulation should be checked and monitors at regular intervals. Water seepage, dampness, water logging be avoided. Accident-prone activities and zone should be earmarked and care taken to ensure strict implementation of safe practices.

Employee training and safety programs should be held as a continuous process and commitment of top management to the safety rules and safe practices is must.

8.3 Questions

Short Type Questions

i) Explain the need for industrial safety.

ii) What are the steps in safety management?

iii) How can we prevent accidents?

iv) What are the environmental factors that affect operations?

Descriptive Type Questions

i) Explain the safety management and planning in an organization.

ii) Describe the safety programmes and its importance.

Unit 9 □ Materials Management

Structure

9.1 Introduction

The flow of materials, for an interrupted production or rendering service, is essential for any firm. The flow will depend on the choice of operation process. In line and continuous flow, the product moves sequentially from raw materials (inputs) to finished products. In this case, goods are produced in bulk, and are only packaged into discrete items (packets) in the final stage of production. The flow as well as choice (quality and quantity)

of material is very important as any change in decision may lead to stoppage of production and therefore has to be done without shutting down production for an extended time.
In batch production, each batch of the goods flow from one work point to another work centre. Each batch may take a different route through the system. Thus the flow of material has to be decided in light of factors such as batch order (size), time of production, quantity, route and time of delivery. In project flow, the resources required to do the work and the material on which work is done are brought together specifically for a project.
Material flows are ascertained and analyzed by using flow process charts, drawings, and of assembly and routing sheets, which together describe how a product is to be produced or service to be rendered.

9.2 Inventory Management

In order to ensure uninterrupted flow of inputs for productions and also to enable supply of finished goods(output) to the customers and clients, raw materials, (inputs) and outputs are held in the firm for future consumption. These inputs and outputs kept in stock are termed as inventory. In manufacturing operations, inventory usually refers to raw materials and suppliers, work-in-process and finished goods.

Raw materials inventory : These are inputs to productions process that are converted into finished goods. Raw materials may include, basic elements and compounds, process parts and components and any other input (such as potatoes forproducing chips).

Supplies : Supplies are inventory items that are used in an indirect way in the production process. These include, cleaning materials, maintenance machines and equipment and other items that do not become part of the finished products or tangible output of a service operation.

Work in process (WIP) : These are inventory items at all immediate stages between raw materials inputs to the process and finished goods.

Finished goods : Finished goods are the final outputs whose conversion has been completed and are ready for delivery to the customers.

An organization aims at reducing the level of inputs (raw materials and components) and finished goods. However, the WIP inventory is nearly inevitable. Some WIP inventory is held because it is being moved between different stages of production. Some stock of intermediate goods is kept as buffer so that interruption to the process is avoided.

9.2.1 Why Inventory is required?

Inventory is required to support the performance objectives of quaiity, reliability, speed,

flexibility and cost in the following ways:

Maintaining quality of product : Variation in supply of raw materials of desired level may lead to quality problems. Uncertainty in availability of quality inputs and disruption in production process due to the shortages of input supply and intermediate items, may lead to drop in quality of the finished goods.

Reliability : The reliability of delivery of finished goods to a customer can be ensured through holding inventory.

Uninterrupted Supply : Decoupling operation from changes in environment is one of the primary reasons for holding inventory. There could be interruption due to vanous reasons.

Uninterrupted (smoothed) production flows: An inventory of finished goods are maintained when the demand for the goods vary. The output of production flow if not delivered to the customer, are maintained as inventory. The uninterrupted production flow leads to optimal utilization of technology and work force.

Meeting Customer Demand : The forecast of demand may go wrong leading to unexpected demand for finished goods. As such, a safety stock, i.e. an inventory is held in excess of the expected level of demand to prevent stock out.

Reduced Delivery Lead Time: The lead-time i.e. the time required to supply goods to the customer is minized through inventory of goods. The objective is to immediately provide goods.

Flexibility : Inventory held is a firm enables the firm to exercise the flexibility of production. It can choose to produce only after receipt of order, only if it holds inventory of inputs and finished goods. The inventory of input reduces the elapses time between supply of material and production, while inventory of goods enable to start the supply from the desired date.

Reduced raw material and component cost: The cost of acquiring inputs may be reduced if purchased is in bulk quantity. Inventory also prevents purchase of goods at times of scarcity when the price increases. Inventory may also mean purchase of goods in advance of price increases.

9.2.2 Objectives of Inventory Management

The primary objective of inventory management is to provide the way to decide on the following :

(i) Make or buy

(ii) When to buy

(iii) How much to buy

Inventory management focuses on optimization of the following :

(i) Ordering Cost

(ii) Holding Cost

(iii) Shortage Cost

Ordering Cost (C) : It includes cost of preparing a purchase order, cost of transportation and shipping, receiving, inspection, handling and storage. If the product is made inhouse, the cost is said to be set-up cost, which refer to cost of preparing for the production, and all other costs such as acquisition of resources (raw materials etc). changing the production process or setting up of machines and equipment.

