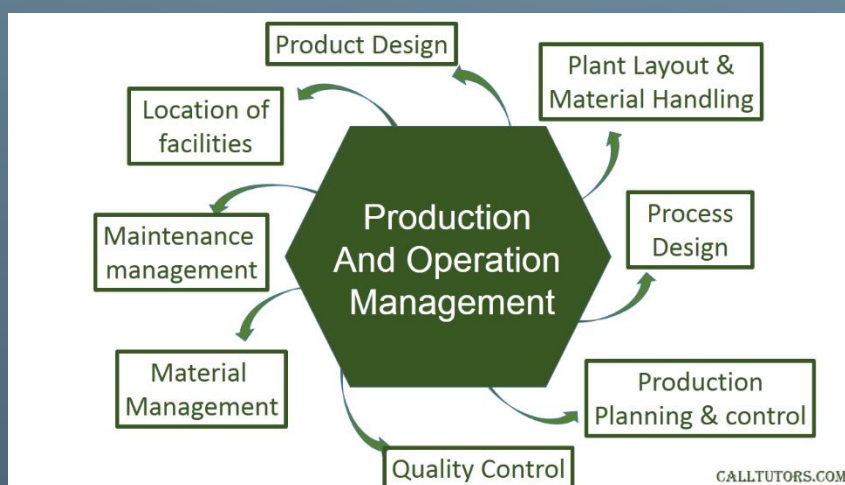




PRODUCTION AND OPERATION MANAGEMENT

Study Material



BIJAY LAL PRADHAN

Ph.D.

Syllabus

Production and Operation Management

Credit hours: 3

Objective: The Course is designed to acquaint the students with decision making in : Planning, scheduling and control of Production and Operation functions in both manufacturing and services; Productivity improvement in operations thought location decision and layout management etc; Effective and efficient flow, replenishment and control of materials with reference to both manufacturing and services organizations.

Class: Due to this pandemic situation, classes will run online. The reading materials (content, vdo materials) will be given to students. Google classroom will be used for the learning management system. Quiz and home assignments will be given to students which will be used for internal evaluation.

Contents:

Chapter I

Introduction to Production Operations Management (POM)

Historical Milestones in Production Operations Management, Definition of Production Operations Management, Difference between Production and Operations, Scope of Production Operations Management, Responsibilities of Production Operations Management, Key Decisions of Production Operation Managers, Recent Trends in POM.

Chapter II

Production Processes, Manufacturing and Service Operations

Manufacturing Operations and Service Operations, Characteristics of Manufacturing, Characteristics of Services, Challenges faced by Operations Managers

Chapter III

Capacity Planning and Facility Location

Introduction to Capacity Planning, Estimating the Capacities of Existing Facilities, Forecasting Long-term Future Capacity Demand, Identifying and Analyzing Sources of Capacity to Meet Future Capacity, Capacity Management, Selecting from among the Alternative Sources of Capacity, Steps in Location, Domestic or International Location, Selection of region, Selection of Community, Selection of Site, Errors in Selection, Location Models.

Chapter IV

Facility Layout

Introduction to Facility Layout, Inputs of the Layout, Types of Process Layout/ Job Shop Layout, Product Layout/ Flow Shop Layout, Group Technology Layout, Fixed Position Layout, Flexible Manufacturing System, Layout Design Procedure, Layout Problem, Importance of Facility Layout.

Chapter V

Project Management and Scheduling

Introduction, Project Design, Setting Project Objectives, Importance of Objectives, Scope of the Project, Work Structure, Project Structure, Project Planning and Scheduling, Bar Charts, Program Progress Charts, Limitations of Bar Chart, Overview of Strategic Planning.

Chapter VI

Inventory Management

Defining Inventory, Nature of Inventory, Raw Materials, Work-In-Process, Finished Goods, MRO Goods Inventory, Types of Inventory, Transit Inventory, Buffer Inventory, Anticipation Inventory, Cycle Inventory, Top 5 Principles of Inventory Management, Inventory Planning: Basic Concepts, Need for Planning, Reasons for Maintaining Raw Material Inventory, Resource Inventory Management, Production Planning, Planning in Inventory Control, Hierarchy of Planning, Business Needs, An Effective Material Organizational Structure, Methods of Valuation of Inventory, Ratio Analysis in Business, Inventory on the Income Statement, Inventory on the Balance sheet .

Chapter VII

Quality Management

Introduction, Definition of Total Quality Management, Defining Quality, Cost of Quality, Continuous Improvement (Kaizen), Plan to Study Cycle, Benchmarking, Employee Empowerment, Team Approach, Tools of Quality Control, Cause-and-Effect Diagrams, Flowcharts, Checklists, Control Charts, Scatter Diagrams, Pareto Analysis, Histograms, Process Management, Quality Standards, ISO 9000 Standards, ISO 14000 Standards, Reason for TQM Failure.

Chapter VIII

JIT and Lean Production

Introduction, History and Philosophy of Just-In-Time (JIT), Just-In-Time Concept, Benefits and Problems, Implementation of JIT, Lean Manufacturing, Lean Production Overview, Basic Elements of Lean Manufacturing, Characteristics of a Lean Manufacturing, Key Feature of Lean Production, Benefits of Lean Production, Five Elements to Enabling Approach, Tips to Transition Company into Lean Enterprise, Six-Sigma, Objectives of Six-Sigma, Integrating Six Sigma with Business Process Management, Six Main Benefits of the Sigma Breakthrough Strategy, Difference between TQM and Six Sigma, Critical Success Factors of an Organization for Successful TPS-Lean, Six Sigma Implementation .

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Chapter I

Introduction to Operations Management

Aim

The aim of this chapter is to:

- introduce 'Operations' and 'Operations Management'
- explain historical milestones in operations management
- elucidate the responsibilities of operations manager

Objectives

The objectives of this chapter are to:

- define 'operations management'
- elucidate the recent trends in operations management
- explain the responsibilities of operations manager

Learning outcome

At the end of this chapter, you will be able to:

- identify the recent trends in operations management
- understand the importance of operations management in organisations
- differentiate between production and operation

1.1 Introduction

- 'Operations Management' is the term often used with production management; therefore it is useful to understand the nature of operations management
- Operations are useful actions or activities which are done methodically as part of plan of work by a process that is designed to achieve the pre-decided objectives.
- Operations management consists of scheduling work, assigning resources including people, equipment, managing inventories, assessing quality standards, process type decisions and the sequence for making individual items is a product mix set.

5 P's of Operations Management

1. Plants: The factory, the location where all the activities take place, machinery and heavy equipments
2. People: Direct or Indirect workforce
3. Parts: The components, sub-assemblies or even products
4. Processes: Methodologies, technology, toolings, fixtures for establishing, maintaining and improving productivity; and
5. Planning and Control: This is an information management system which initiates, directs, monitors and collects feedback to enable efficient use of all other resources

1.1.1 Historical Milestones in Operations Management

The Industrial Revolution

- The industrial revolution developed in England in the 1700s.
- The industrial revolution spread from England to other European countries and to the United States.
- The steam engine invented by James Watt in 1764, largely replaced human and water power for factories.
- Adam Smith's The Wealth of Nations in 1776 touted the economic benefits of the specialisation of labor.
- Thus, the late-1700s factories had not only machine power but also ways of planning and controlling the tasks of workers.
- In 1790, an American, Eli Whitney, developed the concept of interchangeable parts.
- The first great industry in the US was the textile industry.
- In the 1800s, the development of the gasoline engine and electricity further advanced the revolution.
- By the mid-1800s, the old cottage system of production had been replaced by the factory system.

Post-Civil war period

- During the Post-Civil War period, great expansion of production capacity occurred.
- Post-Civil War the following developments set the stage for the great production explosion of the 20th century.
 - Increased capital and production capacity
 - The expanded urban workforce
 - New Western US markets
 - An effective national transportation system

Scientific management

- Frederick Taylor is known as the father of scientific management. His shop system employed these steps,
 - Each worker's skill, strength, and learning ability has to be determined.
 - Stopwatch studies has to be conducted to precisely set standard output per worker on each task.
 - Material specifications, work methods, and routing sequences has to be used to organise the shop.
 - Supervisors have to be carefully selected and trained.
 - Incentive pay system has to be initiated.
- In the 1920s, Ford Motor Company's operation embodied the key elements of scientific management.
 - Standardised product designs
 - Mass production
 - Low manufacturing costs
 - Mechanised assembly lines
 - Specialisation of labor
 - Interchangeable parts

Human relations and behaviourism

- Between 1927 to 1932, researchers in the Hawthorne Studies realised that human factors were affecting production.
- Researchers and managers alike were recognising that psychological and sociological factors affected production.
- From the work of behavior lists, came a gradual change in the way managers thought about and treated workers.

Operations research

- During World War II, enormous quantities of resources (personnel, supplies, equipment,) had to be deployed
- Military Operations Research (OR) teams were formed to deal with the complexity of the deployment
- After the war, operations researchers found their way back to universities, industry, government, and consulting firms
- Operations Research helps operations managers make decisions when problems are complex and wrong decisions are costly.

Service revolution

- The creation of services organisations accelerated sharply after World War II
- Today, more than two-thirds of the US workforce is employed in services
- About two-thirds of the US GDP is from services
- There is a huge trade surplus in services
- Investment per office worker now exceeds the investment per factory worker
- Thus there is a growing need for service operations management

The computer revolution

- Explosive growth of computer and communication technologies
- Easy access to information and the availability of more information

- Advances in software applications such as Enterprise Resource Planning (ERP) software
- Widespread use of email
- More and more firms becoming involved in E-Business using the Internet
- Result: Faster, better decisions over greater distances

1.2 Definition of Operations Management

- “Operations Management” is the process in which resources/inputs are converted into more useful products.
- Operations management is the management of an organisation’s productive resources or its production system.
- It is the design, execution, and control of a firm's operations that convert its resources into desired goods and services, and implement its business strategy.
- Operations management is the conversion of inputs into outputs, using physical resources, so as to provide the desired utility/utilities of form, place, possession or state or a combination there-of to the customer while meeting the other organisational objectives of effectiveness, efficiency and adaptability.

In operations management, the main task is to plan, organise, and control the input and to produce desired output, which is represented in following diagram.

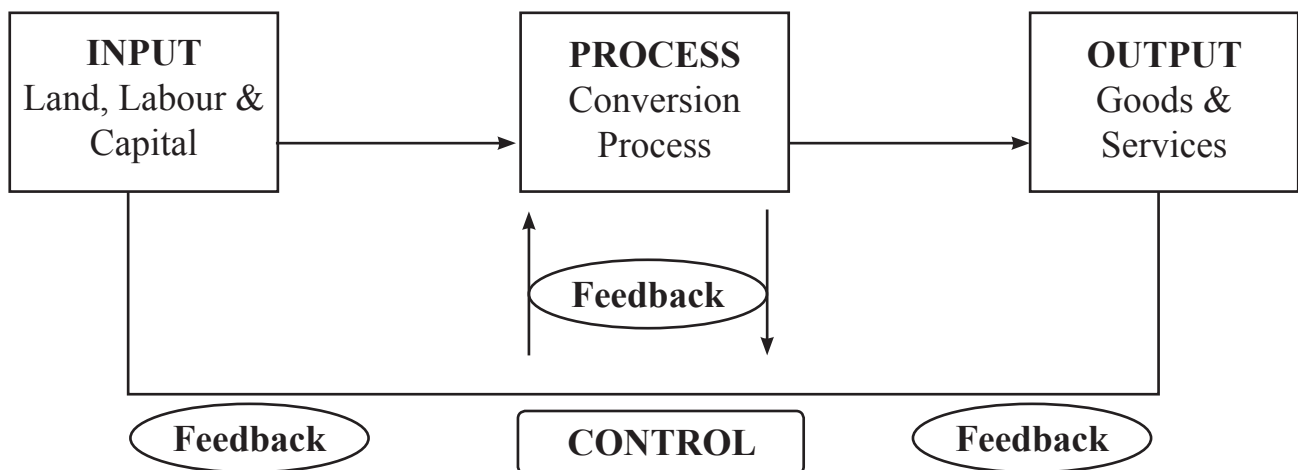


Fig. 1.1 Work flow of conversion of input into output

Inputs of an Operations System Includes	Process (Conversion subsystem) of an Operations System Includes	Outputs of an Operations System
External inputs such as legal, economic, social, technological	Physical (manufacturing)	Direct outputs such as goods and services
Market inputs like competition customer desires, product information	Location services (transportation)	Indirect outputs like waste, pollution, technological advances
Primary resources like manpower, material, machinery, money and utilities	Exchange services (retailing)	
	Storage Services (warehousing)	
	Other private services (insurance)	
	Government services (federal)	

Table 1.1 Various operating systems

1.3 Difference between Production and Operations Management

- Production management and operations management are differentiated on the basis of tangibility of finished goods or services
- Production management and operations management are used interchangeably.

There are only two points for describing the difference between production and operations management.

- The term 'production management' is more frequently used for a system where tangible goods are produced, whereas operations management is used for various inputs are transformed into intangible services.
- The second distinction relates to the evolution of the subject. Operations management is the term used nowadays whereas the production management precedes operations management in the historical growth of the subject.

1.4 Scope of Operations Management

The scope of operations management is very vast, commencing with the selection of location, operations management covers such activities as:

- Forecasting
- Capacity planning
- Scheduling
- Managing inventories
- Assuring quality
- Motivating employees
- Deciding where to locate facilities
- Design of work system
- Operations planning and control
- Resource requirement planning
- Capacity requirement planning
- Project management
- Quality management

- Maintenance management
- Just-In-Time system
- Supply chain management
- Operations function includes all activities directly related to producing goods or providing services

All the above terms are explained in further chapters, as the operations management includes these activities or processes collectively.

1.5 Responsibilities of Operations Management

Operations management responsible for the following activities which are more common in every organisation under following functions of operations management.

Planning	Controlling/ Improving	Organising	Staffing	Directing
Capacity	Inventory	Degree of centralisation	Hiring and Laying off	Incentive plans
Location	Quality	Process selection	Use of overtime	Issuance of work orders
Products and Services	Costs			Job assignments
Make or Buy	Productivity			
Layouts				
Projects				
Scheduling				

Table 1.2 Responsibilities of operations management

1.6 Key Decisions of Operation Managers

Operation managers should focus on following points,

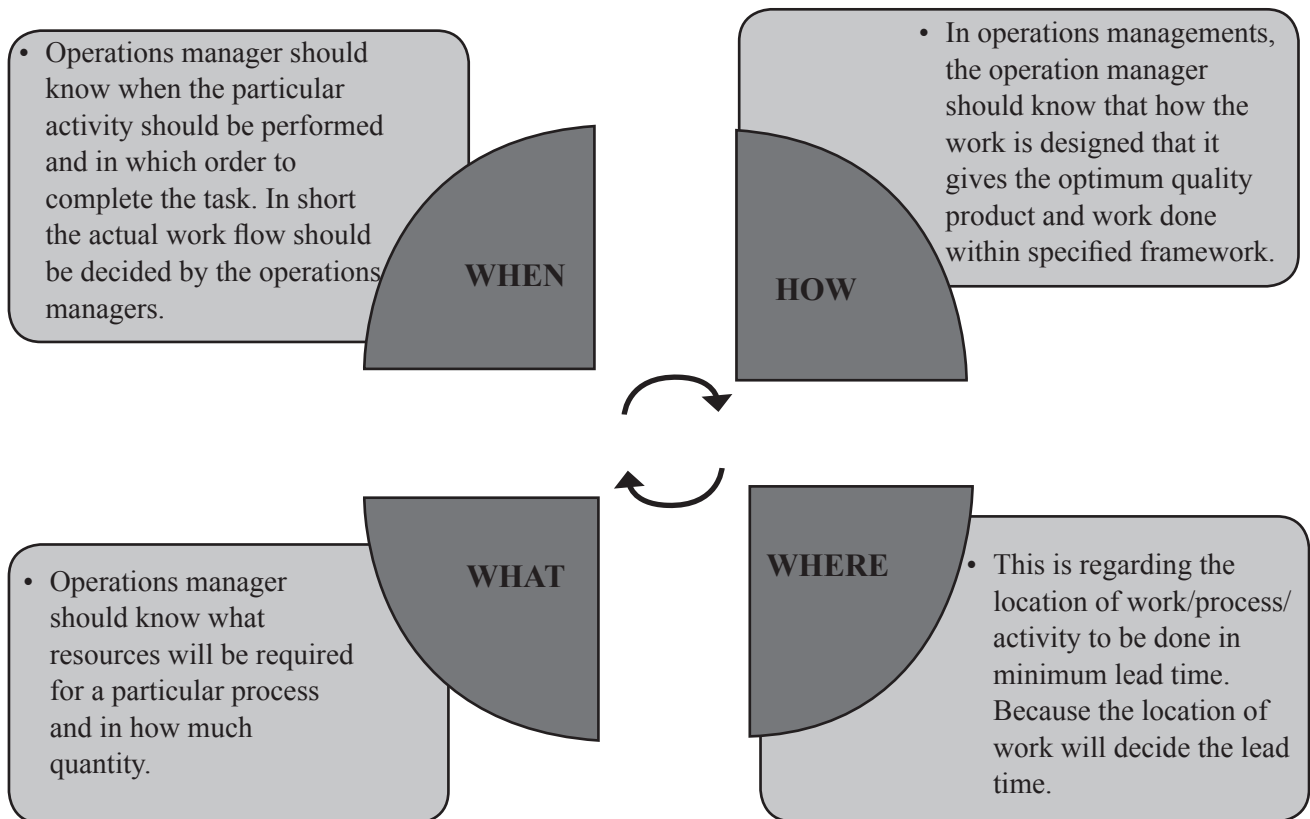


Fig. 1.2 Key decisions of operations management

WHO?

The Work allocation is important task for operation manager because final product quality is dependent on the person and final skill set of that person which (s)he implemented in his work. Therefore the correct person will give optimum quality work.

1.7 Recent Trends in Operations Management

Many recent trends in production/operations management relate to global competition impacting manufacturing firms: Some of the recent trends are;

- **Global market place:** Globalisation of business has compelled many manufacturing firms to have operations in many countries where they have certain economic advantage. This has resulted in a steep increase in the level of competition among manufacturing firms throughout the world.
- **Operations strategy:** More and more firms are recognising the importance of operations strategy for the overall success of their business and the necessity for relating it to their overall business strategy.
- **Total quality management:** TQM approach has been adopted by many firms to achieve customer satisfaction by a never ending quest for improving the quality of goods and services.
- **Flexibility:** The ability to adapt quickly to changes on volume of demand, in the product mix demanded, and in product design or in delivery schedules, has become a major competitive strategy and a competitive advantage to the firms. This is sometimes called Agile Manufacturing.
- **Time reduction:** Reduction in manufacturing cycle time and speed to market for a new product provides products at the same price and quality. Quicker delivery provides one firm competitive edge over the other.

- Technology: Automation, computerisation, information and communication technologies have revolutionised the way companies operate. Technological changes in products and processes can have great impact on competitiveness and quality, if the advanced technology is carefully integrated into the existing system.
- Worker involvement: The recent trend is to assign responsibility for decision making and problem solving to the lower levels in the organisation. This is known employee involvement and empowerment.
- Re-engineering: This involves drastic measures or break-through improvements to improve the performance of a firm. It involves the concept of clean-slate approach or starting from scratch in redesigning the business processes. i.e. BPR Business Process Re-engineering.
- Environmental issues: Today's production managers are concerned more and more with pollution control and waste disposal which are key issues in protection of environment and social responsibility. There is increasing emphasis on reducing waste, using less toxic chemicals and using biodegradable materials for packaging.
- Corporate downsizing (or sizing): Downsizing or right sizing has been forced on firms to shed their obesity. This has become necessary due to competition, lowering cost, productivity, need for improved profit and for higher dividend payment to shareholders.
- Supply chain management: Management of supply chain, from suppliers to final customers reduces the cost of transportation, warehousing and distribution throughout the supply chain.
- Lean production: Production system has become lean production system which uses minimal amounts of resources to produce a high volume of high quality goods with workforce to have advantages of both mass production and job production.