Holding Costs (C_b) : This includes cost of storage facilities, the funds, and reduction in the value of goods held in inventory through obsolescence, pilferage etc.

Shortage Cost : This is the cost incurred due to production stoppage, lost sales and inability to meet customer demand, arising out of inadequate inventory.

The above costs and annual demand (D) of the goods are used to determine the optimal ordering quantity (i.e. "how much to buy").

Economic Order Quantity (EOQ) : It is the optimal fixed quantity that is ordered at a time. This quantity minimizes the total cost of inventory (viz. holding, ordering and shortage cost). The computation of EOQ is based on certain assumptions. For example, the EOQ can be computed as :

$$EOQ = \sqrt{\left[(2DC)\right]/C_b}$$

For the following assumptions :

1. All cost are known and do not vary, and the demand (D) for an item is also known and do not vary.
2. There is no shortage cost.
3. Items are delivered as and when ordered. That is, there is no time lag in supply of materials.
4. The unit cost of an item and the reordered costs are fixed and do not change according to quantity (that is, there is no bulk discount)

9.2.3 Continuous inventory system

In this system, the inventory levels are continuously monitored. A fixed amount of inventory items are ordered as the level of inventory drop below a predetermined level.

9.2.4 Periodic inventory system

In this system, the inventory level is monitored periodically, i.e. after a specific time

period, and a variable (not fixed) amount is ordered depending on the level of inventory in the stock. This type of monitoring is also termed as fixed -time period system. In this fixed time period system, the time period of replenishment is fixed while the amount ordered is variable. The amount ordered is equal to the difference between the pre-determined level and the actual level at the time of inspection. This type of inventory system is generally known as a bin-system. It is either one-bin or two-bin system that is followed. In one bin-system, the inventory is replenished to the extend items are used. Items are replenished even if the quantity is few in number. This type of system is followed in retail shops.

In a two-bin system, there are two bins of items. Order is placed when the first is completely used up. The two bins are of such size, that the consumption period of second bin of items is equal to the delivery period of items for the first bin.

9.2.5 ABC Classification

This is a method of classifying the inventory items. Classification of inventory is done on the basis of usage and cost of items. ABC is based on the Pareto principle (80/20). According to this principle, it is inferred that only a few items account for most of the consumption. The objective of ABC classification is to decide which items are important and need to be tightly monitored, and which are not.

The classification is done on the following way :

A list of all inventories, items are prepared. The unit cost of each item and the quantity of units used is recorded against the list of items.
The annual expenditure against of each item is computed by multiplying cost of each item and quantity of the item used.
The list of items is now sorted in a descending order of annual usage.
The next step is to determine the cumulative percentage of the total annual cost contributed by each item. The cumulative percentage is computed by adding the cost of each item with cost of its previous items, divided by the total expenditure on all items.
The sorted list is now classfied in A, B, and C items. The items with highest annual expenditures are called A items. Class A items are required to be monitored and managed closely as it involves high investment. Holding inventory of class A item will lead less on account of blockade of capital. Aitems generally account for 70-80% of the total inventory cost and constitute about 10% of the total inventory. The items with moderate annual expenditures are called B item. These items are the next category of items that are managed and monitored may be less closely than 'A' items. B items generally account for 20 to 15% of the total inventory cost and constitute

about 15 to 20% of the total items. The items that are consumed in large volumes but with lowest annual expenditures are classified as class C items.

Simple Inventory systems (such as two bin systems) are used for control of their usage. Class C items generally account for 15 to 20% of the total inventory cost and constitute about 75% to 80% of the total items. The graphical representation of class A, B and C items are shown m figure below.

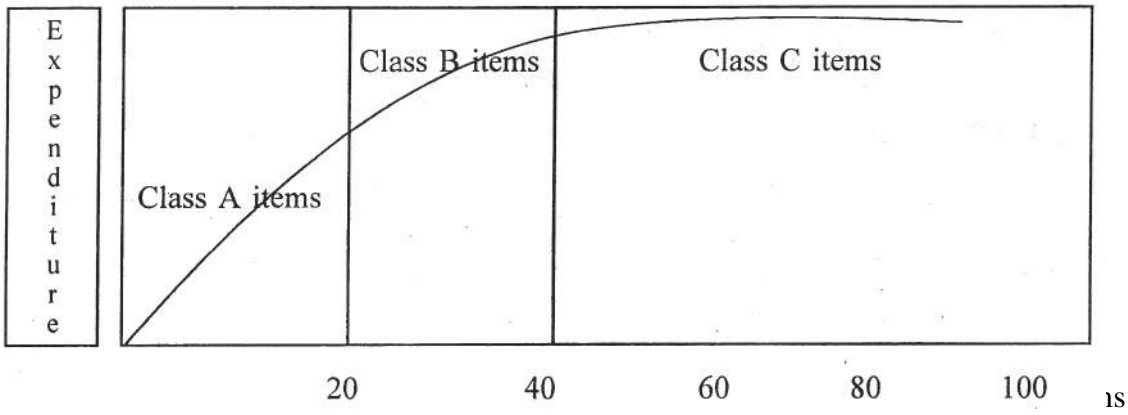


Figure 9.1 The basic of ABC classification

9.2.6 Independent and dependent-demand inventory

There are two categories of items, namely independent demand items and dependent demand items. Independent demand items arc those, which are unrelated or independent of demand of other items. These are normally the end products of an organization whose demand is estimated from the requirements of the customers or clients. Where as dependent items are those, which are related to the indepndent items. Demand for independent demand items given rise to requirement of dependent-demand for televisions by the customers are independent demand items where as the components of a television such a picture-tube, power supply unit etc. are dependent demand items. It is necessary to understand the difference between these categories items. This is because the material requirement planning for end products is based on forecast of customer demand, where as demand for components as based on demand of end products. There is always an uncertainty in the demand for independent items that often results in carrying higher levels of inventory to minimize the risk of stock out.

9.2.7 Materials Requirement Planning (MRP)

It is a top down approach designed to determine the requirement of inputs. As such MRP is a dependent demand system that detumines the requirement of materials and enables production planning based on forecast of sales orders. Thus, it is used to manage

the component demand inventory instead of finished goods inventories. It is used in batch or line/mass process type of operations, where the finished products are manufactured from large number of component items over several production stages.

The demand for inputs is endogenous and is calculated from demand for finished goods. MRP is carried out based on the following :

(i) Demand of finished goods.

(ii) The master production schedule, that indicates the quantities and schedule of outputs.

(iii) The bill of material, that indicates the parts and components that are required as input and the quantity required.

(iv) The inventory master file that provides information about the stock on hand and on order.

MRP forms the basis for capacity requirement plan (CRP). The MRP system is schematically shown in figure 9 2.

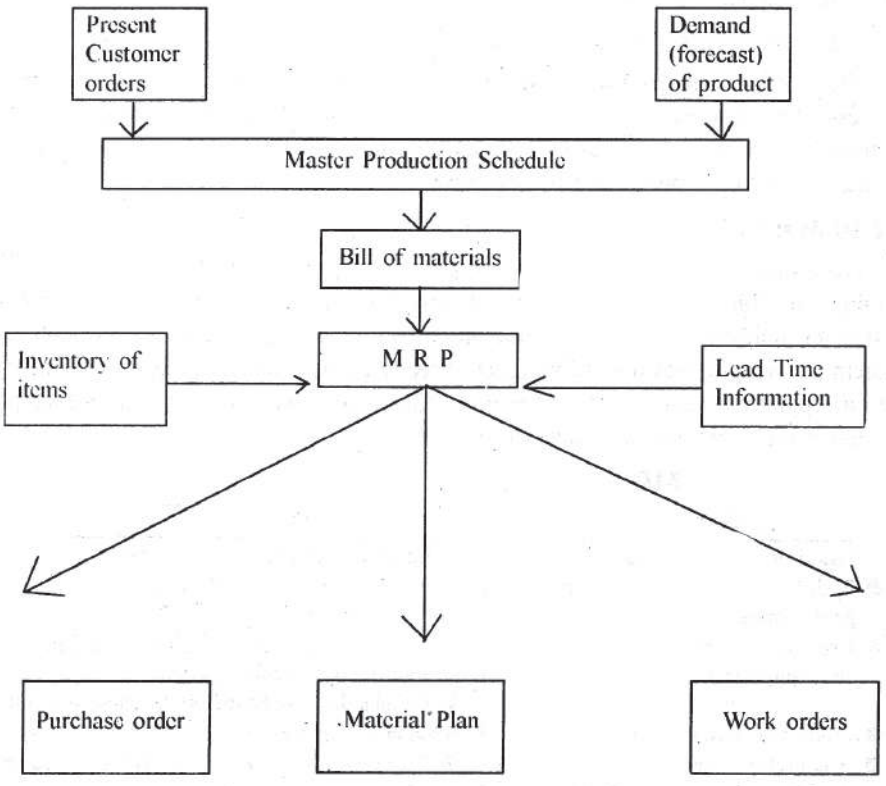


Figure 9.2 The M RP System

The MRP system structure comprises of a set of 5 (five) questions which are as follows :

1. How many products are required to be manufactured?
2. When are these goods required?
3. What is the composition (components) of finished goods?
4. What are quantities of components required?
5. What is lead-time of obtaining the components (inputs)

9.2.8 Manufacturing Resource Planning (MRP II)

It is an improved system to determine the requirements of raw materials and components. It includes all features of MRP and in addition incorporates other management ingredients such as tooling, routing methods, and capacity availability and man-hour requirement.