Summary

- Among all the functional areas of management, operations management considered as crucial in any industrial organisation.
- Operations system model comprises of Input system, Conversion system and Output system
- Operations management consists of scheduling work, assigning resources including people, equipment, managing inventories, assessing quality standards, process type decisions and the sequence for making individual items is a product mix set, put it simple .
- Operations managers are required to make a series of decisions in production function. They plan, organise, staff, direct and control all the activities in the process of converting all the inputs into finished products.
- At each level, operating managers are expected to make decisions and implement them too.
- The decisions made by operation managers about the activities of production system tend to fall into three general categories, viz., Strategic, Operating and Control decisions.
- Operations manager responsible for planning, controlling, staffing, organising of production plant for having command over different activities involved in the production process.
- This chapter introduces the recent trends in production and operations management in which the trends like TQM, JIT, BPR, lean Production System.

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Self Assessment

1. Frederick Taylor is known as father of _____ management.
 - a. operations
 - b. production
 - c. scientific
 - d. resource
2. _____ helps operations managers make decisions when problems are complex.
 - a. Operations Research
 - b. Marketing Research
 - c. Financial Research
 - d. Production Research
3. _____ Management is the conversion of inputs into outputs.
 - a. Processing
 - b. Materials
 - c. Logistics
 - d. Operations
4. Production management and Operations management are differentiated on the basis of tangibility of _____.
 - a. raw material
 - b. finished goods
 - c. processed goods
 - d. unprocessed (stock)
5. _____ involves drastic measures or break-through improvements to improve the performance of a firm.
 - a. Downsizing
 - b. Re-engineering
 - c. Technology
 - d. Networking
6. Methodologies, technology, toolings, fixtures for establishing, maintaining and improving productivity fall under this 'P' of Operations Management.
 - a. Plant
 - b. Processes
 - c. People
 - d. Parts
7. Inputs of an operations management include _____.
 - a. Machinery
 - b. Storage service
 - c. Transpiration services
 - d. Industrial waste

8. Managing issuance of work order falls under _____.
- Planning
 - Organising
 - Directing
 - Staffing
9. The ability of an organisation to accept the changes quickly and continue with the new adaptations with the demands on Productivity, design, lead time, work structure in particular delivery schedule is known as _____.
- Total quality management
 - Lean manufacturing
 - Total production management
 - Agile manufacturing.
10. Using minimal amounts of resources to produce a high volume of high quality goods with workforce to have advantages of both, mass production and job production is known as _____.
- Quality improvement
 - Lean manufacturing
 - Total quality management
 - Just-In-Time

Chapter II

Production Processes, Manufacturing and Service Operations

Aim

The aim of this chapter is to:

- introduce the terms 'production process', 'manufacturing operations' and 'service operations'
- explain the characteristics of manufacturing and service operations
- explain the responsibilities of operations manager in manufacturing and service operations

Objectives

The objectives of this chapter are to:

- explain the similarities between manufacturing and service operations
- differentiate between manufacturing and service operations
- elucidate production process, manufacturing and service operations

Learning outcome

At the end of this chapter, you will be able to:

- understand the challenges faced by the operations manager
- enlist the characteristics of service operations and manufacturing operations
- distinguish between manufacturing and service operations

2.1 Introduction

- The way that businesses create products and services is known as the production process.
- A firm must purchase all the necessary inputs and then transform them into the product (outputs) that it wishes to sell. For instance, a football shirt manufacturer must buy the fabric, pay someone for a design, invest in machinery, rent a factory and employ workers in order for the football shirts to be made and then sold.
- How well-organised a firm is at undertaking transformation process will determine its success is known as the productive efficiency of a firm and it will want to be as efficient as possible in transforming its inputs into outputs (i.e., using the minimum number of inputs as possible to achieve a set amount of output), this will reduce the cost per unit of production and allow the firm to sell at a lower price.
- Ultimately, the objective of the production process is to create goods and services that meet the needs and wants of customers.
- The needs and wants of customers will be met if a business can produce the correct number of products, in the shortest possible time, to the best quality and all at a competitive price.

2.2 Production Processes

- Products are goods and services produced and processes are the facilities, skills and technologies used to produce them.
- Production processes are essential to produce products and the available processes limit what products can be produced.
- Production or operations function of an industrial enterprise is also known as conversion process or transformation process which transforms some of the inputs into outputs which are useful for the consumers.

2.3 Manufacturing Operations and Service Operations

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

Manufacturing Operations: Manufacturing operations or processes convert inputs into tangible outputs. Manufacturing processes are primary processes and can be grouped under three basic categories, viz., forming, Machining and Assembly. Forming includes casting, forging, stamping, embossing, spinning etc. Machining includes metal removal by turning, drilling, milling, grinding, shaping, boring etc, it also includes chip less machining processes such as electro discharge machining (EDM), electromechanical machining (ECM), chemical milling, laser drilling etc. Assembly processes includes joining of parts, i.e., welding, riveting, fastening with bolts and nuts and joining by use of adhesive. Objectives of Manufacturing Operations are as follows:

- To give tools and advices for establishing manufacturing processes
- To show some alternative methods for reducing the cost of the manufacturing process
- To show how to estimate manufacturing cost and running cost of any manufacturing process

Operation 1

Raw Materials: Collect and store the raw materials: Scrap or sponge iron: Where we get it, at what price, how do we store it, what quality is usually needed, how many people do we put on this task: Salary, outsourcing, qualifications, safety regulations and so on.

Operation 2

Melting: Sponge iron is melt in an electric arc furnace: What is the cost of the furnace, where do we implement it, What is the cost of the energy, how many people on this work station, how many quantities can we manage in one hour and how many quantities do we get by the end?

Operation 3

Refining: The melting metal is refined. It means that we separate the chemical elements in order to get the specific steel we need. How do we operate this separation, qualifications wanted, Do we need a chemist for controlling the process?

Operation 4

Casting: The liquid steel is cast in products such as billets: A new list of questions

Operation 5

Rolling: The billets are heated at 1200c and then rolled in order to get the plates: A new list of question

Service Operations: Service operations or non manufacturing operations which also convert set of inputs into set of outputs which are intangible. It can be classified into standard services and custom services according to degree of standardisation of their outputs and /or the processes they perform, such as wholesale distribution and freight transportation etc. An operation does not necessarily provide only service or only goods. Facilitating goods may be provided with services and facilitating services may be provided with goods, for example, Servicing automobiles may include the replacement of some parts.

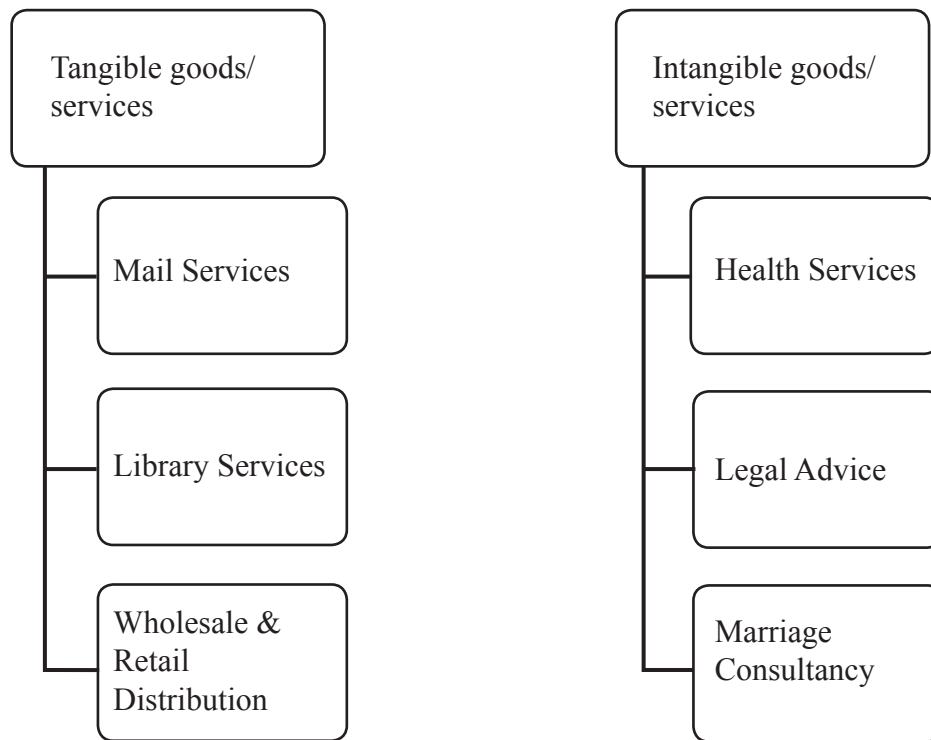


Fig. 2.1 Examples of tangible and intangible goods/services

Differences between Manufacturing and Service Operations: The below mentioned table discusses the difference between manufacturing operations and service operations.

Manufacturing Operations	Service Operations
In Manufacturing operations, productivity can be measured.	In Service operations, it is uncommon to measure the productivity.
Outputs are tangible in nature.	Outputs are intangible in nature.
Quality standards are easily established.	It is difficult to establish quality standards in service operations.
Less customer contact with person who is involved in manufacturing process.	Customers have more contact with persons who provide services.
In continuous production of standard products, it can accumulate or decrease inventory of finished products.	In service operations, it can not produce outputs that can be stored because they are intangible in nature.
The proportion of expenses required for material handling is more.	The proportion of expenses in service operations is very less.
Investment in assets such as facilities, equipments and inventory are higher.	Investment in assets and inventory is less as compared to manufacturing operations.
These are depending more heavily on maintenance and repair works.	In service operations the maintenance is not required as the services are intangible.
MO having longer lead times.	SO having shorter lead times.
These are capital intensive	These are labor intensive

Table 2.1 Difference between manufacturing operations and service operations

Similarities between manufacturing and services

Despite many differences, there are some similarities between manufacturing and service operations which are

compelling. The similarities are;

- Both types of organisations (manufacturing and service) do not just produce or offer goods/services. They normally provide package of goods and services. e.g. customers expect both good service and good food at a restaurant and both are required from a retailer.
- Even though service providers can not inventory their outputs, they must inventory the inputs for their service outputs.
- As for customer contact, there are some services, which have little outside customer contact such as the back room operations of a bank or a baggage handling area at an airport.

2.3.1 Characteristics of Manufacturing

Various characteristics of manufacturing are discussed below.

Specialisation	Mechanisation	Use of Technology of Industrial Engineering	Use of Computers and Data Processing Equipments	Use of Scientific Methods
<ul style="list-style-type: none"> • Specialisation means division of work or effort and this operates both at workers and management level. • The result of specialisation is low cost of production and improved quality. • At management level the efforts are divided into various special functions such as Research and development, design, engineering, finance, accounting, sales, purchase, personnel, maintenance etc. 	<ul style="list-style-type: none"> • Mechanisation replaces human labor by machine power. • The human skill is transferred to machine tools which carryout various manufacturing operations. • Advanced form of mechanisation is known as Automation 	<ul style="list-style-type: none"> • Industrial engineers have been able to devise improvements and to increase productivity by elimination of waste and inefficiency, thereby increasing production and reducing costs. 	<ul style="list-style-type: none"> • Widespread use of computers in manufacturing industries has made possible, the handling of enormous amounts of data and the solving of complex mathematical problems at high speed. • The range of application of computers include product design, control of manufacturing process, production and inventory control, quality control, maintenance control etc. 	<ul style="list-style-type: none"> • Industrial engineering, operations research or management science involves quantitative methods and techniques to solve both engineering and managerial problems. • Operations research is an aid in decision making based on quantitative analysis.

Table 2.2 Characteristics of manufacturing

2.3.2 Characteristics of Services

Intangibility

Most services are intangible. Tangible goods can be seen, touched, smelled, heard or tested prior to purchase unlike services. Most services are performances.

Perishability

It means the service can not be inventoried or stored. Most services, because they are simultaneously produced and consumed are considered as perishable. e.g. Hotel rooms, seats on an airplane or in movie theatre can not be stored and retrieved for later use.

Inseparability

Inseparability refers to the simultaneous production and consumption of services. Goods can be produced and then sold later whereas services can not. They can consume only when they are produced.

Variability

Variability refers to the unwanted or random levels of service quality customers receive when they patronise a service because of the human element involved in providing a service.

Various service employees will perform the same service differently and even the same service employee will provide varying levels from one time to another.

2.3.3 Challenges faced by Operations Managers

The key challenges facing service operations managers are:

Managing multiple customers

Many service organisations often serve heterogeneous group of customers, in different ways and different types of customers. Understanding who the curious customers are, understanding their needs and expectations, developing relationships with them and managing the various customers are key tasks for service operations managers.

Understanding the service concepts

There may be differing views about what service an organisation is selling and/or the customer is buying. Articulating and communicating the service concept is critical for classifying the organisation service product to all its customers and for ensuring that it can be delivered to customer specification.

Managing the outcome and experience

For many services, there is no clear boundary between experience and the outcome. E.g. customers in a restaurant are buying both the meal and the way they are served. The intangible nature of the experience provides particular problems for both specification and control.

Managing the real time

Many services happen in real time. They cannot be delayed or put-off. e.g. aircrafts coming into land cannot be put on hold while controllers take a break.

Also, during a service encounter, it is not possible to undo what is done. In manufacturing operations it is possible to scrap defective products and remake them, but in service operations it is not possible to undo defective service rendered to a customer.

Knowing, implementing and influencing strategy

- Operations which are the doing part of the business are also responsible for implementing strategy of the service organisation. Service operations managers must understand their role, not only in implementing strategy but also in contributing to it or influencing the strategy.
- Service operations managers need to provide platform for their organisations for competitive advantage through competence in service operations.

Continually improving operations

Service operations managers are faced with a challenge of how continually to improve and develop their real improvements. They should manage the increased complexity resulting from change and also improve efficiency as well as quality of service operations.

Encouraging innovations

Innovation looks for what is new rather than improving the existing service operations usually require elements of financial risk because innovations require time and money and personal risk for service managers champion change putting their reputation on the line.

Managing short term and long term issues simultaneously

- Organisations are under pressure to perform in the short term which leaves little time for medium term operational improvement or long term strategic planning.
- Many service operations managers focus their time and effort on managing day to day operations to ensure the delivery of an appropriate quality of service operations management are frequently neglected .

Summary

- Products are goods and services produced and processes are the facilities, skills and technologies used to produce them.
- The objective of the production process is to create goods and services that meet the needs and wants of customers.
- Manufacturing operations or processes convert inputs into tangible outputs.
- Forming includes casting, forging, stamping, embossing, spinning etc.
- Machining includes metal removal by turning, drilling, milling, grinding, shaping, boring etc, it also includes chipless machining processes such as electro discharge machining (EDM), electromechanical machining (ECM), chemical milling, laser drilling etc
- The Production operations are divided in manufacturing and service operations.
- In every organisation the operation manager facing some difficulties and challenges in front of him to achieve an organisations goal.

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Self Assessment

1. The ultimate objective of _____ is to create goods and services that meets the needs and wants of the customers.
 - a. manufacturing
 - b. production process
 - c. service operation
 - d. transformation
2. In manufacturing operations, _____ includes casting, forging, stamping, embossing, spinning.
 - a. transformation
 - b. forming
 - c. deforming
 - d. machining
3. In manufacturing process, _____ includes metal removal by turning, drilling, milling, grinding, shaping, boring.
 - a. assembling
 - b. forming
 - c. machining
 - d. deforming
4. _____ means division of work or effort and this operates both, at workers and management level.
 - a. Specialisation
 - b. Mechanisation
 - c. Transformation
 - d. Operation
5. Mail Service, Library service is considered as _____ goods/service.
 - a. intangible
 - b. standard
 - c. tangible
 - d. customised
6. The unwanted or random levels of service quality customers receive when they patronise a service because of the human element involved in providing a service is known as _____.
 - a. inseparability
 - b. variability
 - c. perishability
 - d. uniformity
7. Advanced form of mechanisation is known as _____.
 - a. Auto-mechanisation
 - b. Advancement
 - c. Computerisation
 - d. Automation

8. Melting, refining, casting are the processes of _____.
- a. service operation
 - b. manufacturing operation
 - c. production
 - d. processing
9. Which of the following is not the characteristic of Service operation?
- a. Intagibility
 - b. Inseperability
 - c. Variability
 - d. Mechanisation
10. Operations research is an aid in decision making based on _____.
- a. qualitative analysis
 - b. quantitative analysis
 - c. statistical analysis
 - d. methodology

Chapter III

Long Range Capacity Planning and Facility Location

Aim

The aim of this chapter is to:

- introduce the idea of long range capacity planning and facility location
- explain capacity and capacity planning, short range, intermediate range and long range planning
- enlist various types of capacity

Objectives

The objectives of this chapter are to:

- explicate various determinants of effective capacity
- elucidate the concept of 'facility location'
- explain the steps in location selection

Learning outcome

At the end of this chapter, you will be able to:

- describe the approaches to develop capacity alternatives
- understand location factors
- identify the importance capacity planning and facility location

3.1 Introduction

Capacity is known as the amount of output, that a system is capable over a specific period of time. Capacity is the upper limit or ceiling on the load that an operating unit can handle. Examples of Capacity measures:

Type of Organisation	Measures of Capacity	
	Inputs	Outputs
Manufacture	Machine hours per shift	Number of units of shifts
Hospital	Number of berths/beds	Number of patients treated
Airline	Number of planes or seats	Number of seat miles flown
Restaurant	Number of seats	Customer/time
Retailer	Area of store	Sales
Theatre	Number of seats	Customer/time

Table 3.1 Example of capacity measure

Capacity Planning is the process of determining the production capacity needed by an organisation to meet changing demands for its products. It is the process used to determine how much capacity is needed (and when) in order to manufacture greater product or begin production of a new product. Capacity planning is central to the long term success of an organisation. Capacity planning is generally viewed in terms of three time horizons or durations.

- Long Range Capacity Planning which is usually having a time horizon of more than one or two years. It is carried out for productive resources which take a long time to acquire or dispose of such as buildings, equipment or facilities such as machinery, materials handling equipments and transportation vehicles etc.
- Intermediate Range Capacity Planning which has a time horizon or duration for the next 6-18 months. The intermediate range capacity may be varied by such alternatives such as hiring or laying off labour, purchasing or making new tools and minor equipments and outsourcing/subcontracting etc.
- Short Range Planning which has a time horizon or duration of less than one month. This is concerned with day to day planning such as daily scheduling of activities and machine loading or weekly scheduling process which involves making adjustments to eliminate the variance between planned output and actual output. It is concerned with overtime, transfer of personnel and changing the production routings.

Capacity planning can address following questions:

- HOW MUCH long range capacity is needed
- WHEN additional capacity is needed
- WHERE the production facilities should be located
- WHAT will be the layout and characteristics of the facilities should be

A firm must live with its facility planning decisions for a long time, and these decisions affect:

- Operating efficiency
- Economy of scale
- Ease of scheduling
- Maintenance costs
- Profitability

Capacity plans are made at two levels:

- Long-term Capacity Plans which deals with investments in new facilities and equipments covering the requirements for at least two years into the future
- Short-term Capacity Plans which focuses on work force size, overtime budgets, inventories etc.

3.2 Long Range Capacity Planning

- Capacity planning that establishes some expectations about the capacity a company acquires and develops over time.
- Long term capacity planning is an important part of strategic planning of the firm. It establishes some expectations about the capacity a company acquires and develops over time which is vitally important to the company's strategic success.
- Companies which are in business for the long run must make continued investment in people, technology, research and development and capital assets (such as buildings, machinery and equipments etc).
- External environment conditions such as economic, political, technological, social and market conditions and forecast of future levels of demand provide important inputs into long term strategic planning and also into short term plans and decisions made by managers of the firm.

Managers must evaluate and consider trade-offs of a number of factors while establishing a long term capacity plan for their firms. Some of these factors are:

- forecast growth in demand
- future upgrading of technology which may become necessary to gain competitive edge over others
- anticipated moves by competing firms
- reliance on learning curves without additional investment
- forecast of availability of funds for the future investments
- the cost of new capacities and capacities which can provide economies of scale

Capacity decisions have long term effects on many aspects of the business. Finance is affected because of the influence of capacity decisions on the level of capital investment and return on that investment. Production affected because capacity sets constraints within which operations must work to meet its objective of producing high quality goods or services at competitive cost and lead times.

Long range capacity decisions made in early years determine the current level of capital assets such as buildings machinery and equipments of the firm.

3.3 Estimating the Capacities of Existing Facilities

To estimate the capacities of existing facilities in a firm, it is necessary to know about the various types of capacity and the measures of capacity.

Production capacity

It is the maximum rate of production (or output) of an organisation. Several factors underlying the concept of capacity make its understanding and use somewhat complex. Variation in employee absenteeism, equipment breakdowns, vacations, holidays, delays in material procurement/delivery, work schedules, working hours, use of overtime, temporary workers, outsourcing etc., must be taken into account when estimating the production capacity.

Design capacity

Design capacity refers to the maximum output that can possibly be attained. It is the maximum rate of output achieved under ideal conditions.

Effective capacity

Effective capacity is the maximum possible output given a product mix, scheduling difficulties, machine maintenance, quality factors, absenteeism etc.

Effective capacity is usually less than design capacity because of capacity losses due to realities such as product mix changes, need for periodic preventive maintenance of equipment, problems in scheduling and balancing operations, coffee breaks, lunch breaks and so on.

Maximum capacity

It is also known as Peak capacity, it is the maximum output that a facility can achieve under ideal conditions. Where capacity is measured relative to equipment alone, it is known as related capacity.

Measures of capacity

Different measures of capacity are applicable in different situations. For example, capacity of an automobile plant can be measured in terms of the number of automobiles produced per unit of time whereas capacity of a hospital is measured in terms of the number of patients that can be treated per day. Therefore, capacity of a facility can be either measured in terms of inputs.

An important measure of system effectiveness is the capacity utilisation rate which reveals how close a firm is to its best operating point i.e. design capacity.

$$\text{Capacity utilisation rate} = \frac{(\text{Capacity used(i.e. Actual output)})}{(\text{Best operating level (or design capacity)})}$$

Best operating level is the level of capacity for which the facility was designed and thus is the volume of output at which average unit cost is minimum.

Another measure of system effectiveness is efficiency which is the ratio of actual output to the effective capacity.

$$\text{Efficiency} = \frac{(\text{Actual Output})}{(\text{Effective Capacity})}$$

Determinants of effective capacity

Many decisions about design of the production system and operation of the production system may have an impact on capacity. The main factors relate to the following:

- Facilities
- Product or services
- Process
- Human resource considerations
- Operations
- External forces

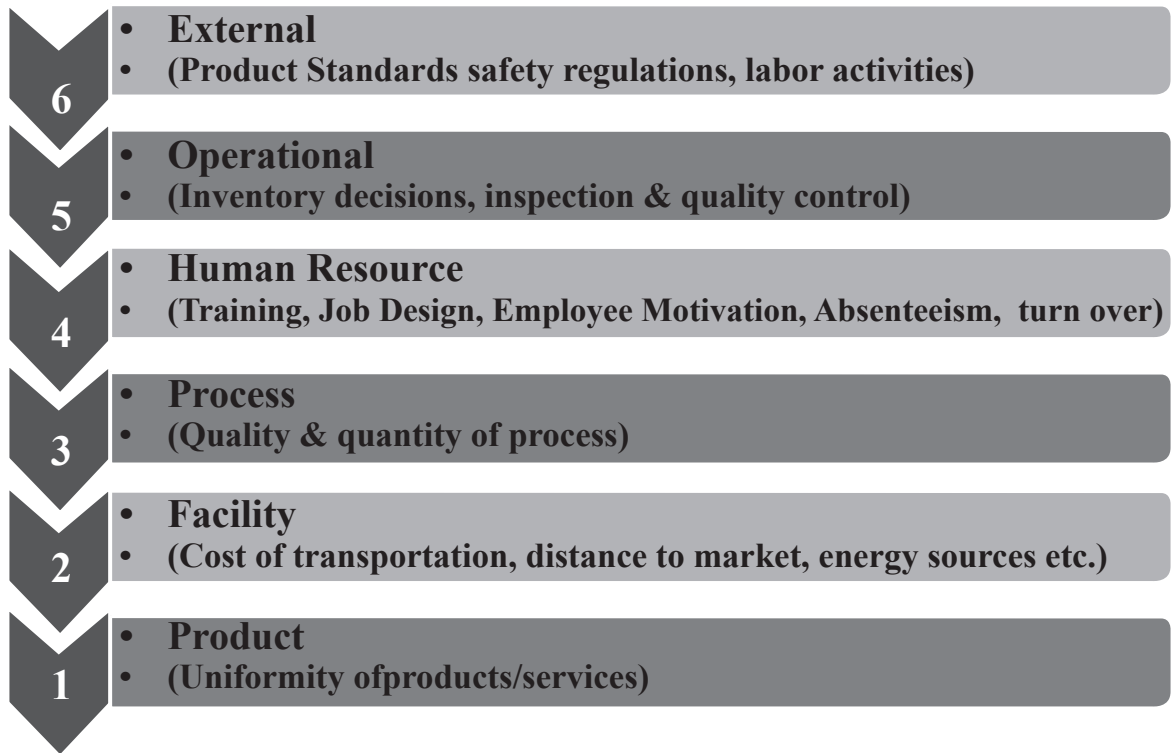


Fig. 3.1 Determinants of effective capacity

3.4 Forecasting Long-term Future Capacity Demand

- Long range capacity planning involves providing facilities such as land, buildings, machines, tools, equipments, materials, personnel, utilities.
- Planning and establishing a new production facility could take 5-10 yrs. and therefore such a facility would be expected to remain economically productive for another 15-20 yrs or so.
- Therefore, forecasting demand for the products or services to be produced from such a facility must cover a timer horizon of 10-30 yrs.
- But because of changes taking place in the external business environment forecast over such long periods of time are difficult to make and may not be reliable.

Forecasting production capacity for a product or service usually involves the following four steps:

- estimate the total demand for a particular product from all producers
- estimate the market share for the company for which capacity has to be forecasted
- estimate the demand for the company by multiplying the total demand by its market share
- translate the product and service demand for the company into capacity needs

Then the production capacity must be allocated to each product and service based on the best estimates of demand for each product and service.

However, the production capacity to be provided by a firm may not necessarily equal to the amount of product and services expected to be demanded.

There are several reasons for this:

- The firm may not have enough capital and other resources to satisfy all the demand.
- Because of uncertainties of forecast and the need to link production capacity to competitive priorities of the firm, a capacity cushion may have to be provided.
- A capacity cushion is an additional amount of production capacity over and above the required capacity to meet the expected demand.

Advantages of having capacity cushion are:

- Extra capacity to meet demand excess of forecasted demand
- Ability to satisfy peak demands
- Reduced production costs
- Product and volume flexibility
- Improved quality of products and services

3.5 Identifying and Analysing Sources of Capacity to Meet Future Capacity Needs

There are many ways available to a firm to change its capacity. Firms may either have shortage of capacity or excess capacity. The long range capacity needs of an organisation can be changed in the following ways:

- Where present capacity is not sufficient to meet the forecast demand for the products and services, capacity can be expanded by:
 - Subcontracting component parts, sub units or even entire products to other firms
 - Acquiring other firms, facilities or resources
 - Building new plants and buying equipments/machinery etc
 - Expanding, modernising or modifying existing facilities
 - Reactivating facilities which are on stand by status
- When the present capacity is in excess of the expected future needs, capacity can be reduced by:
 - Selling off existing facilities, selling inventories and laying-off or transferring employees placing some facilities on stand by status and selling the inventories and laying off or transferring employers of such surplus facilities
 - Developing and phasing in new products as other products decline, so that capacity rendered surplus can be made use of

3.6 Capacity Management

To enhance capacity management, the following approaches to capacity alternatives could be developed:

Designing Flexibility into the System

- Designing flexible production system can offer potential benefits in long range capacity planning because of the risks inherent in long term forecast.
- When flexibility is built in the design of the system itself it would become easy to implement expansion plans later.
- Other factors to be considered in flexible design include layout of equipment, location and equipment selection, production planning, scheduling and inventory policies.

Differentiating between new and mature products or services

- Capacity requirements of mature products can be predicted more precisely and mature products may have limited life spans.
- The possible limited life span of the matured products or service may necessitate finding an alternative use for the resulting excess capacity at the end of the life span.
- On the other hand, new products tend to carry higher risk because the quantity demanded and duration of the demand can not be predicted accurately.
- Therefore having flexibility becomes a more attractive option to production managers.

Taking a big picture approach to capacity changes

When developing capacity alternatives, a firm must consider how different parts of the system interrelate.

For example when the management of a five star hotel makes a decision to increase the number of rooms, it must also consider probable increased demand for parking lots, restaurant seating capacity, bigger dining hall and kitchen capacity, increase in no. of hotel staff and house-keeping staff etc.

Preparing to deal with 'chunks' of capacity

Usually capacity increased is often acquired in the form of fairly large chunks of capacity rather than small increments in capacity.

For example in a steel plant, the existing capacity, of a furnace may not be enough to meet the demand, but installing an additional furnace would result in having excess capacity because additional furnaces can not be installed in small capacity chunks.

Attempting to smoothen out capacity requirements

- Having unevenness in capacity requirement can be problematic. E.g. during seasons of bad or extreme weathers, more and more people may tend use public transport vehicles for their travel rather than using their own vehicles.
- Consequently the public transportation system may tend to alternative between under utilisation and over utilisation.
- Demand for consumer products could vary partly because of chance factors because of seasonality.
- Seasonal variations can be predicted and hence can be better coped with than random variations.
- However seasonal variations can still pose problems because of their uneven demands on the production system.
- This problem of seasonality can be overcome by producing products having complementary demand patterns.
- If products having complementary demands patterns involve the use of the same resources but at different times then, the overall capacity requirements remain fairly stable.

Identifying the optimal operating level

- The optimal operating level is the ideal level of operation at which the cost per unit is the lowest for the production unit.
- Larger or smaller volumes of output would result in higher unit cost.

3.7 Selecting from among the Alternative Sources of Capacity

Before selecting the best alternative from among the several alternative sources of capacity an organisation needs to examine or evaluate the alternatives for future capacity from several different perspectives.

The most important perspective is economic consideration. The questions to be answered are:

- Will an alternative be economically feasible?
- What would be the operating and maintenance cost?
- How soon it can be acquired?
- What would be the operating and maintenance cost?
- What would be its useful life?
- Would it be compatible with present personnel and present operating methods?
- What would be the public opinion or reaction to a new facility?

The capacity planning and facility planning decisions can be analysed by different approaches such as:

- Break-even analysis or cost volume analysis
- Financial analysis
- Decision analysis or decision tree analysis
- Waiting line analysis

These approaches are briefly discussed below:

Break-even Analysis

- It focuses on relationships between cost, revenue and volume of output
- This analysis facilitates estimation of profit under different operating conditions; it is particularly useful for comparing capacity alternatives
- This technique involves identification of all costs related to the production of a given product
- These costs are categorised as fixed costs and variable costs
- Fixed costs do not vary when volume of output changes. For example, rent, property tax, equipment cost, administrative costs, heating and air conditioning expenses etc
- Whereas variable costs vary with volume of output, for example, material cost and labour costs
- The total cost is equal to the sum of the fixed and variable cost per unit multiplied by the volume of output (q) the total revenue associated with a given volume of output q is;

Total revenue = unit price x volume of output (Q)

The total profit is computed as,

Total profit (P) = Total revenue – volume of output (Q)

$P = TR - TC$

Where, TR = (Unit selling price) x volume of output

$TR = sQ$

Total cost (TC) = Fixed cost + (variable cost/unit x volume of output)

$TC = (FC + vQ)$ where v is the variable cost/unit

$P = TR - TC$

$P = (sQ) - (FC + vQ)$

$P = (s-v) Q - FC$

$Q = (P+FC)/((s-v))$

When total revenue equal total cost, (i.e. break-even point)

Total profit = Nil

Then, $QBEP = FC/((s-v))$

Assumptions

For cost volume analysis following assumptions to be made:

- One or a few products having the same cost characteristics are involved
- The volume of the product produced can be sold
- The variable cost per unit does not change with volume of output
- Fixed cost do not change when volume of output changes or they are set up changes
- The revenue per unit is the same regardless of volume sold
- Revenue per unit exceeds variable cost per unit

Financial analysis

Financial analysis helps managers to take decisions regarding allocation of scarce funds to alternative investment proposals.

Two important terms used in financial analysis are:

Cash flow

It refers to the difference between the cash received from sales and cash outflow for labor, materials, overhead and taxes etc.

Present value

It is the sum of all future cash received from sales and cash flows of an investment proposed. The three most commonly used methods of financial analysis are:

- pay back period method
- net present value method
- internal rate of return method

NOTE: A detailed discussion on Pay back period, net present value, internal rate of return is beyond the scope of the syllabus.

Decision Theory/Decision Tree Analysis

- Decision analysis is helpful for financial comparison of alternatives under conditions of risk or uncertainty.
- A decision tree is a schematic model of the sequence of steps in a problem and the condition and consequences of each step.
- Decision trees are used in situations involving multiphase decisions and interdependent decisions as aids to managers who must see clearly what decisions must occur and the interdependence of the decision.

- Decision tree analysis provides
 - always structuring complex multiphase decisions,
 - a direct way of dealing with uncertain event and
 - an objective way of determining the relative value of each decision alternative
- The concept of expected value (EV) used in decision tree analysis gives only relative measures of value and not absolute measures.
- Decision tree analysis allows decision makers to see clearly what decision must be made, in what sequence they must occur, and their interdependence.

NOTE: A detailed discussion on Decision tree analysis is beyond the scope of the syllabus.

Waiting Line Analysis

Waiting line analysis or queuing theory is often used for designing of service system by determining the service capacity and expected cost for various levels of service capacity.

NOTE: A detailed discussion on Waiting Line analysis is beyond the scope of the syllabus.

3.8 Facility Location

- Plant location may be understood as the function determining where the plant should be located for maximum operating economy and effectiveness.
- The selection of a place for locating a plant is one of the problems, perhaps the most important, which is faced by an entrepreneur while launching new enterprise.
- A selection on pure economic considerations will ensure an easy and regular supply of raw materials, labour force, efficient plant layout, proper utilisation of production capacity and reduced cost of production.

The need for the selection of the location may arise under any of the following conditions:

- When the business is newly started
- The existing business unit has outgrown its original facilities and expansion is not possible, hence a new location has to be found
- The volume of business or the extent of market necessities the establishment of branches
- A lease expires and the landlord does not renew the lease
- When a company thinks that there is a possibility of reducing manufacturing cost by shifting from one location to another location and
- Other social or economic reasons for instance, inadequate labour supply, shifting of the market, etc.

3.9 Steps in Location Selection

To be systematic, in choosing a plant location, the entrepreneur would do well to proceed step by step, the steps being:

- Within the country or outside
- Selection of the region
- Selection of the locality or community
- Selection of the exact site

3.9.1 Domestic or International Location

- The 1st step in plant location is to decide whether the facility should be located domestically or internationally.
- A few years ago, this factor would have received little consideration. But with increasing internationalisation of business, the issue of home or foreign country is gaining greater relevance.
- If the management decides on foreign location the next logical step would be to decide upon a particular country for location.
- This is necessary because countries across the world vary with each other to attract foreign investments. The choice of particular country depends on such factors as political stability, export and import quotas, currency and exchange rates, cultural and economic peculiarities, and natural or physical conditions.

3.9.2 Selection of region

The selection of a particular region out of the many natural regions of a country is the second step of plant location.

The following factors influence such selection:

Availability of raw materials

As the manufacturing plant is engaged in the conversion of raw material into final product, it is essential that it should be located in a place where the supply of raw material with minimum transport cost.

Nearness to raw materials offers such advantages as:

- Reduced cost of transportation
- Regular and proper supply of materials uninterrupted by transportation breakdowns and
- Savings in the cost of storage of materials

Nearness to the market

- Since the goods are produced for sale, it is very essential that the factory should be located near their market.
- A reduction in the cost of transporting finished goods to the market.
- The ability to adjust the production program to suit the likes and dislikes of consumers.
- The ability to render prompt service to the consumers, provide after sales services, and execute replacement orders without delay these are some of the advantages that accrue to the entrepreneur if he/she establishes his / her factory near his market.
- Industries using pure or non-weight losing raw materials, industries producing perishable or bulky products and servicing units tend to be located near their market.

Availability of power

- Power is essential to move the wheels of an industry. Coal, electricity, oil and natural gas are the sources of power.
- Where coal is the source of power as in the case of the iron and steel industry, the factory has to be located near the coal fields.

Transport Facilities

- While going with the process of selection of location an entrepreneur considers the question of the availability of transport facilities.
- Transport facilities are essential for bringing raw materials and men to the factory and for carrying the finished products from the factory to the market.
- A place which is well connected rail, road and water transport is ideal for a plant location.

Suitability of climate

- The climate has its own importance in the location of a plant because of two reasons.
- First there are certain industries which, because of the nature of their production, require particular climatic conditions. For example, humid climate for cotton textiles and jute.
- Secondly, climate affects labour efficiency. Extreme climatic conditions adversely affect labour efficiency and such places do not attract industries.
- It is for this reason that little industrial activity is found in tropical and polar regions, whereas there is a heavy concentration of industrial activities in cool and temperate regions.

Government policy

- The influence of government policies and programs on plant location is apparent in every country, particularly in planned economies like ours.
- In the name of balanced regional development, many backward regions in India have been selected for the location of new industries, which would generate the region's economy and on larger canvas, the national economy.
- The government of India has been influencing plant location in a number of ways. Some of these are:
 - Licensing policy
 - Freight rate policy
 - Establishing a unit in the public sector in remote area and developing it to attract other industries
 - Institutional finance and government subsidies

Competition between States

- States compete with other to attract new industries. Various states offer investment subsidies and sales tax exemptions to new units.
- The incentives may not be of big help to big sized plants.
- But for small and medium sized plants the incentives do matter. The owners of these plants certainly consider incentive in selection of region.

3.9.3 Selection of Community

Selecting a particular locality or community in a region is the third step in selection of plant location
The selection of a locality in a particular region is influenced by the following factors:

Availability of labour

Labour is an important factor in the production of goods. An adequacy of labour supply at reasonable wages is very essential for the smooth and successful working of an organisation.

Civic amenities for workers

Besides good working conditions inside the factory, the employees require certain facilities outside it. Recreation facilities such as clubs, theatres, parks, must be provided for the employees. They require schools for their children. A place which abounds in all these facilities will naturally be preferred to another place which lacks them.

Existence of complimentary and competing industries

The existence of complementary industries is favorable to the location of industries, because an industrial unit, in association with other units, can get the following benefits:

- An industrial unit, in collaboration with other similar units, can secure materials on better terms than it can do it by itself.
- The concentration of similar industries at one place improves the labour market both for the employer and employee.
- The specialised centers, bank, become familiar with the requirements of the industry, this makes the granting of loans easy
- The group of plants will attract a variety of repair plants, such as foundries, machine, shops, tool makers and the like.
- The reputation build up by the existing units will be shared by the new units established in the same locality.

Finance and research facilities

Adequate capital is essential for the successful working of any organisation. A place where facilities for raising capital are available attracts new industries. This is particularly true in developing countries, where capital is not available uniformly throughout the country. In advanced countries the case is different because, in such countries, capital is distributed uniformly.

Availability of water and fire fighting facilities

Some industries require a plentiful supply of water for their working. Some of these are fertiliser units, rayon manufacturing units, absorbent cotton manufacturing units, leather tanneries, bleaching, dyeing and screen printing units.

These factories must be located in places where water is available in abundance.

Water may be obtained from the local authority, from the canal, from a river or a lake, or by sinking a borewell. In any case, the supply of water should be considered with respect to its regularity, cost and purity.

Local taxes and restrictions

Local authorities collect charges for the supply of water, electricity and other facilities. They also collect various taxes from industrial units. They impose restrictions on the location of new units in the public interest. It is natural, therefore for industrialists to prefer an area where such taxes and restrictions are the least tedious

Personal factors

There are entrepreneurs, especially small industrialists, who locate their plants purely on personal grounds disregarding economic considerations. Such locations sometimes may totally disapprove the current theories of plant location.