9.2.9 Enterprise Resource Planning (ERP)

This system is an extension of MRP II that integrates internal and external business process. The external business processes include the customer - retailer-physical distribution sub-systems that are integrated with the supply chain. Thus, it incorporates all the aspects of supply chain management.

9.2.10 Just in Time (JIT)

According to this system, items are procured in exact quantities at the time of production. This is based on principle of zero inventories. Thus it attempts to ensure a smooth, uniform flow of small amounts of the right type of material through the system. JIT emphasizes flow of materials directly to the production centre rather than into a separate storage area or warehouse. This type of system is suitable for simple repetitive manufacturing of standard product.

- Comparison of MRP with JIT :

MRP	JIT
◆ Based on forecast of sales	◆ Based on actual customer requests
◆ Push based system as it relies on predetermined schedules	◆ Pull bases system as it based on customer request
◆ Use special purpose set up (machine and equipment)	◆ Uses general-purpose machines that can perfonn serveral basic functions.
	◆ Cellular layouts Based on Japanese principles
◆ Production layout is line type	◆ Kanban of and Kaizen
◆ It is useful where there is complexity of products and variability in demand	◆ Perfonns best in stable conditions, including simple product structures, clearly defined material flow, and level and predictable demand

The two systems can complement each other in the following ways :

First, a production process can use JIT for managing the actual day-to-day operation and MRP for material and production planning and control.

Secondly, JIT can be used for standard products that are repeatedly used while. MRP for end products that are infrequently produced.

9.2.11 Optimized Production technology (OPT) System

This system is based on Goldratt's theory of constraints that performs similar functions as MRP. In addition to features of MRP, this system incorporates the constraints in flow of materials. This system identifies the obstructions and delays in flow of materials. Goldratt's theory of constraints outlines the need for identifying the bottlenecks, setting the pace of process accordingly to the capacity of bottleneck, need to make provision for buffer of jobs and release of job on the receipt of order signals from the bottleneck to avoid excess jobs queuing up as WIP inventory. Thus, while planning for production, the flow of inputs, bottlenecks and queuing of jobs are required to be considered.

9.3 Purchase Management

Purchase Management involves procurement of right material, in right quantities, of right quality from the right and reliable source, at right price and receives and delivers materials at right place and at right time.

Activities, duties and functions of purchasing section :

(i) To keep record of inventory of items.

(ii) To determine the quantity, type and quality of materials to be procured.

(iii) To standardize the materials.

(iv) To develop a vendor base.

(v) To process indents of materials.

(vi) To select the right source of supply.

(vii) To issue purchase order.

(viii) To follow up and expedite the order.

(ix) To inspect, receive and approve receipt of materials.

(x) To process payment to the vendors.

(xi) To close completed order.

(xii) To maintain records & files.

9.3.1 Purchasing Procedures

The departments raise indents or purchase requisition. The purchase requisition contains the following information:
   (i) Material description and quality
   (ii) Quantity of material
   (iii) Date and place of delivery

A bill of material is generally used for raising the purchase requisition.

The purchase department develops a vendor base for selection of possible source of supply. It obtains information about vendors from existing supplies. Internet, journals, catalogues, advertisements, trade exhibitions and fairs, and trade directions (i.e. yellow pages etc.) The purcahse department decides on local, national or global vendors. It decides on a single vendor or multi-vendor supply of a material.
The purchase department makes request for quotation. It seeks offer through e-mails, letters and faxes, notices displayed in web site, newspapers and other media. The quotation seeks information on vendor's ability to supply the material, unit cost, taxes & duties, total cost, delivery period, warranty conditions, payment terms, validity of offer and other relevant information.
The purchase department receives and analyses the quotation. It involves primarily two stages. The first stage includes technical and commercial evaluation of the bid. The second stage includes evaluation of price offered by the vendor.
The purchase department issues the work (purchase) order. This includes, name and address of firm, material, description, quantity, total cost and other terms and conditions.
The purchase department follows up with the vendor for tinely supply. If inspects, receives and approves supply of material.
The process and makes payment to the vendors. The stores department records the receipt of material.

9.3.2 Accounting

All purchase transactions initiate a chain of accounting transactions. The purchase and receipt of materials as well as payment to the vendors are accounted in the books of accounts.

9.4 Stores and Material Control

Stores management involves handling, storage, security, preservation, dispatch and

control of materials procured by the purchase department. In other words, it is responsible for the custody of materials.