3.9.4 Selection of Site

The selection of an exact site in a chosen locality is the fourth step in plant location. The selection of the site is influenced by the following considerations:

Soil, size and topography

- For factories producing engineering goods, the fertility or otherwise of the soil may not be a factor influencing plant location. But for agro-based industries, a fertile soil is necessary for ensuring a strategic plant location.
- The area of the land should be such as to accommodate not only the existing manufacturing facilities, but offer scope for future expansion programs as well.
- Besides the area, the cost of land deserves consideration. If the land is to be purchased, and if the place enjoys all the facilities for plant location, its price should not affect the decision to locate the plant in that particular place, because the cost of land forms a small percentage of the total fixed investment.
- But if the land is to be leased, the question of rent, rates and taxes has to be seriously considered because they constitute a part of the permanent working expenses.
- The topography of the place deserves consideration to some extent. A hilly, rocky and rough terrain is unsuitable for plant location because a great deal of expenditure has to be incurred to level it.

Disposal of waste

The site selection for the location of the plant should have the provision for the disposal of the waste. There must be enough land for dumping of the solid waste. The site selected should, as far as possible, be in the midst of good scenery. The question of beauty should not be ignored.

3.10 Errors in Selection

Though location selection is relatively easy, businessmen commit errors and wrong locations are selected. Interestingly, errors in site selection seem to fall into a pattern.

Some of the most common errors are:

- Lack of investigation
- Personal likes and dislikes
- Reluctance of key executives to move from traditional established home ground to new and better locations
- Moving to congested areas already or about to be over industrialised
- Preference for acquiring an existing structure that is improperly located or not designed for the most efficient production
- Choice of community with low cultural and educational standards

3.11 Importance of Location Factors

The site selected may be a urban, a suburban or a rural one. All these offer advantages as industrial sites.

Rural site

The facilities available at a village site are not as many as are found in a city; but they are more attractive.

- Land is available at cheaper rates.
- The rates and taxes are negligible.
- Spacious layout available and open spaces are possible.
- Advantages of single storey buildings are available.
- Low wages for unskilled workers but high wages for skilled workers because they have to be mobilised from elsewhere.
- Fewer labour troubles

- Avoidance of danger from fire and other hazards resulting from the operations of neighboring units
- Avoidance of undesirable neighbors
- Lack of supply of skilled workers
- Lack of civic amenities for employees
- Lack of transport facilities

Suburban site

- They are less costly.
- All transport facilities are available.
- Quarters for workers provided by local authorities or by private entrepreneurs.
- Easy availability of labors.
- Land is available at cheap rates.

Urban site

A big city has all the facilities which favor a location for a plant.

- Transportation facilities are no problem.
- Labour is available in plenty.
- Municipal services for water, sewage disposal, public health and education are available.
- banking, repair and related services are available
- facilities for contracting out a portion of the work are available
- a large local market is available
- high advertising value is available

3.12 Location Models

Various models are available which help identify a near ideal location. The most popular models are:

Factor Rating Method

In this method, factor ratings are used to evaluate alternative locations. The method has the following advantages:

- Simplicity which facilitates communication about why one location/site is better than another.
- Enables bringing diverse locational consideration into the evaluation process.
- Foster consistency of judgment about location alternatives.

Point Rating Method

In selecting a site or location companies have several objectives, but not all are of equal importance.

The relative weight a company assigns to each objective or to each location factor may be represented by the number of points a perfect site would receive in each category. Each potential site is then evaluated with respect to every factor a company is looking for and points are assigned for each factor. The site with the highest total number of points is considered superior to other sites.

Break Even Analysis

In comparing several potential locations on an economic basis, the only revenues and costs that need to be considered are the ones that vary from one location to another. If revenue per unit is the same regardless of where the good is produced, the total revenues can be eliminated from consideration. An economic comparison of locations can be made by identifying the fixed costs and variable costs and plotting the break even-analysis on a graph for each location. The graphical approach can easily identify the range of annual production volume over which a location is preferable.

The steps involved in this method are:

- Determine all relevant costs that vary with each location.
- Categorise the costs for each location into annual fixed costs (FC) and variable cost per annum (VC), for each location.
- Plot the total cost associated with each location on a single chart or graph of annual cost versus annual production volume.
- Select the location with the lowest total annual cost (TC) at the expected production volume per annum (Q).

Qualitative Factor Analysis

If economic criteria are not sufficiently influential to decide the location alternative; a system of weighting the criteria might be useful in making a plant location decision. This approach is referred to as qualitative factor analysis. The steps involved are:

- Develop a list of relevant factors.
- Assign a weight to each factor to indicate its relative importance.
- Assign a common scale to each factor and designated any minimum point to be scored by any location.
- Score each potential location according to the designated scale and multiply the scores by the weights to arrive at the weighted scores.
- Total the points for each location, and choose the location with the maximum points.

Summary

- Long-term capacity plans which deals with investments in new facilities and equipments covering the requirements for at least two years into the future
- Short term capacity plans which focus on work force size, overtime budgets, inventories etc.
- Capacity planning is central to the long term success of an organisation.
- Capacity planning is generally viewed in terms of three time horizons or durations;
- Long range capacity planning which is usually having a time horizon of more than one or two years. It is carried out for productive resources which take a long time to acquire or dispose of such as buildings, equipment or facilities such as machinery, materials handling equipments and transportation vehicles etc.
- Intermediate range capacity planning which has a time horizon or duration for the next 6-18 months. The intermediate range capacity may be varied by such alternatives such as hiring or laying off labour, purchasing or making new tools and minor equipments and outsourcing/subcontracting etc.
- Short range planning which has a time horizon or duration of less than one month. This is concerned with day to day planning such as daily scheduling of activities and machine loading or weekly scheduling process which involves making adjustments to eliminate the variance between planned output and actual output. It is concerned with overtime, transfer of personnel and changing the production routings.
- Many decisions about design of the production system and operation of the production system may have an impact on capacity.

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Self Assessment

1. _____ capacity planning which is usually having a time horizon of more than one or two years.
 - a. Short range
 - b. Intermediate range
 - c. Long range
 - d. Medium range
2. Intermediate range capacity planning which has a time horizon or duration for _____ months.
 - a. 10-12
 - b. 6-8
 - c. 10-20
 - d. 6-18
3. _____ capacity refers to the maximum output that can possibly be attained. It is the maximum rate of output achieved under ideal conditions.
 - a. Production
 - b. Design
 - c. Effective
 - d. Efficient
4. The capacity is measured relative to equipment is known as _____.
 - a. Peak Capacity
 - b. Relative Capacity
 - c. Design Capacity
 - d. Measure of Capacity
5. Effective capacity is usually less than _____ capacity because of capacity losses due to realities such as product mix changes, need for periodic preventive maintenance of equipment, problems in scheduling and balancing operations, coffee breaks, lunch breaks and so on.
 - a. peak
 - b. relative
 - c. design
 - d. measure of
6. Following analysis focuses on relationships between cost, revenue and volume of output is known as _____.
 - a. financial analysis
 - b. break-even analysis
 - c. decision tree analysis
 - d. waiting line analysis

7. Which of the following analysis helps managers to take decisions regarding allocation of scarce funds to alternative investment proposals?
 - a. Financial analysis
 - b. Break-even analysis
 - c. Decision tree analysis
 - d. Waiting line analysis

8. The difference between the cash received from sales and cash outflow for labor, materials, overhead and taxes etc., is known as _____.
 - a. Present value
 - b. Cash inflow
 - c. Cash flow
 - d. Interest

9. The expected value (EV) gives only relative measures of value and lot absolute measures is used in _____.
 - a. Waiting line analysis
 - b. Decision tree analysis
 - c. Financial analysis
 - d. Break-even analysis

10. Adequate _____ is essential for the successful working of any organisation, where facilities for raising capital are available attracts new industries.
 - a. machinery
 - b. manpower
 - c. capital
 - d. materials

Chapter IV

Facility Layout

Aim

The aim of this chapter is to:

- elucidate the concept of facility layout
- explicate the importance of facility layout
- explain different types of layout

Objectives

The objectives of this chapter are to:

- explain the importance of facility layout in operations management
- comprehend the meaning of facility layout
- enlist the steps involved in facility layout

Learning outcome

At the end of this chapter, you will be able to:

- describe the steps in designing layout
- understand and discuss the problems of facility layout
- identify the inputs of layout

4.1 Introduction to Facility Layout

A typical manufacturing plant has a number of diverse activities interacting with each other. Thus, raw materials arrive at a shipping dock, they are unpacked and checked in quality control area, then they might be processed through several processing areas, and finally the finished product again passes through the shipping dock.

- In addition to areas specifically related to production, there must be dressing rooms, lunch rooms, and restrooms for employees; offices for supervision, design, and production control; and space for inventory and aisles.
- In fact, a plant might be viewed as a large number of finite geometric areas arranged on the floor space of the building.
- The problem of arranging these areas in an effective manner is the facility layout problem.
- Clearly, the layout problem has relevance in many areas of facility and equipment design, from the layout of the rooms in a home to the layout of chips on an electronic circuit board.
- Although the facility layout problem may arise in many contexts, in this section we assume we are dealing with a plant manufacturing products for sale.

4.2 Inputs of the Layout

Layout decisions entail determining the placement of departments, work groups within the departments, workstations, machines, and stock-holding points within a production facility.

The objective is to arrange these elements in a way that ensures a smooth work flow (in a factory) or a particular traffic pattern (in a service organisation).

In general, the inputs to the layout decision are as follows:

- Specification of the objectives and corresponding criteria to be used to evaluate the design.
- The amount of space required, and the distance that must be traveled between elements in the layout, are common basic criteria.
- Estimates of product or service demand on the system.
- Processing requirements in terms of number of operations and amount of flow between the elements in the layout. Space requirements for the elements in the layout.
- Space availability within the facility itself, or if this is a new facility, possible building configurations.

4.3 Types of Layout

Several alternative layout types are appropriate for different product mixes and production volumes. Determination of the layout type is a major design decision because it affects so many other aspects of the production system.

The formats by which departments are arranged in a facility are defined by the general pattern of work flow; there are four basic types:

4.3.1 Process Layout/ Job Shop Layout

- A process layout (also called a job-shop or functional layout) is a format in which similar equipment or functions are grouped together, such as all lathes in one area and all stamping machines in another.
- A part being worked on then travels, according to the established sequence of operations, from area to area, where the proper machines are located for each operation.
- This type of layout is typical of hospitals, for example, where areas are dedicated to particular types of medical care, such as maternity wards and intensive care units.
- In the Job Shop Layout, machines are grouped according to function into machine centers. Orders for individual products are routed through the various machine centers to obtain the required processing.

- This layout may be appropriate when there are many different products, each with a low volume of production. Machines are general purpose, within their general function area, so that a wide variety of products can be handled. Because the expense of automation may be too great to be justified by the low volume, the machines in this arrangement will probably be at a relatively low level of automation. Workers will be highly skilled.
- Production scheduling is difficult with this type of arrangement because the level and type of work is highly variable.
- This results in large amounts of work-in-process, long product lead times, and high levels of management interaction.
- Typically there is a high degree of product movement required by the long and variable routes of individual products through the system.
- The costs for setting up machines to produce the various products will be high because of the variety of different products and small lot sizes.
- The arrangement can adapt readily to changes in product volume and design because of its inherent flexibility

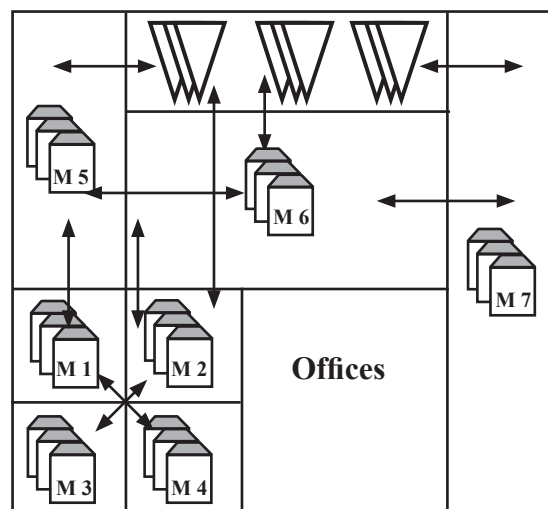


Fig. 4.1 Job shop layout

4.3.2 Product Layout/ Flow Shop Layout

- A product layout (also called a flow-shop layout) is one in which equipment or work processes are arranged according to the progressive steps by which the product is made.
- The path for each part is, in effect, a straight line. Production lines for shoes, chemical plants, and car washes are all product layouts.
- Here the product (or products) follows a fixed path through the production resources. The resources are arranged to minimise the material movement required.
- This type of layout is typical for an assembly line where a single product, or a few very similar products, passes through the line in a continuous fashion. Because of the high volume of production, the machines on the line can be designed with a high level of fixed automation, with very little manual labor.
- Direct labor will be much less than for the job shop, but there will be high costs for maintenance. Setup costs and work in progress will be low for this arrangement.
- The line, in general, is not flexible to product or volume changes. It is very sensitive to failures that cause the entire line to shut down.
- The arrangement is also appropriate for a flow shop that may have a number of products that all pass through the machine centers in the same order.

- In this case, the machines implementing the system may or may not be automated depending on the product mix and volume, but one would expect a higher level of automation than for the job shop.

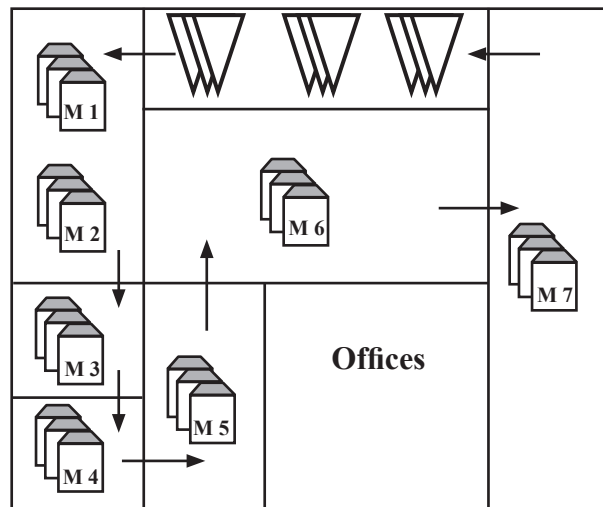


Fig. 4.2 Flow shop layout

4.3.3 Group Technology Layout

- A group technology (cellular) layout groups dissimilar machines into work centers (or cells) to work on products that have similar shapes and processing requirements.
- A group technology (GT) layout is similar to a process layout in that cells are designed to perform a specific set of processes, and it is similar to a product layout in that the cells are dedicated to a limited range of products.
- Group technology also refers to the parts classification and coding system used to specify machine types that go into a cell. The product mix appropriate for this arrangement is similar to that of the job shop.
- Products are grouped into classes that have some similarity with respect to processing. A manufacturing cell is designed for each group consisting of machines particularly adapted to the processing required.
- The figure shows the cells as collections of dissimilar machines. Because the range of products manufactured by each cell is less than that for the job shop, the machines and workers can be more specialised.
- Typically, the workers in a cell are given more of the responsibility for production scheduling of a product class. This, together with the start-to-finish nature of the processing, results in more interesting jobs for the workers.
- The group technology arrangement requires less setup time and cost than the job shop because of the greater specialisation of function.
- It is compatible with the just-in-time concept of manufacture, so prevalent today, because of the smaller lot sizes made possible by the low setup costs.
- Often the level of automation with group technology is low, indicating the dependence of the concept on the skill of the labor force.
- Many companies have, however, introduced highly automated flexible manufacturing cells into the system. Because the cell has a smaller range of products than the entire plant, it is easier to design the automation to handle the set of products in a group.
- The group technology approach is more sensitive to changes in product mix and volume than the job shop, again because of the specialisation introduced because of the manufacturing cell approach. When a product requires processing in more than one cell, problems similar to those of the job shop are introduced.

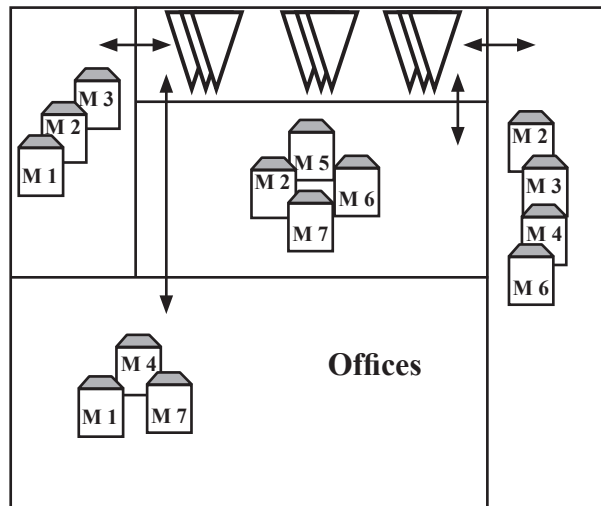


Fig. 4.3 Group technology layout

4.3.4 Fixed Position Layout

- In a fixed-position layout, the product (by virtue of its bulk or weight) remains at one location. Manufacturing equipment is moved to the product rather than vice versa. Construction sites and movie lots are examples of this format.
- For tasks on large objects such as the manufacture of an electrical generator, the construction of a building, or the repair of a large airplane, the machines implementing the operation must come to the product, rather than the product moving to the machines.
- Here the question is more often the scheduling of operations rather than the layout of machines.
- A relatively low number of production units in comparison with process and product layout formats characterises fixed-position layout.
- In developing a fixed-position layout, visualise the product as the hub of a wheel with materials and equipment arranged concentrically around the production point in their order of use and movement difficulty.
- Thus, in building custom yachts, for example, rivets that are used throughout construction would be placed close to or in the hull; heavy engine parts, which must travel to the hull only once, would be placed at a more distant location; and cranes would be set up close to the hull because of their constant use.
- In fixed-position layout, a high degree of task ordering is common, and to the extent that this precedence determines production stages, a fixed-position layout might be developed by arranging materials according to their technological priority.
- This procedure would be expected in making a layout for a large machine tool, such as a stamping machine, where manufacture follows a rigid sequence; assembly is performed from the ground up, with parts being added to the base in almost a building-block fashion.

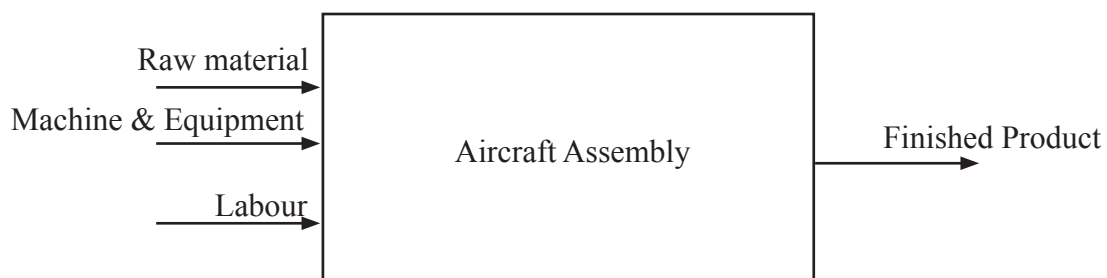


Fig. 4.4 Fixed position layout

4.3.5 Flexible Manufacturing System

- The FMS is a system with automated material handling moving individual units of product between automated processors. Robotic manipulators often handle material.
- Using computer controlled movement and processing, a wide variety of products can be manufactured. All of this is to be accomplished with very low setup time, great flexibility of function, and very little manual labor.
- The diversity of possible FMS, and the rapidly changing technologies, makes detailed consideration of the design of FMS beyond the scope of this text.
- Certainly many of the classical questions (and answers) associated with facility design are no longer relevant for the FMS. In this text, we consider the FMS as just another kind of machine, with perhaps a very broad range of capabilities.

4.4 Layout Design Procedure

Designing of layout of a plant is a specialised activity and should be carried out systematically. The various steps to be followed in the layout design are:

- Statement of specific objective
- Collection of basic data on sales
- Preparation of various kinds of charts, such as flow charts, flow diagrams, templates etc
- Designing the production process
- Planning material flow pattern
- Planning individual work centers
- Selection of materials handling equipments
- Planning of auxiliary and service facilities
- Determination of routing, space requirements for each work station, service department, employee facility etc
- Draw building specifications to fit the requirements of layout
- Preparation of floor plan indicating location of doors, windows, stair case, lifts etc
- Preparation of tentative or draft layout plans
- Preparation of detailed layout drawing and get approval of top management
- Preparation of work schedule for the installation of layout

4.5 Layout Problem

- The layout problem is to arrange the physical spaces required for several departments in a given space provided for the departments.
- In practice the facility layout problem is often solved by intuition, using the artistic and spatial skills of the human designer; however, when there are quantitative considerations associated with the layout problem, the human is at a disadvantage as compared to the computer.
- In this chapter we concentrate on computerised procedures for solving the layout problem. There are a variety of problems regarding layout one might encounter. In this section we explain the problem by specifying the data and describing the decisions.

Input data

- Here we are considering the problem of arranging several departments on a plant with a single floor and fixed dimensions.
- Certain data is necessary to describe the layout problem.

- Number of departments, n , Physical area of each department, A_i for $i = 1 \dots n$
- Physical dimensions of the plant in which the departments are to be placed: Length, L , and Width, W .
- Product flow between every pair of departments: f_{ij} for $i = 1 \dots n$ and $j = 1 \dots n$.
- Material handling cost between every pair of departments measured in dollars per unit-foot: c_{ij} for $i = 1 \dots n$ and $j = 1 \dots n$.

Distance

- Our models involve the distance from one department to another. The distance depends on the layout. To illustrate consider a problem with ten departments with each department having an area of 100 square feet.
- The ten departments are to be placed in an area that is 50 feet long by 20 feet wide. One layout is shown in Fig. 5.5.

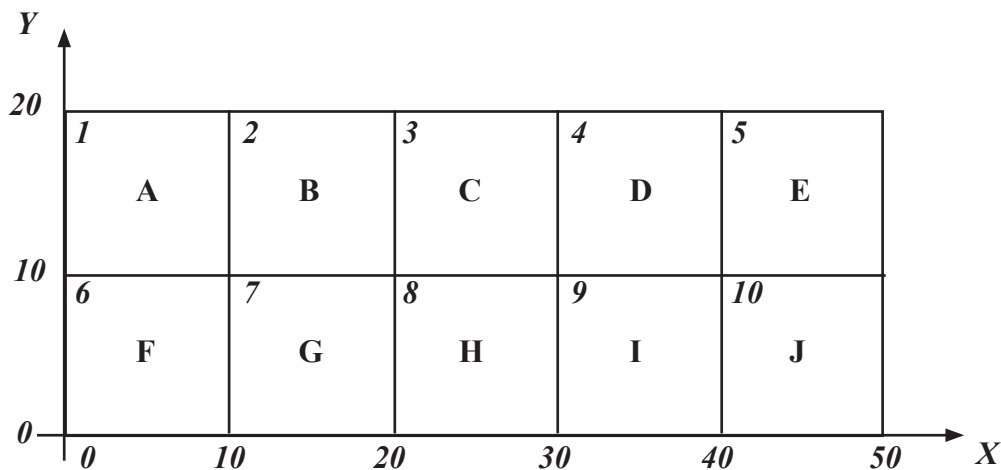


Fig. 4.5 A layout of departments

- This is only one of many possible layouts. If we assume that the departments must maintain a square shape, every permutation of the letters A through J is a different layout. There are $n!$ Permutations.
- The matrix as in Fig. 4.6 describes the flow between the departments. This is called the From-To matrix because an element (i, j) contains f_{ij} , the flow from department i to department j

From \ To	A	B	C	D	E	F	G	H	I	J
A					5				1	9
B				3	4		1			
C				1			9			2
D							6		1	
E						8	3			
F							2	5		
G								6		
H									8	
I										
J										

Fig. 4.6 From to matrix for the office example

- The criterion for the layout problem involves the distance between departments. First we must prescribe the end points for the distance measurement.
- Here we assume that distances are measured between the centroids or centers of gravity of departments. Second, we must specify the route of travel. One possibility is that flow will follow a straight-line path. This is the Euclidean measure. More common in layout analysis, is to assume that flow travels via paths that are parallel to the axes of the layout. This is the rectilinear measure.
- The centroids are specified in terms of the coordinate system as,
 $x(i)$ = x-coordinate of the centroid of department i, and
 $y(i)$ = y-coordinate of the centroid of department i.
- The centroid is the same as the center of the area when the department is rectangular. For a more general shape, the centroid is the center of gravity of area.
- In the example case of Fig. 1 we have the centroids as follows.

Department A: $x(A) = 5, y(A) = 15$.

Department B: $x(B) = 15, y(B) = 15$.

Department C: $x(C) = 25, y(C) = 15$.etc.

The distance between two departments by a rectilinear measure is

$$d_{ij} = |x(i) - x(j)| + |y(i) - y(j)|.$$

- Here the vertical lines indicate absolute value. Fig. 4.7 shows both the flow and distance between all pairs of departments on the from-to chart.
- The flow appears above the diagonals and the distance appears below.

From \ To	A	B	C	D	E	F	G	H	I	J	Sum
A					5 40				1 40	9 50	690
B				3 20	4 30		1 10				190
C				1 10			9 20			2 30	250
D							6 30		1 10		190
E						8 50	3 40				520
F							2 10	5 20			120
G								6 10			60
H									8 10		80
I											0
J											0

Fig. 4.7 Computation of the total distance travelled

Criterion for comparison

- The flow multiplied by the distance and summed over all cells of the chart. We compute the cost for the flow from i to j as the product of the material handling cost, the flow and the distance between the departments.

- The cost of the layout is the sum of the flow cost.

$$z = \sum_{i=1}^n \sum_{j=1}^n c_{ij} f_{ij} d_{ij}$$

- The cost associated with each row of the chart is shown at the right of Fig. 4.7. The cost of the layout is the sum of the row costs.
- The factors c_{ij} and f_{ij} are given as data, but the factor d_{ij} depends on the layout.

4.5.1 Importance of Facility Layout

The importance of layout would be better appreciated if one understands the influence of an efficient layout on the manufacturing function; it makes it smooth and efficient.

- Good layout helps to manufacture quality goods in less manufacturing cost.
- Long distance movements should be avoided and irrelevant operations are eliminated.
- Full utilisation of area and work force.
- It minimises the lead time and production delays.
- It helps to improve quality control and inspection.
- Investment on equipment can be minimised by planned machine balanced and location.
- It helps in better production control and easy supervision.
- Ultimately all above factors will improve the employee morale, which depends on working conditions, employee facilities, reduced number of accidents and increased earnings.

Summary

- The formats by which departments are arranged in a facility are defined by the general pattern of work flow; there are three basic types (process layout, product layout, and fixed-position layout) and one hybrid type (group technology or cellular layout).
- A process layout (also called a job-shop or functional layout) is a format in which similar equipment or functions are grouped together, such as all lathes in one area and all stamping machines in another.
- A part being worked on then travels, according to the established sequence of operations, from area to area, where the proper machines are located for each operation. This type of layout is typical of hospitals, for example, where areas are dedicated to particular types of medical care, such as maternity wards and intensive care units.
- A product layout (also called a flow-shop layout) is one in which equipment or work processes are arranged according to the progressive steps by which the product is made. The path for each part is, in effect, a straight line. Production lines for shoes, chemical plants, and car washes are all product layouts.
- A group technology (cellular) layout groups dissimilar machines into work centers (or cells) to work on products that have similar shapes and processing requirements. A group technology (GT) layout is similar to a process layout in that cells are designed to perform a specific set of processes, and it is similar to a product layout in that the cells are dedicated to a limited range of products. (Group technology also refers to the parts classification coding system used to specify machine types that go into a cell.)
- In a fixed-position layout, the product (by virtue of its bulk or weight) remains at one location. Manufacturing equipment is moved to the product rather than vice versa.
- Different types of layouts may be used in each area, with a process layout used in fabrication, group technology in subassembly, and a product layout used in final assembly.
- Facility layout is where the rubber meets the road in the design and operation of a production system. A good factory (or office) layout can provide real competitive advantage by facilitating material and information flow processes. It can also enhance employees' work life.

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Self Assessment

1. The problem of arranging floor space of the building, restrooms for employees; offices for supervision, design, and production control and space for inventory etc. is known as _____.
 - a. Inventory problem
 - b. Layout conflict
 - c. Facility layout problem
 - d. Facility design problem

2. _____ is a format in which similar equipment or functions are grouped together, such as all lathes in one area and all stamping machines in another.
 - a. Flow shop layout
 - b. Job shop layout
 - c. Fixed position layout
 - d. Group technology layout

3. _____ type of layout is typical for an assembly line where a single product, or a few very similar products, passes through the line in a continuous fashion.
 - a. Job shop layout
 - b. Fixed position layout
 - c. Flow shop layout
 - d. Group technology layout

4. _____ also refers to the parts classification and coding system used to specify machine types that go into a cell.
 - a. Group technology layout
 - b. Job shop layout
 - c. Fixed position layout
 - d. Flow shop layout

5. In _____ layout, a high degree of task ordering is common, and to the extent that this precedence determines production stages, a fixed-position layout might be developed by arranging materials according to their technological priority.
 - a. Job shop
 - b. Fixed position
 - c. Flow shop
 - d. Group technology

6. Which of the following system is a system with automated material handling moving individual units of product between automated processors?
 - a. Assembly line system
 - b. Robotic system
 - c. Flexible Manufacturing system
 - d. MRP

7. Good Facility Layout helps to manufacture quality goods in _____.
 - a. Economical manufacturing cost
 - b. Less manufacturing cost
 - c. Average manufacturing cost
 - d. Controlled manufacturing cost
8. Production scheduling is difficult with which type of arrangement in which the level and type of work is highly variable?
 - a. Fixed-position layout
 - b. Group technology layout
 - c. Product layout
 - d. Process layout
9. Which of the following layout is similar to process layout?
 - a. Fixed-position layout
 - b. Group technology layout
 - c. Product layout
 - d. Process layout
10. Construction sites and movie lots are examples of which of the following format of layout?
 - a. Product layout
 - b. Process layout
 - c. Group technology layout
 - d. Fixed-position layout

Chapter V

Project Management and Scheduling

Aim

The aim of this chapter is to:

- explicate project planning and scheduling
- explain project design
- elucidate capital budgeting and strategic planning

Objectives

The objectives of this chapter are to:

- explain work structure and project structure
- elucidate bar charts and gantt charts
- enlist project objectives

Learning outcome

At the end of this chapter, you will be able to:

- understand project and work structure
- enlist setting project objectives
- identify types of analysis in a project

5.1 Introduction

Project planning is a discipline for stating how to complete a project within a certain timeframe, usually with defined stages and with designated resources. It involves the development of action items and scheduling that will keep the project moving forward on a consistent basis. When executed properly, project planning will also include target dates for the completion of each action item, making it possible to move forward with other pending items in an orderly manner. An actual project plan is referred to as an escalation list in some business settings.

It is also referred to as "gaining the most benefit while making the wisest use of available resources". To that end, one goal of this type of planning is to establish realistic data in terms of how much is needed of each resource required and how long that resource will be required.

Planning is a primary function of management and is deciding in advance the future course of action. The process of planning involves the following main steps:

- defining the objectives of the project.
- making forecasts for achieving the goals.
- identifying the alternative course of action for achieving the goals.
- evaluating the resources available to the organisation.
- evaluating the available alternative courses of actions and selecting the course of action/actions that are most suited to achieve the desired results, taking into account resource constraints, if any.

5.2 Project Design

- Project design begins once the project has received formal consent to proceed. This approval is usually in the form of a PID (Project Initiation Document) signed off by all parties involved in the project. Purpose of project design is to formally document the product or output of the project and decide how the work will be undertaken.
- The project manager will carry out this work, in consultation with the project sponsor and sub-project manager where there are sub-projects. Large projects may be divided into sub-projects, with each requiring its own design.
- It is necessary that a project manager is appointed before work on project design starts.

The project design includes the following activities:

- clarify objectives
- determine project scope
- determine work structure
- identify the major project milestones
- ensure project structure and responsibilities established
- determine management systems
- document the project design

5.3 Setting Project Objectives

- Effective objectives in project management are specific. A specific objective increases the chances of leading to a specific outcome.
- Therefore, objectives shouldn't be vague, such as "to improve customer relations," because these are not measurable.

- Objectives should show how successful a project has been, for example “to reduce customer complaints by 50%” would be a good objective. The measure can be, in some cases, a simple yes or no answer, for example, “did we reduce the number of customer complaints by 50%?”
- While there may be one main project objective, in pursuing it there may be interim project objectives.
- At many instances, project teams are tasked with achieving a series of objectives in pursuit of the final objective. In many cases, teams can only proceed in a stair-step fashion to achieve the desired outcome.
- If they were to proceed in any other manner, they may not be able to develop the skills or insights along the way that will enable them to progress in a productive manner.
- Objectives are the real statements that describe the things a project is trying to achieve. A project objective should be written so that it can be evaluated at the conclusion of a project to see whether it was achieved.
- The objectives should not be general statements like to reduce “rate of accidents” or “ensure welfare of people”. These types of objectives do not form an effective guide for planning and monitoring project effectiveness.
- The objectives need to give specific (preferable quantifiable) with description of desired project outcomes. To become an effective tool for project management, the objectives should be “SMART”, that is they should be:
 - Specific
 - Measurable
 - Achievable
 - Realistic
 - Timed

5.3.1 Importance of Objectives

Three important project objectives are as follows:

1. They are in business terms: Once they are approved, they represent an agreement between the project manager and the project sponsor (and other major stakeholders) on the main purpose of the project. The specific deliverables of an IT project, for instance, may or may not make sense to the project sponsor. However, the objectives should be written in a way that they are understandable by all the project stakeholders.
2. They help frame the project: If one knows the project objectives, one can determine the deliverables needed to achieve the objectives. This in turn helps nail down the overall project scope, helps identify risks and allows providing estimates on effort, duration and cost. Once the project starts, one can validate that all of the work that is being performed will ultimately help to achieve one or more project objectives.
3. They help declare success: At the end of the project, one should be able to talk to his/her sponsors to determine whether everything expected in the project objectives has, in fact, been achieved. If all of the objectives were not fully met, one may still be able to declare partial success.

5.4 Scope of the Project

- Determining the scope of the project helps to clarify objectives and set the boundaries of the project. The scope is of two types—product scope and process scope.
- Product scope describes the products of the project that will help in achievement of project and the process scope describes the work to be done or process to be adopted to create the project products.
- The project product take many different forms such as physical assets to produce goods or services, changes in condition of physical asset, design of new processes involving people and things, social and psychological change, new knowledge such as a new product design or insights into market behaviour gained through market research and an event.
- While clarifying scope, it is often useful to state limitations i.e., what the project will not cover.

5.5 Work Structure

- Determination of work structure is essentially systematic planning and execution of projects. Large projects can be better controlled and are therefore more likely to be successful, if they can be divided into smaller units of work.
- Determination of work structure involves breaking down the project into its component activities and understanding their sequential relationships. This step involves identifying tasks which can be arranged into logical groups to form sub-projects.
- Grouping could be on the basis of criteria such as:
 - tasks relating to one functional area
 - tasks to be performed by staff in one geographic location
 - tasks relating to a particular deliverable
 - tasks to be performed by team members belonging to the same division or department
- Milestones are significant events in the life of the project, such as installation of hardware or completion of training. They are used in tracking project progress. Dates will be added to these during planning.

5.6 Project Structure

- Developing project structure and establishment of responsibilities requires effective organisation of the project team including its relationship with other project stakeholders. It is necessary to assign sub-project managers where appropriate.
- The organisation set up along with description of responsibilities and relationships is documented in a project organisation structure document and is communicated to all concerned people/departments.
- Management systems will vary according to the size and nature of the project but should always include:
 - A progress control system for recording planned and actual times (this could be an automated system or a manual one).
 - Acceptance procedures for formal review and agreement of each project deliverable .

Scheduled management checkpoints

- If the project is divided into sub-projects it is important that consistent management systems are used across them all.
- The results of project definition must be documented and distributed for agreement to:
 - Project sponsor
 - Steering group members (if applicable)
 - Sub-project managers
 - Line managers who are contributing significant resource to the project
- The precise format of the document is left to the discretion of the project manager. However, the following topics should be covered:
 - Goals and objectives: State the business goals and the project objectives.
 - Work structure and scope: A high level description of the work to be performed including:
- a brief statement of the current business situation and the changes which the project is intended to bring about
 - A list and brief description of each sub-project
 - Key events in the project i.e. the major milestones
 - Organisation and responsibilities: Include an organisation chart, names and responsibilities. Highlight any functions or responsibilities peculiar to this project.

- **Risks and assumptions:** List and briefly describe each identified risk. Give an indication of its severity i.e. the probability of its occurrence and the impact on the project if it does occur.
- **Management systems:** Outline the systems to be used for tracking and controlling the work.
- **Potential problems:** List any other outstanding issues which might affect the project and any actions being taken to resolve them. Include details of who is responsible for the action and the completion date.
- **Appendices:** The 'project definition document' will first be issued as a draft. Once the sub-project managers have completed sub-project definition, their reports can be added as appendices. The sub-project definition should include objectives, work structure and scope and organisation.

5.7 Project Planning and Scheduling

- Project planning can begin as soon as project design is completed. The process involves planning sub-projects first and hence definition must at least have identified the sub-projects and the main tasks involved in them. From this point, planning and definition tend to continue in parallel as a series of iterations, gradually refining and hardening both definition and plans.
- The purpose of the project plan, at this stage, is to provide detailed realistic estimates of time, duration, resource and cost and planning should be carried out only in sufficient detail to allow this to be achieved. Detailed planning for allocation of tasks to individuals is carried out progressively as the work proceeds.
- Where there are sub-projects these should be planned first and then combined to produce the overall project plan. Produce a plan for each sub-project or for the total project if there are no sub-projects as follows:
- **Identify major activities:** Break down the work into activities of the order of 20-50 days of effort, ensuring that milestones correspond to completion of one or more of these. In practice, the achievement of a milestone is usually good basis for identifying an activity, e.g., 'preparing and performing user training'.
- **Identify and chart dependencies:** Produce a network chart for the sub-project showing dependencies between the major activities and dependencies on other sub-projects or external events.
- **Estimate effort and duration:** Estimate effort and duration of each major activity.
- **Provide contingency:** At this stage, estimates are likely to be 'soft' and probably expressed in ranges, because precise details of the work are not settled. Contingency needs to be allowed on both, the estimated effort and elapsed time because of the likelihood of:
 - unforeseen work arising
 - tasks taking longer than expected
 - changes to requirements or plans before publication—subsequent changes should be processed through change control
- **Schedule major activities:** Determine start and end dates for each major activity and produce a bar chart or other diagram, showing relationships between activities.
- **Calculate resource requirements:** Calculate requirements for each time period. Identify needs for each resource type (e.g., systems analyst, user staff) and identify needs for special skills or scarce resources.
- **Calculate costs:** Calculate costs for the sub-project. This should include 'hardening up' items such as cabling, training etc., for which an order of costs had been produced previously.
- All activities consume resources of three types—time, men and materials. (Or money). The project scheduling techniques are concerned with the resource 'time'.
- One of the objectives of project management is to optimise the use of resources. Scheduling techniques offer solutions to optimising the project time.

5.8 Bar Charts

- Bar chart is a pictorial representation showing the various activities involved in a project. The chart has two co-ordinate axes, one axis represents the activities and the other activities representing the time required for completion of the individual activities.
- Bar chart was first developed by Henry L. Gantt and hence is referred to as Gantt chart.