Stores management takes care that inventory level is not more than desired level and the same is never out of stock. It keeps record of materials received, stored and issued. The stores department ensures that the materials are kept under proper environment and in proper condition.

Stores management involves decision on location and layout of stores. The location of stores is decided on the basis of its proximity to other functional units, access to the materials, its security and other infrastructural requirement.

The layout of the stores depend on shape, size and volume of materials stores in the stores (warehouses etc.). The layout of stores should be such that handling, movement and access of materials can be smoothly done. The layout should ensure optimal utilization of space.

9.4.1 Centralized-vs-decentralized stores

In big enterprises, stores department cannot be situated where it is convenient to supply materials to the functional units. In this case it becomes often convenient to set up sub-stores close to the functional units. This leads to the concept of decentralized stores.

The advantages of centralized and de-centralized stores are as follows :

(I) Advantages of centralization of stroes are :

(i) Better supervision and control.

(ii) Low manpower.

(iii) Less cost.

(iv) Better layout and security of stores.

(II) Advantages of decentralization of stores are.

(i) Less material handling and the associated cost

(ii) Easy dispatch and prompt availability of materials

9.4.2 Other aspects of stores management

(i) Maintenance of bin cards. A bin card or a stock card indicates the details of materials, its quantity, issued and on hand each day. Bin card are attached to each shelf. Bin cards may be made in duplicate; one card is attached to the bin/ stock holding the material, and the second remains with the storekeeper. Bin

cards may also contains information such a ordering level, maximum and minimum quantity of each material to carried out, normal quantity of each material to be ordered etc.

(ii) Maintenance of stores ledger : Store ledger is similar to that of bin card.

It keeps record of stores transaction in four sections which are as follows :

(a) Material ordered

Date ordered

Purchase order number

Quantity

Date Delivery expected

(b) Material Received

Date of receipt

Purchase order number

Quantities received

Unit cost

Total cost

(c) Material issued

Date of issue

Receipt number

Department

Quantity

Unit cost

Total cost

(d) Stock on hand (Balance)

Quantity

Unit cost

Total cost

(iii) Codification of materials :

The materials in the store are assigned specific and unique codes. A code may comprise letters or numbers or both (alphanumeric). Codes enable easy identification of materials and hence better control. It enables better record maintenance.

(iv) Physical verification of stores (stock taking)

Physical verification of stores is done to verify and reconcile the actual stock of materials with the records maintained in bin card and for stock ledger. Physical verification indicates the losses in inventory due to pilferage, misplacement, damage, deterioration etc. It enables update of record. It reduces the chance of stock out. It also enables to effect insurance coverage of the materials in the store.

Physical verification is done either annually or is a continuous process. In this process damaged, lost and obsolete items are identified and stock updated. It leads to decision on classification of materials as fast, moderate and slow moving of materials. It also leads to review of security, layout and other matters. Care should be taken to ensure that operation is not stalled beyond certain time period in order to avoid production loses.

9.4.3 Computerisation of purchase and stores function

In the present day context all activities of purchase and stores section can be computerized to keep track of all transactions. Ready-to-use or customized application software packages enable to input data, compile information and generate reports on all related aspects. A Decision Support System (DSS) can help in decision-making on matters such as order quantity, vendor management, lead-time management and financial management.

9,5 Questions

Short Type Questions

i) What are the different types of inventories?
ii) Why inventories are required?
iii) What are the objectives of materials management?
iv) Distinguish between continuous and periodic inventory management system.
v) How is MRPII different from MRP?
v) What is the role of purchase manager?
vi) Why store function is required?

Descriptive Type Questions

i) Describe MRP.
ii) Distinguish between MRP and JIT.
iii) Write short notes on
   a) JIT
   b) Optimized Production technology (OPT) System

Unit 10 ◘ Quality Control

Structure

10.1 Process Control

It refers to attaining the desired quality during the production process. The two important techniques associated with the process control are as follows.

(i) Statistical process control

(ii) Quality at the sources

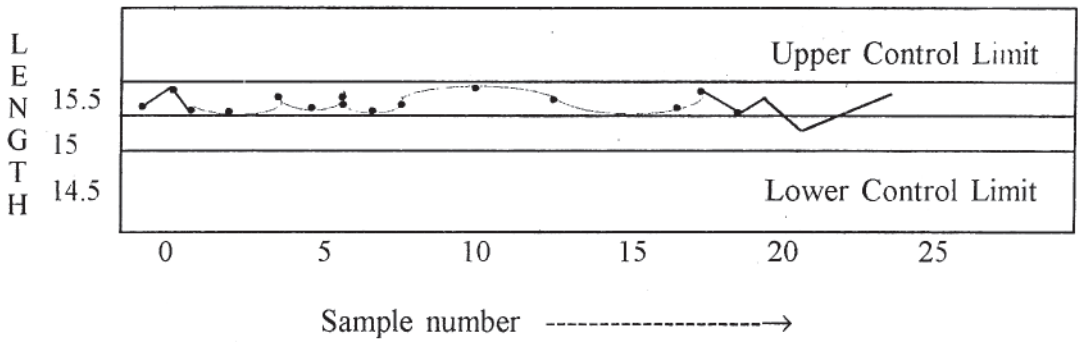
10.1.1 Statistical process Control (SPC)