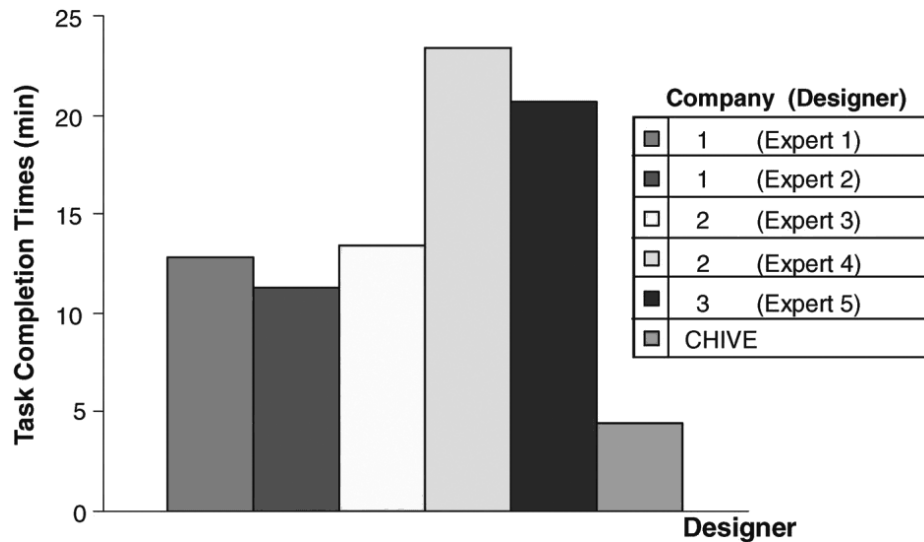


Fig. 5.1 Bar chart

- In the axis that represents activities that can be taken simultaneously, while some activities can be taken up only after completion of some activities. There may be also some activities which are independent of other activities.
- Consider the example of construction of a residential house.
- The following are some of the activities involved in the construction of a residential building:

Activities	Time required (in week/s)
Digging of foundation	3
Pouring foundation concrete	1
Construction of walls	10
Construction of roof slab	3
Fixing of doors and windows	1
Digging of well	1
Plastering and finishing of walls	2

Table 5.1 Activities for construction of a residential building

- The above table can be shown in a bar chart after identifying their logical sequence. If water required for the construction work is not available at the project site, the activity “digging of well” takes priority.
- If the water required for the construction work can be obtained without much difficulty, digging of well can be deferred to a later date and it need not be the starting activity.

5.8.1 Program Progress Charts

- The bar chart what we have discussed in the previous paragraph depicts the proposed activities of a project with their estimated time duration.
- A bar chart is drawn in order to have a pictorial view of the logical sequence of operations and their interrelationships and to have an estimate as to when the project is likely to be completed. It is only a projection in the future.
- A program process chart is also a bar-chart; but apart from depicting the activities with their proposed duration, this chart also incorporates the actual progress of the different activities.
- Both, the estimated time and the actual time taken for the completion of different activities are incorporated in the program progress chart.
- This chart helps in knowing the time lag between the estimated and actual progress of work during the implementation of the project.

5.8.2 Limitations of Bar Chart

- Bar charts are difficult to update when there are many changes.
- When there are changes between the plan and the actual achievement, bar charts become quickly obsolete.
- Bar charts do not equate time with cost; hence time-cost relationship cannot be derived from them.
- Bar charts do not provide methods for optimising allocation.
- In view of the above limitation, bar charts are useful only for smaller projects and cannot be effectively used for medium sized and large projects.

5.9 Overview of Capital Budgeting

Capital expenditures are the allocation of resources to large, long term projects. The capital budget is a statement of the planned capital expenditures. It is more than a simple listing, however and is not a “budget” in the usual sense.

- Given the nature of capital expenditures, the capital budget is best thought of as an expression of the goals and strategy of the firm. Creation of the capital budget is a central task that affects and is affected by, all others areas of decision making. The “capital budgeting process” can be envisioned as shown in fig. 5.2.
- Present and anticipated business conditions are the opportunities and constraints from which the goals of the firm are developed. The goals drive the strategic decisions of capital budget and financing, but feasibility and consistency with the interdependent financing and capital budget decisions must be considered in setting the goals.

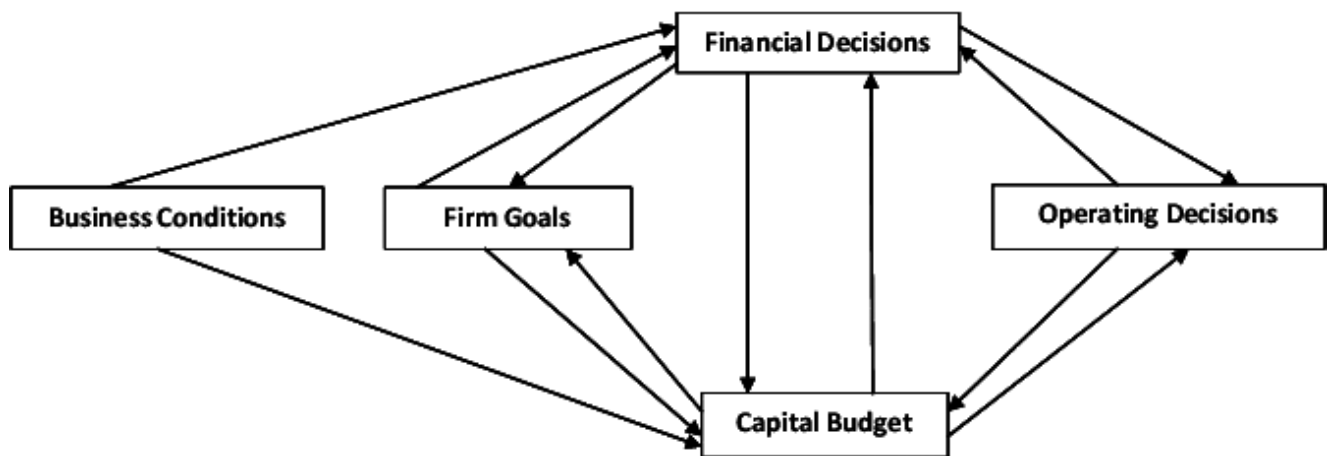


Fig. 5.2 Capital budgeting

- Operating decisions may be thought of as the tactical choices driven by strategy, but again, feasibility and consistency of operating decisions must be considered in setting strategy. The process is in actuality part simultaneous, part iterative.
- Given the interdependency of goals, strategy and tactics in a changing environment, the capital budget is properly considered as an active planning document, rather than a fixed conclusion.
- From a narrow economic viewpoint, creating the capital budget is relatively simple: a project should be accepted if the return is greater than the cost.
- Projects are listed in order of decreasing return and investment should continue until the marginal return (roughly, the return to the next dollar spent) is greater than marginal cost (roughly, the required rate of return on the next dollar spent).
- This simple, elegant statement of the problem masks a number of complications. Projects of different risk will likely have different required returns, will be of different sizes and have different existence and may be mutually exclusive or interdependent.
- The rule of accepting projects until marginal return no longer exceeds marginal cost also assumes unlimited funds. This assumption is theoretically justified by the argument that, if marginal return exceeds marginal cost, increasing the capital budget will return more than it costs and more funds should be acquired.
- There are, however, a number of reasons for limiting the size of the capital budget. Project analysis is often based on individual projects, but overall firm performance will be degraded if too many new projects are attempted in a short space of time.
- Externally, lenders or investors may be unwilling to provide funds or may require added return or limitations on an overly ambitious management. Further, some attractive projects may simply not fit the goals and strategy of the firm. Investors and creditors may react adversely to new projects if they are inconsistent with the perceived nature of the firm.
- Since capital budgeting is the concrete expression of the goals and strategy of the firm, it must often consider factors that defy exact measurement or even definition.

5.10 Overview of Strategic Planning

- Strategic planning is a tool for organising the present on the basis of the projections of the desired future. That is, a strategic plan is a road map to lead an organisation from where it is now to where it would like to be in five or ten years.

- It is necessary to have a strategic plan for your chapter or division. In order to develop a comprehensive plan for your chapter or division which would include both long-range and strategic elements, the following methods and mechanisms are outlined.

The plan must be

- simple
- written
- clear
- based on the real current situation
- have enough time allowed to give it a time to settle
- It should not be rushed
- Strategic planning is intended to accomplish three important tasks:
- To clarify the outcomes that an organisation wishes to achieve.
- To select the broad strategies that will enable the organisation to achieve those outcomes.
- To identify ways to measure progress.
- In addition, many organisations use the process to affirm their links to important stakeholders by involving

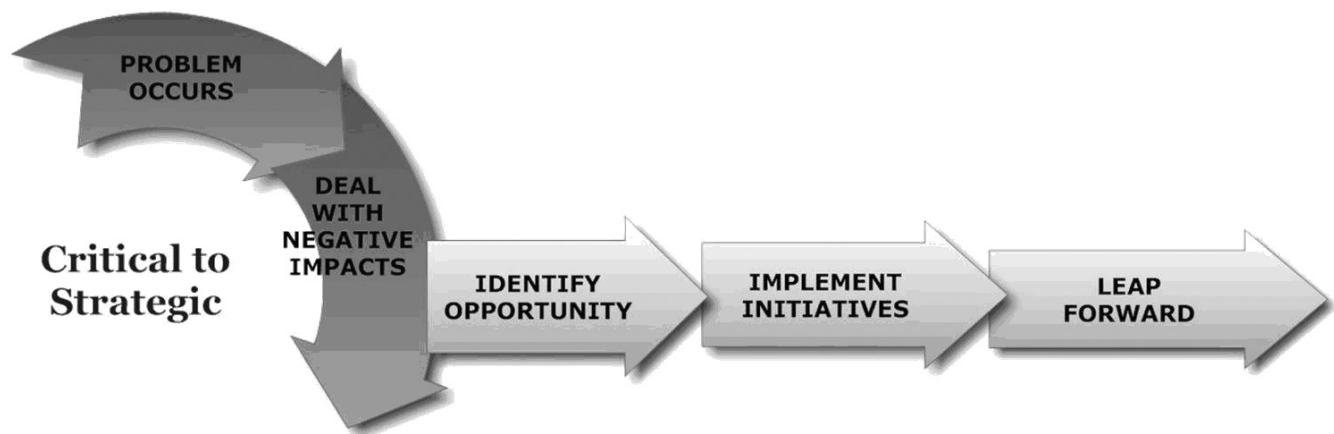


Fig. 5.3 Critical issues review

- SWOT (Strengths, Weaknesses, Opportunities, Threats): An analysis and evaluation of internal conditions and external factors that affect the organisation.

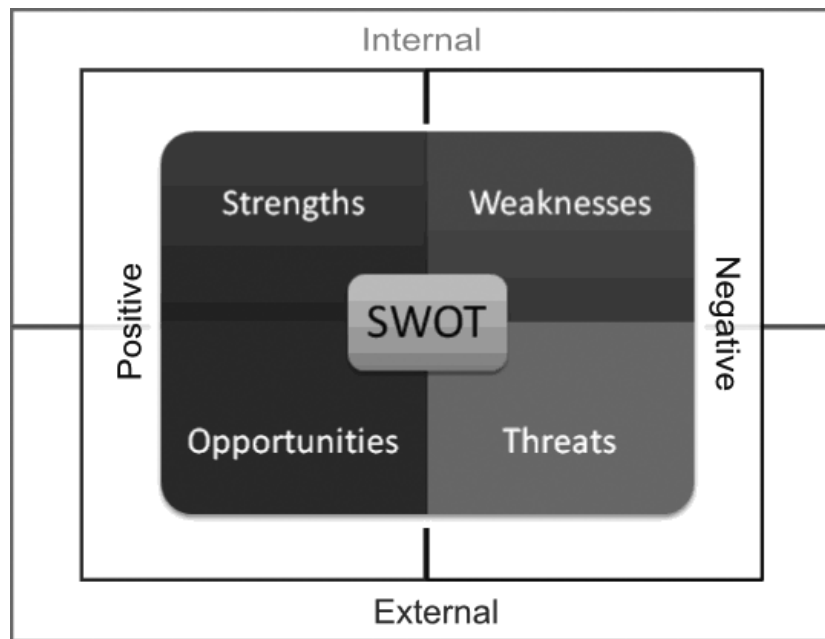


Fig. 5.4 SWOT analysis

- Force field analysis: An analysis of the forces propelling an organisation forward and those holding it back.

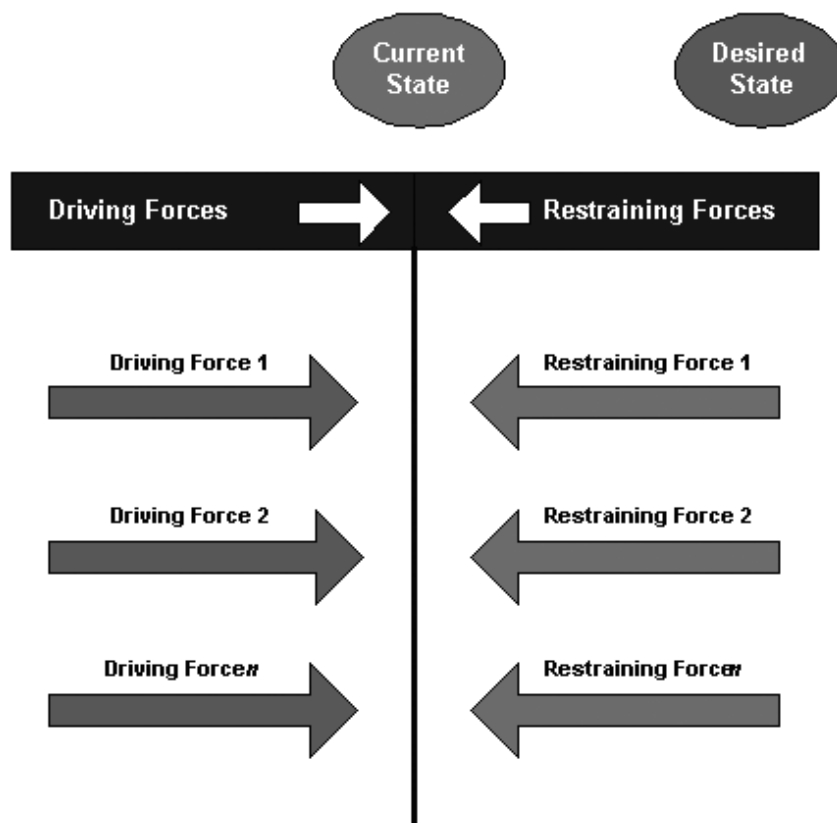


Fig. 5.5 Force field analysis

(Source: <http://www.relationship-economy.com/?p=361>)

- Customer/stakeholder/competitor analysis: Identification of those directly or indirectly affected by the agency's actions.

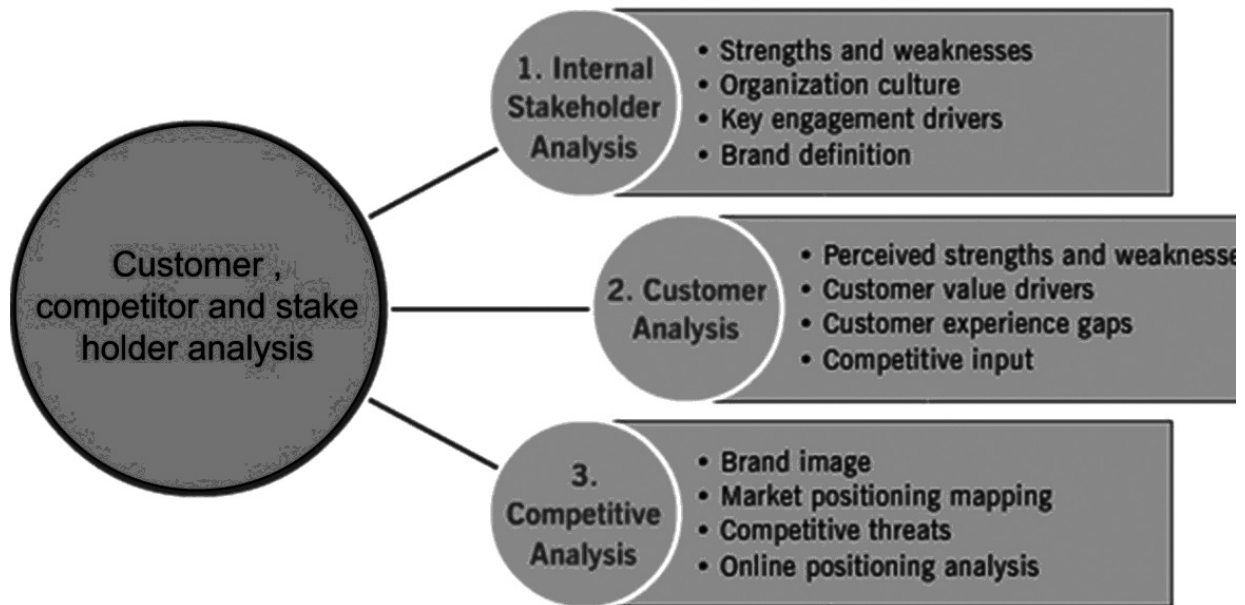


Fig. 5.6 Customer, competitor and stakeholder analysis
(Source: http://www.brand-matters.com/brand_model.html)

Summary

- Planning is a primary function of management which includes deciding in advance the future course of action.
- Project planning can begin as soon as project design is completed. The process involves planning sub-projects first and hence, definition must at least have identified the sub-projects and the major tasks involved in them.
- Large projects may be divided into sub-projects, with each requiring its own design.
- The project objectives should be defined and agreed upon before the project starts.
- The objectives should not be general statements like to reduce “rate of accidents” or “ensure welfare of people”. These types of objectives do not form an effective guide for planning and monitoring project effectiveness.
- Product scope describes the products of the project that will help in achievement of project and the process scope describes the work to be done or process to be adopted to create the project products.
- Bar chart is a pictorial representation showing the various activities involved in a project. The chart has two co-ordinate axes, one axis represents the activities and the other activities represent the time required for completion of the individual activities.
- Capital expenditures are the allocation of resources to large, long term projects. The capital budget is a statement of the planned capital expenditures. It is more than a simple listing, however and is not a “budget” in the usual sense.
- Strategic planning is a tool for organising the present on the basis of the projections of the desired future. That is, a strategic plan is a road map to lead an organisation from where it is now to where it would likely to be in five or ten years.

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Self Assessment

1. _____ are difficult to update when there are many changes.
 - a. Bar charts
 - b. Scheduling
 - c. Controlling
 - d. Designing

2. _____ are/is the allocation of resources to large, long term projects.
 - a. Working capital
 - b. Capital expenditures
 - c. Cash cycle
 - d. Capital budgeting

3. The _____ is a statement of the planned capital expenditures.
 - a. working capital
 - b. capital expenditure
 - c. cash cycle
 - d. capital budget

4. The purpose of _____ is to provide detailed realistic estimates of time, duration, resource and cost and planning should be carried out only in sufficient detail to allow this to be achieved.
 - a. project plan
 - b. project schedule
 - c. project change management
 - d. project tasks

5. Determination of _____ is essentially systematic planning and execution of projects.
 - a. work design
 - b. project design
 - c. work structure
 - d. project controlling

6. What does PID stand for?
 - a. Project Income Document
 - b. Project Initiation Document
 - c. Project Initiation Department
 - d. Planning Initiation Document

7. Which of the following statements is true?
 - a. Determining the design of the project helps to clarify objectives and set the boundaries of the project.
 - b. Determining the structure of the project helps to clarify objectives and set the boundaries of the project.
 - c. Determining the process of the project helps to clarify objectives and set the boundaries of the project.
 - d. Determining the scope of the project helps to clarify objectives and set the boundaries of the project.

8. Which is an analysis and evaluation of internal conditions and external factors that affect the organisation?
 - a. Force field analysis
 - b. Critical issues review
 - c. SWOT
 - d. Customer/stakeholder/competitor analysis
9. Which of the following statements is true?
 - a. Bar chart is a pictorial representation showing the various activities involved in a project.
 - b. Scheduling is a pictorial representation showing the various activities involved in a project.
 - c. Controlling is a pictorial representation showing the various activities involved in a project.
 - d. Designing is a pictorial representation showing the various activities involved in a project.
10. Which of the following statements is true?
 - a. Scheduling is a tool for organising the present on the basis of the projections of the desired future.
 - b. Strategic planning is a tool for organising the present on the basis of the projections of the desired future.
 - c. Controlling is a tool for organising the present on the basis of the projections of the desired future.
 - d. Planning is a tool for organising the present on the basis of the projections of the desired future.