It measures the performance of the process and it can be used for monitoring and correcting the quality during production (of product or service) process. SPC uses control charts to track the performance of the quality variables or attributes. Control charts are graphical representations of process measures over time. It depicts the process variation and enables the process controller to take corrective action. There are two types of control chart. These are as follows :

X-Chart : An X-chart plots the sample mean to determine whether it is in control or whether the mean of the process samples is varying from the desired mean.

Example :

A control chart is used for assessing the diameter of a metal ball. Five samples are taken in regular intervals. The desired diameter is set at 15mm.



A sample of 5 balls are tested at regular intervals. Their diameter is plotted against the desired diameter of 15 mm. The sample means vary around the desired mean. But if they stay within the upper and lower control limits, the process is said to be under control.

R-chart are the control charts where the output is measured against a range of values. The process range is defined as the difference between highest value and the lowest value of the output. This difference is plotted against a desired difference of range within a upper and lower control limits. The purpose of this chart is to determine whether process is in control and also to detect changes in the variation of the process. For example, a sample of 5 balls at a time, the difference between the highest diameters value and the lowest diameter value in the sample is plotted against the desired process range.

Attribute charts are used for measuring attributes as well as variables. A **P-chart** plots the samples proportion defective to determine whether the process is in control.

Statistical Process control (SPC), is primarily applied to manufacturing industry.

However, its application in services especially quasi-manufacturing or back office environment has shown mixed levels of success.

10.2 Total Quality Management (TQM)

Total Quality Management (TQM) is a management approach advocating the involvement of the employees in the continuous improvement process (Kaizen). It does not confine the task of continuous improvement with just the quality control specialists. Dr. W. Edwards Deming, the American statistician, described many of the. TQM concepts, who guided the Japanese industry's recovery after World War I1 and who formed many of his ideas during World War II when he taught American industries how to use statisticalmethods to improve the quality of military products.

The basic assumptions of the Total Quality Control approach include :

- Work can be broken down into tasks, which are a series of related steps.
- A process groups all related tasks done to accomplish an outcome (i.e. hiring a new employee or producing a product).
- People completing a series of related tasks have interdependent roles in the organization.
- A group of related processes can be seen as a stem (i.e. producing or selling a product).

The practice of defining the steps and outcomes (Products and Services) in their processes and systems by employee's results in a common language and understanding of what their jobs should be and how they fit into the larger picture.

The factors affecting quality and the causality of the factors can be studied with the flow charts, work-flow diagrams, deployment charts, pareto charts and, cause and effect (influence) diagrams people can see their interdependence and that the quality of what comes out is in measure determined by the quality that goes into a process.

Key aspects of TQM include customer-driven quality, top management leadership and commitment, continuous improvement fast response actions based on facts employee participation, and a TQM culture.

Customer-driven quality

TQM has a customer-first orientation. It emphasizes on customer satisfaction. It gives priority to customers, and not internal activities and constraints. The organization believes it will only be successful if customers are satisfied and responds quickly to customer requirements. The concept of requirements is extended to not only product and service attributes that meet basic requirements, but also those that enhance and differentiate them for competitive advantage. Each part of the organization is involved in Total Quality, operating as a customer to some functions and as a supplier to others. The Materials management department is a supplier to downseam functions such as Manufacturing and Field Service, and has to treat these internal customers with the same priority and responsiveness as it would external customers.

TQM leadership from top management

TQM can be successful only with commitment and personal involvement of the top management. It has to be introduced and led by top management. Commitment of the top management is required in creating and deploying clear quality values and goals consistent with the objectives of the organization and in creating and deploying well-

defined systems, methods and performance measures for achieving those goals.

These systems and methods guide all quality activities and encourage participation by all employees. The development and use of performance indicators is linked, directly or indirectly, to cusomer requirements and satisfaction, and to management and employee remuneration.