Chapter VI

Inventory Management

Aim

The aim of this chapter is to:

- explain the meaning of inventory
- enlist different types of inventory in business
- elucidate the nature of inventory in business

Objectives

The objectives of this chapter are to:

- explain the principles of inventory management
- enlist different methods of inventory valuation
- explicate the different assessment ratios of inventory in business

Learning outcome

At the end of this chapter, you will be able to:

- understand the concepts and procedures in inventory management
- describe the crucial role of inventory in business profitability
- identify the formulation and application of methods for inventory

6.1 Defining Inventory

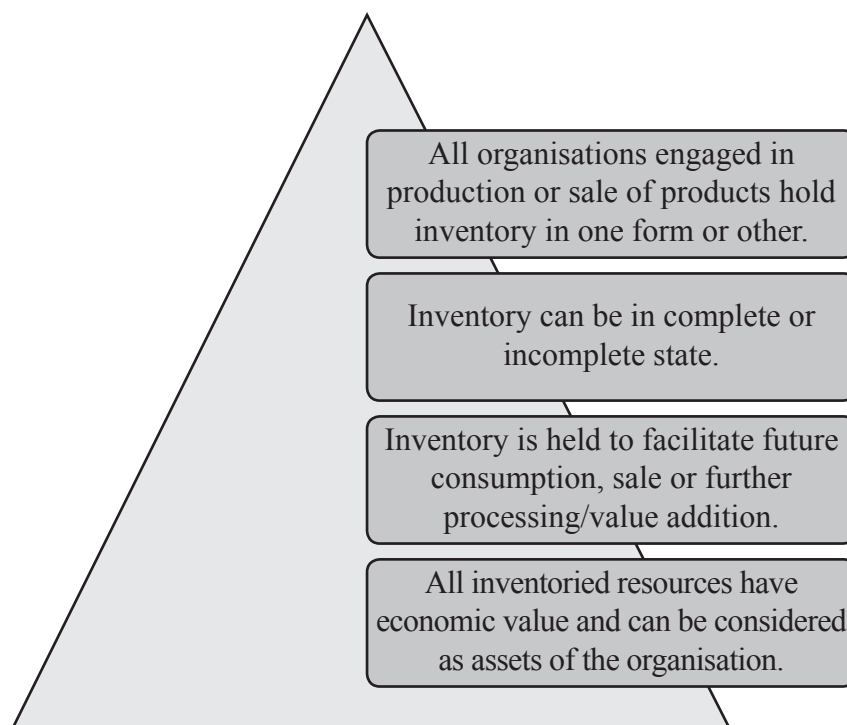
Inventory is one of the new, noticeable and concrete aspects for many small business owners. Raw materials, goods in process and finished goods all represent various forms of inventory. Each type represents money tied up until the inventory leaves the company as purchased products. Similarly, merchandise stocks in a retail store contribute to profits only when their sale puts money into the cash register. Inventory is an idle stock of physical goods that contain economic value, and are held in various forms by an organisation in its custody awaiting packing, processing, transformation, use or sale in future.

Literally, inventory refers to stocks of anything necessary to do business. These stocks represent a large portion of the business investment and must be well managed in order to maximise profits. In fact, many small businesses cannot absorb the types of losses arising from poor inventory management. Unless inventories are controlled, they are unreliable, inefficient and costly.

Inventory is a list of goods and materials or those goods and materials themselves, held available in stock by a business. Inventory are held in order to manage and hide from the customer the fact that, manufacture delay is longer than delivery delay, and also to ease the effect of imperfections in the manufacturing process that lower production efficiencies if production capacity stands idle for lack of materials.

Any organisation which is into production, trading, sale and service of a product will necessarily hold stock of various physical resources to aid in future consumption and sale. While inventory is a necessary evil of any such business, it may be noted that the organisations hold inventories for various reasons, which include speculative purposes, functional purposes, physical necessities etc.

From the above definition the following points stand out with reference to inventory:



One of the most significant aspects of inventory control is to have the items in stock at the moment they are required. This includes going into the market to buy the goods early enough to ensure delivery at the proper time. Thus, buying requires advance planning to determine inventory needs for each time period and then making the commitments without procrastination. For instance, a retail firm must formulate a plan to ensure the sale of the greatest number of units. Similarly, a manufacturing business must formulate a plan to ensure enough inventory is on hand for production of a finished product. In summary, the purchasing plan details will be as follows:

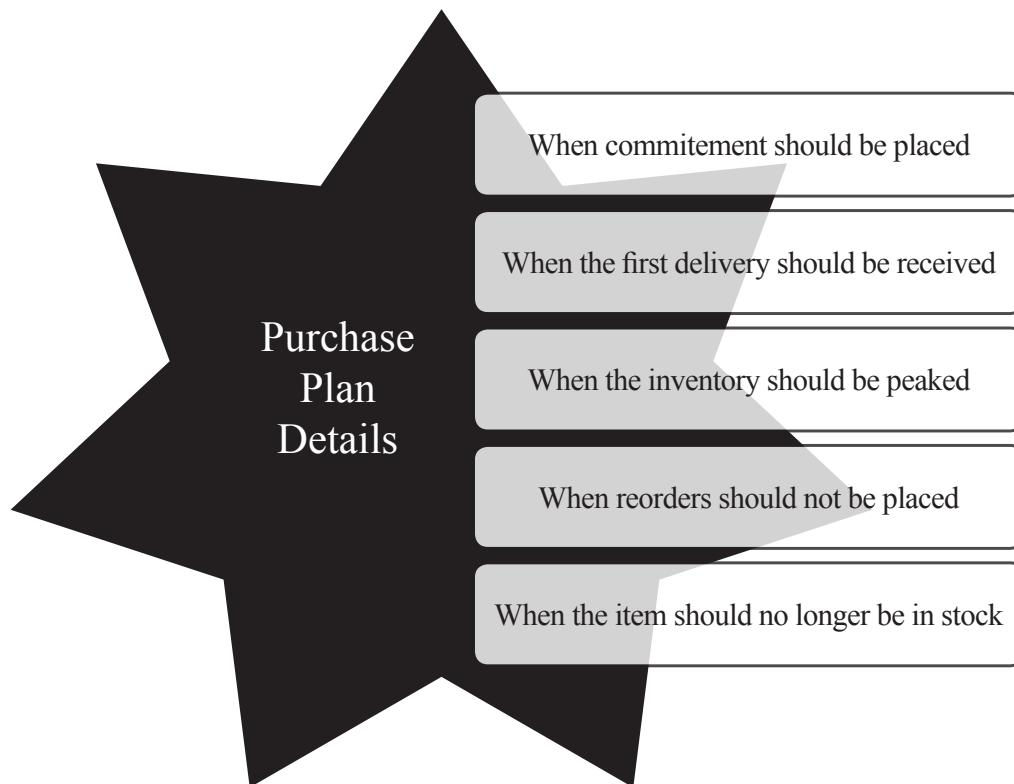


Fig. 6.1 Summary of purchasing plan

Well planned purchases affect the price, delivery and availability of products for sale.

6.2 Nature of Inventory

Inventory of materials occurs at various stages and departments of an organisation. A manufacturing organisation holds inventory of raw materials and consumables required for production. It also holds inventory of semi-finished goods at various stages in the plant with various departments. Finished goods inventory is held at plant, FG Stores, distribution centres etc. Further both raw materials and finished goods those which are in transit at various locations also form a part of inventory depending upon who owns the inventory at the particular juncture. Finished goods inventory is held by the organisation at various stocking points or with dealers and stockiest until it reaches the market and end customers.

Besides raw materials and finished goods, organisations also hold inventories of spare parts to service the products. Defective products, defective parts and scrap also form a part of inventory as long as these items are inventoried in the books of the company and have economic value. Generally, inventory types can be grouped into four classifications:

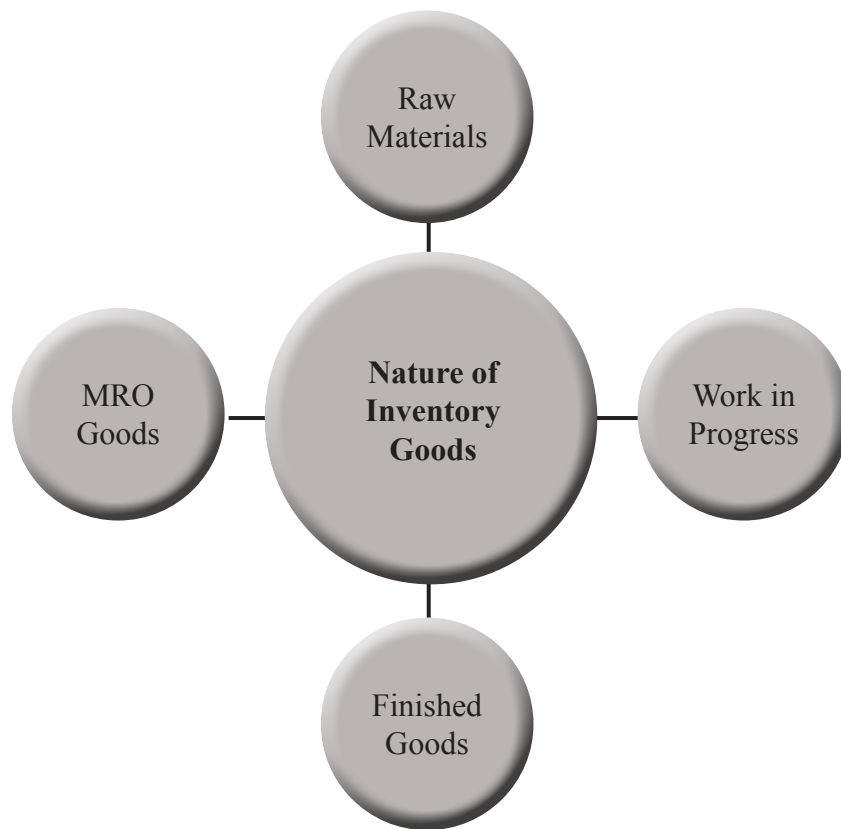


Fig. 6.2 Nature of inventory goods

6.2.1 Raw Materials

Raw materials are inventory items which are used in the manufacturer's conversion process to produce components, subassemblies, or finished products. These inventory items may be objects or elements that the firm has purchased from outside the organisation. They also may be commodities or extracted materials that the firm or its subsidiary has produced or extracted. Even if the item is partially assembled or is considered a finished good to the supplier, the purchaser may classify it as a raw material if his or her firm had no input into its production. Usually, raw materials are commodities such as ore, grain, minerals, petroleum, chemicals, paper, wood, paint, steel, and food items. However, items such as nuts and bolts, ball bearings, key stock, casters, seats, wheels, and even engines may be considered as raw materials if they are purchased from outside the firm.

The bill-of-materials file in a material requirements planning system (MRP) or a manufacturing resource planning (MRP II) system utilises a tool known as a product structure tree to clarify the relationship among its inventory items and provide a basis for filling out or "exploding," the master production schedule. Consider an example of a rolling cart. This cart consists of a top that is pressed from a sheet of steel, a frame formed from four steel bars, and a leg assembly consisting of four legs, rolled from sheet steel, each with a caster attached.

Commonly, raw materials are used in the manufacture of components. These components are then incorporated into the final product or become part of a subassembly. Then, the subassemblies are used to manufacture or assemble the final product. A part that goes into making another part is known as a component, while the part it goes into is known as its parent. Any item which does not have a component is regarded as a raw material or purchased item. From the product structure tree it is clear that the rolling cart's raw materials are steel, bars, wheels, ball bearings, axles, and caster frames.

6.2.2 Work-In-Process

Work-in-process (WIP) is made up of all the materials, parts (components), assemblies, and subassemblies that are being processed or are waiting to be processed within the system. This generally includes all material from raw material that has been released for initial processing up to material that has been completely processed and is awaiting final inspection and acceptance before inclusion in finished goods.

Any item that has a parent but is not a raw material is considered to be work-in-process. A glance at the rolling cart product structure tree example reveals that work-in-process in this situation consists of tops, leg assemblies, frames, legs, and casters. Actually, the leg assembly and casters are labelled as subassemblies because the leg assembly consists of legs and casters and the casters are assembled from wheels, ball bearings, axles, and caster frames.

6.2.3 Finished Goods

A finished good is a completed part that is ready for a customer order. Therefore, finished goods inventory is the stock of completed products. These goods have been inspected and have passed final inspection requirements so that they can be transferred out of work-in-process and into finished goods inventory. From this point, finished goods can be sold directly to their final user, sold to retailers, sold to wholesalers, sent to distribution centres or held in anticipation of a customer order.

Any item that does not have a parent can be classified as a finished good. By looking at the rolling cart product structure tree example one can determine that the finished good in this case is a cart.

6.2.4 MRO Goods Inventory

Maintenance, repair, and operating supplies, or MRO goods, are items that are used to support and maintain the production process and its infrastructure. These goods are usually consumed as a result of the production process but are not directly a part of the finished product. Examples of MRO goods include oils, lubricants, coolants, janitorial supplies, uniforms, gloves, packing material, tools, nuts, bolts, screws, shim stock, and key stock. Even office supplies such as staples, pens and pencils, copier paper, and toner are considered part of MRO goods inventory.

6.3 Types of Inventory

Inventories can be further classified according to the purpose they serve. These types include transit inventory, buffer inventory, anticipation inventory, decoupling inventory, cycle inventory, and MRO goods inventory. Some of these also are known by other names, such as speculative inventory, safety inventory, and seasonal inventory.

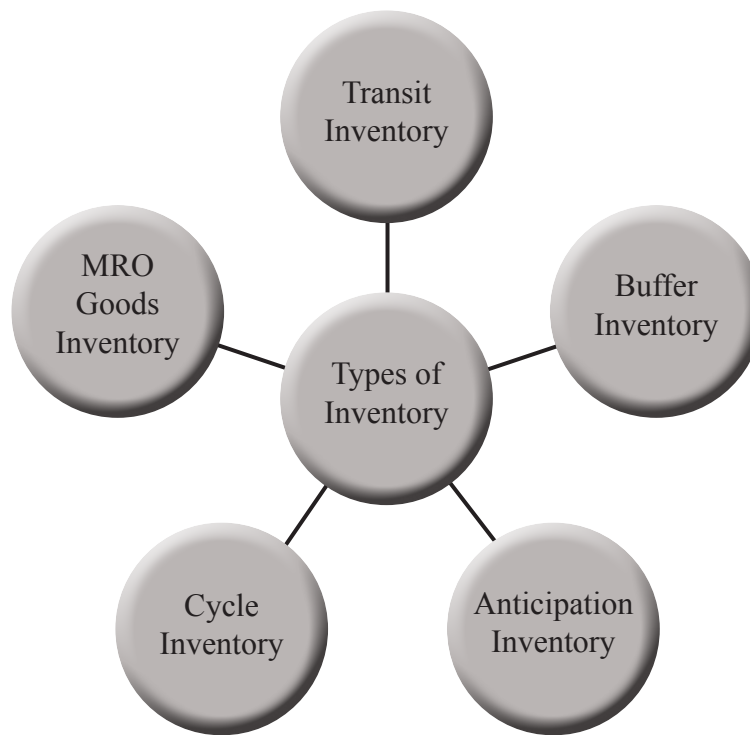


Fig.6.3 Types of inventory

6.3.1 Transit Inventory

Transit inventories are the ones that need to transport items or material from one location to another, and from the fact that there is some transportation time involved in getting from one location to another. Sometimes this is referred to as pipeline inventory. Merchandise shipped by truck or rail can sometimes take days or even weeks to go from a regional warehouse to a retail facility. Big companies such as automobile manufacturers, employ freight consolidators to pool their transit inventories coming from various locations into one shipping source in order to take advantage of economies of scale. Of course, this can greatly increase the transit time for these inventories, hence an increase in the size of the inventory in transit. Take the case of HPCL, the transports are done from refinery to the customer through different modes of transport i.e., Pipeline, Roadways (Tankers), Shipping, etc. the time taken for goods to reach from refinery to the customer is called transit inventory.

6.3.2 Buffer Inventory

Some inventory used to protect against the uncertainties of supply and demand, as well as unpredictable events such as poor delivery reliability or poor quality of a supplier's products. These inventory cushions are often referred to as safety stock. Safety stock or buffer inventory is any amount held on hand that is over and above that currently needed to meet demand. Generally, the higher the level of buffer inventory, the better the firm's customer service. This occurs because the firm suffers fewer "stock-outs" (when a customer's order cannot be immediately filled from existing inventory) and has less need to backorder the item, make the customer wait until the next order cycle, or even worse, causes the customer to leave empty-handed to find another supplier. Obviously, the better the customer service the greater the likelihood of customer satisfaction.

6.3.3 Anticipation Inventory

Some firms will purchase and hold inventory that is in excess of their current need in expectation of a possible future event. Such events may include a price increase, a seasonal increase in demand, or even an impending labour strike. This tactic is commonly used by retailers, who routinely build up inventory months before the demand for their products will be unusually high (i.e., at Halloween, Christmas, or the back-to-school season). For manufacturers, anticipation inventory allows them to build up inventory when demand is low (also keeping workers busy during slack times) so that when demand picks up the increased inventory will be slowly depleted and the firm does not have to react by increasing production time (along with the subsequent increase in hiring, training, and other associated

labour costs). Therefore, the firm has avoided both excessive overtime due to increased demand and hiring costs due to increased demand. It also has avoided layoff costs associated with production cutbacks, or worse, the idling or shutting down of facilities. This process is sometimes called “smoothing” because it smoothes the peaks and valleys in demand, allowing the firm to maintain a constant level of output and a stable workforce.

Case I: Let’s take a case of Dulux paint, in paint industry there will be a seasonality of demand. Which means their production will be throughout the year and distribution will be on peak time i.e., market demand will be more in the month of March to May and June to November, this will be done for smooth distribution. Very rarely, if ever, will one see a production facility where every machine in the process produces at exactly the same rate. In fact, one machine may process parts several times faster than the machines in front of or behind it. Yet, if one walks through the plant it may be seen that all machines are running smoothly at the same time. It also could be possible that while passing through the plant, one notices that several machines are under repair or are undergoing some form of preventive maintenance. Even so, this does not seem to interrupt the flow of work-in-process through the system. The reason for this is the existence of an inventory of parts between machines, a decoupling inventory that serves as a shock absorber, cushioning the system against production irregularities. As such it “decouples” or disengages the plant’s dependence upon the sequential requirements of the system (i.e., one machine feeds parts to the next machine). The more inventory a firm carries as a decoupling inventory between the various stages in its manufacturing system (or even distribution system), the less coordination is needed to keep the system running smoothly. Naturally, logic would dictate that an infinite amount of decoupling inventory would not keep the system running in peak form. A balance can be reached that will allow the plant to run relatively smoothly without maintaining an absurd level of inventory. The cost of efficiency must be weighed against the cost of carrying excess inventory so that there is an optimum balance between inventory level and coordination within the system.

Case II: Take a case of Book making industry. The manager knows that paper making machine will not be working after two days and production will stop because of that so, they will produce more quantity of papers in advance and when the machine is not working at that time binding will be done. As a result distribution will not be affected by stopping the production.

6.3.4 Cycle Inventory

Those who are familiar with the concept of economic order quantity (EOQ) know that the EOQ is an attempt to balance inventory holding or carrying costs with the costs incurred from ordering or setting up machinery. When large quantities are ordered or produced, inventory holding costs are increased, but ordering/setup costs decrease. Conversely, when lot sizes decrease, inventory holding/carrying costs decrease, but the cost of ordering/setup increases since more orders/setups are required to meet demand. When the two costs are equal (holding/carrying costs and ordering/setup costs) the total cost (the sum of the two costs) is minimised. Cycle inventories, sometimes called lot-size inventories, result from this process. Usually, excess material is ordered and, consequently, held in inventory in an effort to reach this minimisation point. Hence, cycle inventory results from ordering in batches or lot sizes rather than ordering material strictly as needed.