Continuous improvement

Continuous improvement of all operations and activities is at the core of TQM. Continuous improvement of the quality of the product is viewed as the only way to maintain a high level of customer satisfaction. TQM also recognizes that product quality is the result of process quality. It emphasizes that focus on continuous improvement of the organization's processes will lead to an improvement in process quality. Process quality in turn will lead to an improvement in product quality. Product quality will in turn increase customer satisfaction. Elimination of waste is a major component of the continuous improvement approach. There is also a strong emphasis on prevention rather than detection, and an emphasis on quality at the design stage. The customer-driven approach helps to prevent errors and achieve defect-free production. When problems do occur within the product development process, they are generally discovered and resolved before they can get to the next internal customer.

Fast response

The organization has to respond quickly to customer needs to achieve customer satisfaction. Thus organization should have short product and service introduction cycles. These can be achieved with customer-driven and process-oriented product development.

Action based on facts

Process quality can be improved through right decision at the right time. Right decision can be taken only if the right information is made available to the decision makers. Information is defined as processed data. Data or raw facts are collected, collated and compiled. Compiled data are analyzed that provide the basis for planning, review and performance tracking, improvement of operations, and comparison of performance with competitors. The statistical analysis of engineering and manufacturing facts is an important part of TQM. The TQM approach is based on the use of objective data, and provides a rational rather than an emotional basis for decision-making. The statistical approach to process management in both engineering and manufacturing recognizes that most problems are system-related, and are not caused by particular employees.

Emoployee participation

Employee participation or employee involvement, as stated in the definition, is central to TQM. TQM environment requires that work force be well trained and committed that participates fully in quality improvement activities. Participation of employees should be encouraged with regards and recognition systems. On-going education and training of all employees supports the drive for quality. TQM links remuneration to customer satisfaction metrics.

A TQM culture

An open, cooperative and conducive culture is essential to introduce TQM. This has to be ensured by the management. Employees have to be made to feel that they are responsible for customer satisfaction. They should be involved with the development of visions, strategies and plans.

10.2.1 Product development in a TQM environment

Product development in a TQM environment is likely to render the following benefits :

1. Improved process and improved product quality
2. ii. Minimized wastage, rework, scraps and changes
3. iii. Conducive environment, less conflicts
4. iv. Teams are process-oriented, and interact with their internal customers to deliver the required results.
5. v. Management's focus on controlling the overall process, and rewarding teamwork.
6. vi. Motivated workforce
7. vii. Product development is customer-driven and focused on quality.

10.2.2 Quality Circle

Quality Circle refers to a small group of employees organized to solve work related probles; often voluntarily.

10.3 Zero Defects

Zero Defects is an approach to quality based on prevention of errors; often adopted as a standard for performance or a definition of quality.

10.4 Six Sigma

Six Sigma is a project based problem solving approach that focusses on reducing/

preventing defects resulting in increased customer satisfaction and lower costs. It employs a methodology that uses data and statistical analysis to measure and improve a organization's operational performance. It does by identifying and eliminating "defects" in manufacturing and service-related processes. The statistical representation of Six Sigma describes quantitatively how a process is performing. It is commonly defined as 3 .4 defects per million opportunities. Six Sigma can be defined and understood at three distinct levels: metric, methodology and philosophy. The term "Six Sigma" was coined by Motorala engineer, named Bill Smith (mid-1980s).

Six Sigma has evolved over time. It's more than jsut a quality system like TQM or ISO. It's a way of doing business. Geoff Tennant, in his book Six Sigma: SPC, and TQM, in Manufacturing and Services, describes Six Sigma as a vision; a philosophy, a symbol, a metric, a goal, a methodology:

Six Sigma is a disciplined, data-driven approach and methodology for eliminating defects (driving towards six standard deviations between the mean and the nearest specification limit) in any process-from manufacturing to transactional and from product to service.

The fundamental objective of the Six Sigma methodology is the implementation of a measurement-based strategy that focuses on process improvement and variation reduction through the application of Six Sigma improvement projects.

There are two Six Sigma sub-methodologies that are as follows :

- DMAIC : DMAIC is the acronym for "define, measure, analyze, improve and control" the process. The Six Sigma DMAIC process is an improvement system for existing processes falling below specification and looking for incremental improvement.
- DMADV : DMADV stands for define, measure, analyze, design, and verify the process. The Six Sigma DMADV process is an improvement system used to develop new process or products at Six Sigma quality levels. It can also be employed if a current process requires more than just incremental improvement. Both Six Sigma processes are executed by Six Sigma Green Belts and Six Sigma Black Belts, and are overseen by Sig Sigma Master Black Belts. As per the Six Sigma Academy, organizations that are Black Belts save approximately $230,000 per project and can complete four to 6 projects per year. General Electric, one of the most successful-companies implementing Six Sigma, has estimated benefits on the order of $10 billion during the first five years of implementation. GE first began Six Sigma in 1995 after Motorola. Since then, thousands of organizations, around the world, have discovered the extensive benefits of Six Sigma.

10.5 International Organization for Standardization (ISO)

ISO (International Organization for Standardization) is the world's largest developer of standards. ISO's principal activity is the development of technical standards. ISO is a network of the national standards institutes of around 151 countries, on the basis of one member per country. It has a Central Secretariat in Geneva, Switzerland, that coordinates the system. ISO is a non-governmental organization.

10.5.1 ISO 9000

ISO has been. developing voluntary technical standards over altriost all sectors of business, industry and technology since 1947. In 1987, ISO 9000 was introduced, followed by ISO 14000, nearly 10 years later.

The ISO 9000 family of standards, an international consensus on good management practices is primarily concerned with "quality management". ISO 9000 aims at ensuring that the organization fulfils the following requirements :

- the customer's quality requirements, and
- applicable regulatory requirements.

ISO 9000 focuses on enhancement of customer satisfaction, and achievement of continual improvement of its performance in pursuit of these objectives.

Quality standards such as I1SO 9000 can be, and has been, widely adopted around the globe. It provides generic guidelines and sets procedures for accrediting the firm's quality management system. It focuses on conformity to practices specified in the firm's own quality systems, sets how the firm will establish, document and maintain an effective quality system.

The ISO 14000 family of standards is primarily concerned with "environmental management". It aims at ensuring that the organization minimizes harmful effects on the environment caused by its activities, and continually to improve its environmental peformance.

"Quality management" refers to the activities of the organization so as to ensure that its products or services satisfy the customer's quality requirements and comply with any regulations applicable to those products or services.

ISO 9000 : 2000

ISO 9000 : 2000 introduced as a revision of ISO 9000 is based on eight quality management principles. These are defined in ISO 9000 : 2000, Quality management systems Fundamentals and vocabulary.

ISO 9000 : 2004

The principles are defined in ISO 9000:2004, quality management systems guidelines for performance improvements.

10.5.2 Quality management principles as defined in ISO 9000 : 2000 Principle 1: Customer focus

Organizations depend on their customers and therefore should understand current and future customer needs, should meet cvstomer requirements and strive to exceed customer expectations.

Principle 2 : Leadership

Leaders establish unity of purpose and direction of the organization. They should create and maintain the internal environment in which people can become fully involved in achieving the organization's objectives.

Principle 3 : Involvement of people

People at all levels are the essence of an organization and their full involvement enables their abilities to be used for the organization's benefit.

Principle 4 : Process approach

A desired result in achieved more efficiently when activities and related resources are managed as a process.

Principle 5 : System approach to management

Identifying, understanding and managing interrelated processes as a system contributes to the organization's effectiveness and efficiency in achieving its objectives.

Principle 6: Continual improvement

Continual improvement of the organization's overall performance should be a permanent objective of the organization.

Principle 7 : Factual approach to decision making

Effective decisions are based on the analysis of data and information

Principle 8 : Mutually beneficial supplier relationships

An organization and its suppliers are interdependent and a mutually beneficial relationship enhances the ability of both to create value.

Both ISO 9000 and ISO 14000 are concerned with the way an organization does work, and not directly with the outcome of the work. In other words, they are both concerned with processes, and not with products-at least, not directly. However, it is obvious that processes affect quality of product. Well-managed and well-designed processes

result in high quality of products. It ensures that it meets customers' quality requirement.

ISO is responsible for developing, maintaining and publishing the ISO 9000 and ISO 14000 families of standards. It does not itself audit or assess the management systems of organizations to verify that they have been implemented in conformity with the requirements of the standards. ISO does not issue ISO 9001:2000 or ISO 14001: 2004 certificates. The auditing and certification of management systems is carried out independently of ISO by certification agencies/bodies. ISO has no authority to control their activities. The ISO 9001 :2000 and ISO 14001 :2004 certificates issued by certification bodies are issued under their own responsibility and not under ISO's name.

An organization is responsible for auditing its ISO 9000-based quality system to verify that it is managing its processes effectively. It can audit by itself, or may invite its clients to audit the qualitysystem (in order to give them confidence that the organization is capable of delivering products or services that will meet their requirements), or may engage the services of an independent quality system certification body to obtain an ISO 9000 certificate of conformity. The certificate serves as a business reference between the organization and potential clients, especially when supplier and client are new to each other, or far removed geographically, and also reduces multiple audits by different firms.

The ISO 9000 certification suffers from the drawback that if not implemented with the right spirit with top management commitment, it may turn out to be document intensive process, resulting in de-motivation in a long run.

10.5 Questions

Short Type Questions

i) What is process control ?

ii) What is the significance of TQM?

iii) How quality circles help in quality control?

iv) What is six sigma?

Descriptive Type Questions

i) Describe Total Quality Management (TQM)?

ii) Explain the features of ISO 9000.

iii) Explain the Statistical process control (SPC) techniques and procedures.