6.4 Top 5 Principles of Inventory Management

Inventory management is the most integral part of any business, small or large. The principles of inventory management can be listed as under :

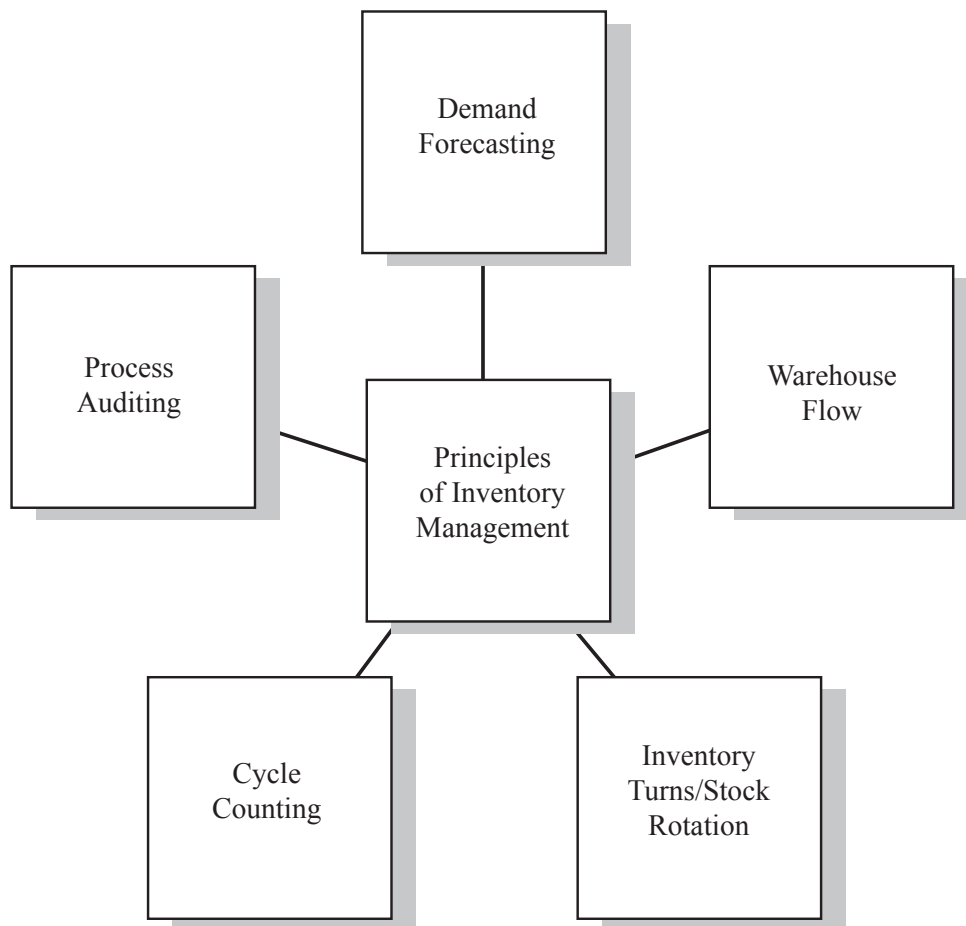


Fig. 6.4 Five principles of inventory management

Demand forecasting

Depending on the industry, inventory ranks in the top five business costs. Accurate demand forecasting has the highest potential savings for any of the principles of inventory management. Both over supply and under supply of inventory can have critical business costs. Whether it is end-item stocking or raw component sourcing, the more accurate the forecast can be.

Establishing appropriate max-min management at the unique inventory line level, based on lead times and safety stock level help ensure that you have what when you need it. This also avoids costly overstocks. Idle inventory increases incremental costs due to handling and lost storage space for fast-movers.

Warehouse flow

The old concept of warehouses being dirty and unorganised is out dated and costly. Lean manufacturing concepts, including 5S have found a place in warehousing. Sorting, setting order, systemic cleaning, standardising, and sustaining the discipline ensure that no dollars are lost to poor processes.

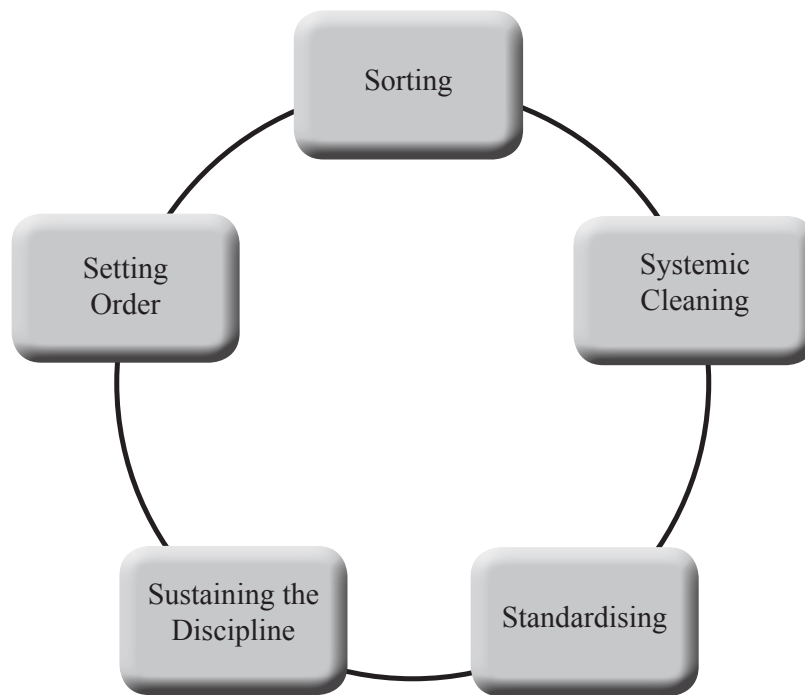


Fig. 6.5 The 5S

The principles of inventory management are not any different from other industrial processes. Disorganisation costs money. Each process, from housekeeping to inventory transactions needs a formal, standardised process to ensure consistently outstanding results.

Inventory turns/stock rotation

In certain industries, such as pharmaceuticals, foodstuffs and even in chemical warehousing, managing inventory can be critical to minimising business costs. Inventory turns is one of the key metrics used in evaluating how effective your execution is of the principles of inventory management. Defining the success level for stock rotation is critical to analysing your demand forecasting and warehouse flow.

Cycle counting

One of the key methods of maintaining accurate inventory is cycle counting. It helps measure the success of your existing processes and maintains accountability of potential error sources. There are financial implications to cycle counting. Some industries require periodic 100% counts. These are done through perpetual inventory count maintenance or through full-building counts.

Proactive

One of the cornerstone principles of inventory management is to audit early and often. Error source identification starts with process audits. Process audits should occur at each transactional step, from receiving to shipping and all inventory transactions in between.

6.5 Inventory Planning: Basic Concepts

Every organisation which is engaged in production, sales or trading of products, hold inventory in one or the other form. While production and manufacturing organisations hold raw material inventories, finished goods and spare parts inventories, trading companies might hold only finished goods inventories depending upon the business model.

Raw material inventory management essentially deals with two major functions, which are:

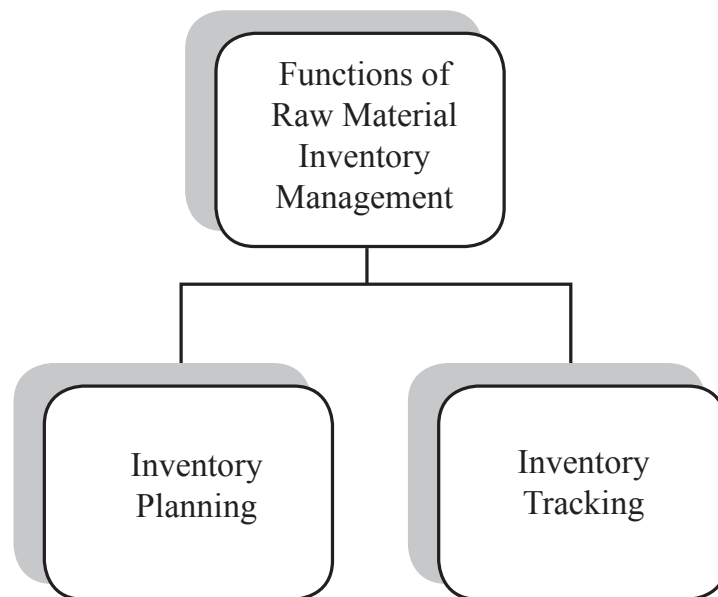


Fig. 6.6 Functions of raw material inventory management

As inventory planners, their main job consists of analysing demand and deciding when to order and how much to order new inventories. Traditional inventory management approach consists of three models namely:

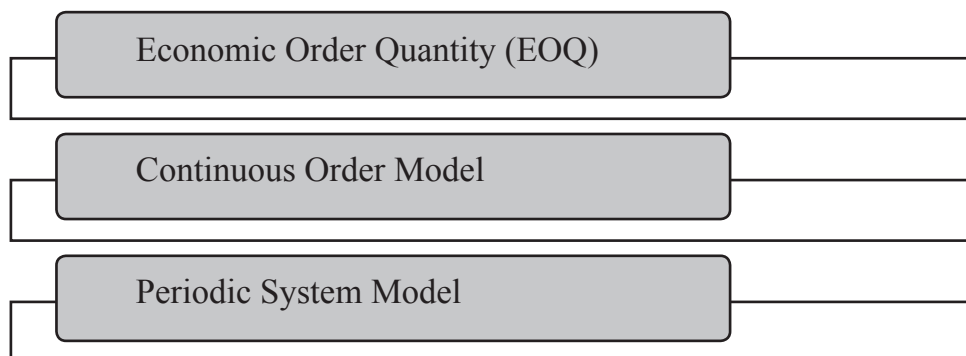


Fig. 6.7 Models of inventory management approach

EOQ (Economic Order Quantity): Economic Order Quantity method determines the optimal order quantity that will minimise the total inventory cost. EOQ is a basic model and further models developed based on this model include Production Quantity Model and Quantity Discount Model.

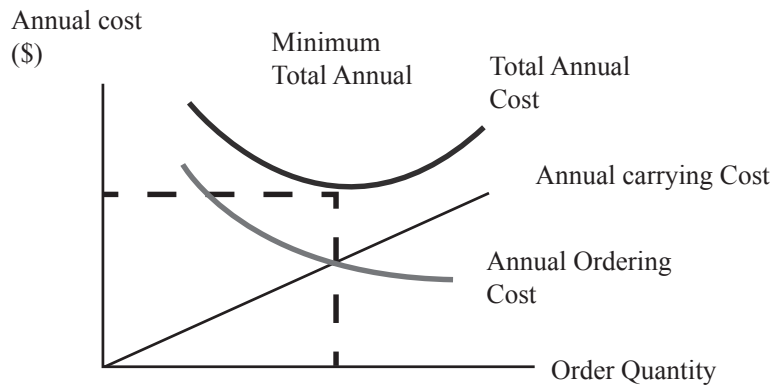


Fig. 6.8 EOQ model

(Source: <http://www.managementstudyguide.com/inventory-planning.htm>)

EOQ for Production Lot: This model is also used to determine the order size and the production lot for an item to be produced at one stage of production and stored as work in progress inventory to be supplied to the next state of production or to the customer.

Continuous Order Model: This model works on fixed order quantity basis where a trigger for fixed quantity replenishment is released whenever the inventory level reaches predetermined safety level and triggers re ordering.

Periodic System Model: This model works on the basis of placing order after a fixed period of time.

Example: Biotech. Co produces chemicals to sell to wholesalers. One of the raw materials it buys is sodium nitrate which is purchased at the rate of \$22.50 per ton. Biotech's forecasts show a estimated requirement of 5, 75,000 tons of sodium nitrate for the coming year. The annual total carrying cost for this material is 40% of acquisition cost and the ordering cost is \$595. What is the Most Economical Order Quantity?

Solution: $EOQ = \sqrt{\frac{2DS}{C}}$

D = Annual Demand

C = Carrying Cost

S = Ordering Cost

D = 5, 75,000 tons

C = 0.40(22.50) = \$9.00/Ton/Year

S = \$595/Order

$$EOQ = \sqrt{\frac{2(5,75,000)(595)}{9.00}}$$

= 27,573.135 tons per Order

This model pre supposes certain assumptions as under:

- No safety stocks available in inventory.
- No shortages allowed in order delivery.
- Demand is at uniform rate and does not fluctuate.
- Lead time for order delivery is constant.
- One order = One delivery (no shortages allowed)
- This model does not take into account other costs of inventory such as stock out cost, acquisition cost etc to calculate EOQ.

In this model, the demand increases for production the inventory gets depleted. When the inventory drops to a critical point the re order process gets triggered. New order is always placed for fixed quantities. On receipt of the delivery against the order the inventory level goes up. In addition, by using this model, further data extrapolation is possible to determine other factors like how many orders are to be placed in a year and what is the time lapse between orders etc.

6.6 Need for Planning

Every organisation would have to maintain inventory for various purposes. Optimum inventory management is the goal of every inventory planner. Over inventory or under inventory both affect financial impact as well as effect business opportunities.

Inventory holding is resorted to by organisations as hedge against various external and internal factors such as precaution, opportunity, a need and for speculative purposes. Planning is defining organisational goals, establishing a strategy for reaching those goals and developing a comprehensive hierarchy of plans to integrate and coordinate activities. It can be either formal or informal, depending on the time frame and amount of documentation. Planning should be done for four reasons.

- First planning coordinates effort by giving direction to managers and non-managers. When all members of organisation understand where the organisation is going and what they should do to contribute to the objectives, they will coordinate their activities and cooperate with each other. On the other hand, various organisational members or their units might work against one another.
- Second planning reduces uncertainty by forcing managers to look ahead, anticipate change and develop appropriate responses. If the environment never changes, there would be little need for planning. In that case everything can be spell out in some manual. Technological, social, political, economic, and legal changes are ever-present. The environment is too dynamic to left the organisation's survival to chance.
- Third planning reduces redundancy. Coordination beforehand can uncover the redundancy and when ends and means are clear, inefficiencies become obvious.
- Fourth planning sets standards or objectives that facilitate control over the process of achieving goals.

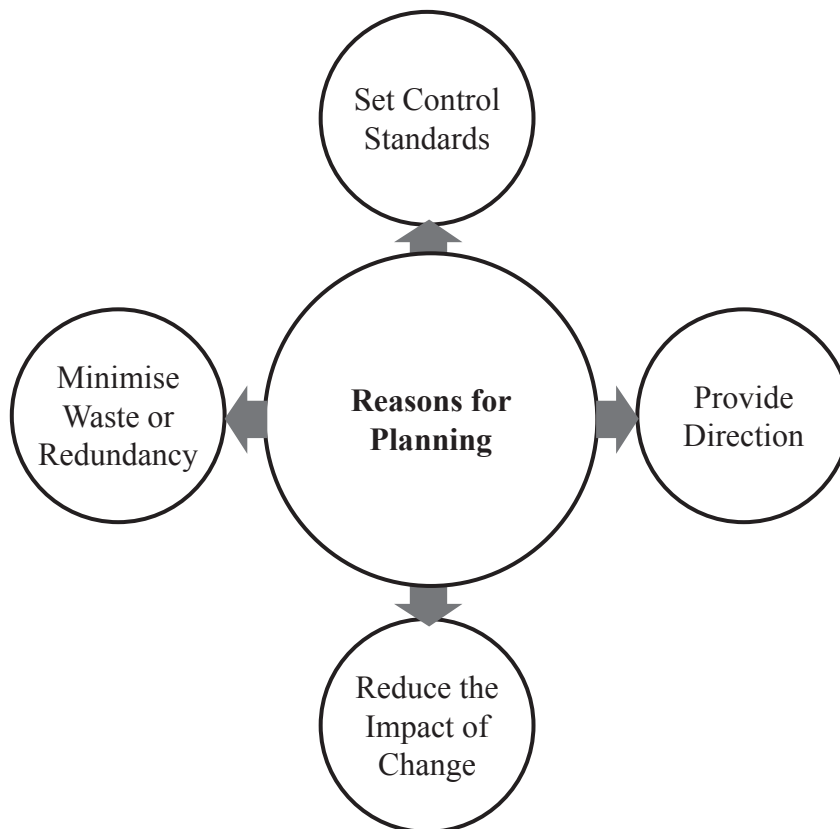


Fig. 6.9 Reasons for planning

Planning is essential to:

- define an organisation's goals and requirements for organisational structure and employees
- establish an overall strategy and objectives for leading and directing
- develop a comprehensive hierarchy of plan and standards for controlling organisation's activities

6.7 Reasons for Maintaining Raw Material Inventory

raw material inventory warehouses attached to the production facilities in many organisations. The raw materials, consumables, and packing materials are stored and issue for production on JIT (Just in Time) basis. The reasons for holding inventories can vary from case to case basis which can be reviewed as under:

Meet variation in production demand

The sales, estimates, orders, and stocking patterns in an organisation keep changing, resulting in Production plan changes. Accordingly, the demand for raw material supply for production varies with the product plan in terms of specific SKU (**Stock Keeping Unit**) as well as batch quantities. Issuing the required quantity and item to production just in time makes holding inventories at a nearby warehouse important.

Cater to cyclical and seasonal demand

Some demand in the market and supplies are seasonal, depending upon various factors like seasons; festivals etc. and past sales data help companies to anticipate a huge surge of demand in the market well in advance. Accordingly, they stock up raw materials and hold inventories to be able to increase production and rush supplies to the market to meet the increased demand.

Economies of scale in procurement

Many organisations buy raw materials in larger lot and holding inventory as it is found to be cheaper for the companies than buying frequent small lots. In such cases one buys in bulk and holds inventories at the plant warehouse.

Take advantage of price increase and quantity discounts

If there is a price increase anticipated by the managers few months down the line due to changes in demand and supply in the national or international market, impact of taxes and budgets etc. So the companies tend to buy raw materials in advance in order to hedge against increased costs holds stocks. Companies resort to buying in bulk and holding raw material inventories to take advantage of the quantity discounts offered by the supplier. The savings on account of the discount enjoyed would be substantially higher than that of inventory carrying cost in such cases.

Reduce transit cost and transit times

One can save a lot in terms of transportation cost by buying in bulk and transporting as a container load or a full truck load as raw materials being imported from a foreign country or from a far away vendor within the country. Part shipments can be costlier. In terms of transit time too, transit time for full container shipment or a full truck load is direct and faster unlike part shipment load where the freight forwarder waits for other loads to fill the container which can take several weeks. There could be a lot of factors resulting in shipping delays and transportation too, which can hamper the supply chain forcing companies to hold safety stock of raw material inventories.

Long lead and high demand items need to be held in inventory

Often raw material supplies from vendors have long lead running into several months. If the particular item is in high demand, and short supply one can expect disruption of supplies making it safer to hold inventories and have control.

6.8 Resource Inventory Management

Resource inventory management manages the information pertaining to all the resources used to implement services and products. Various element management systems and resource inventory database systems are areas which typically linked to this application. Resource Management applications also play a role in managing spare parts; dumb resources such as cable pairs, and external plant and customer premises equipment. These applications can also be used to discover and manage underutilised or 'stranded' resources. Resources are the most integral part of Inventory management. Emergency management and incident response activities which require carefully managed resources such as personnel, teams, facilities, equipment, and/or supplies to meet incident needs. Utilisation of the standardised resource management concepts such as typing, inventorying, organising, and tracking will facilitate the dispatch, deployment, and recovery of resources before, during, and after an incident. If resource management is flexible and can be scaled then it will support any incident and be adaptable to changes. Efficient and effective use of resources requires that resource management concepts and principles be used in all phases of emergency management and incident response.

The resource management process would be divided for convenience as two separate processes: resource management as an element of preparedness and resource management during an incident. The preparedness activities (resource typing, credentialing, and inventorying) are carried out on a regular basis which helps ensure that resources are ready to be mobilised when called to an incident. During an incident, Resource management would be considered as a finite process, as shown in the below figure, with a distinct beginning and ending specific to the needs of the particular incident.

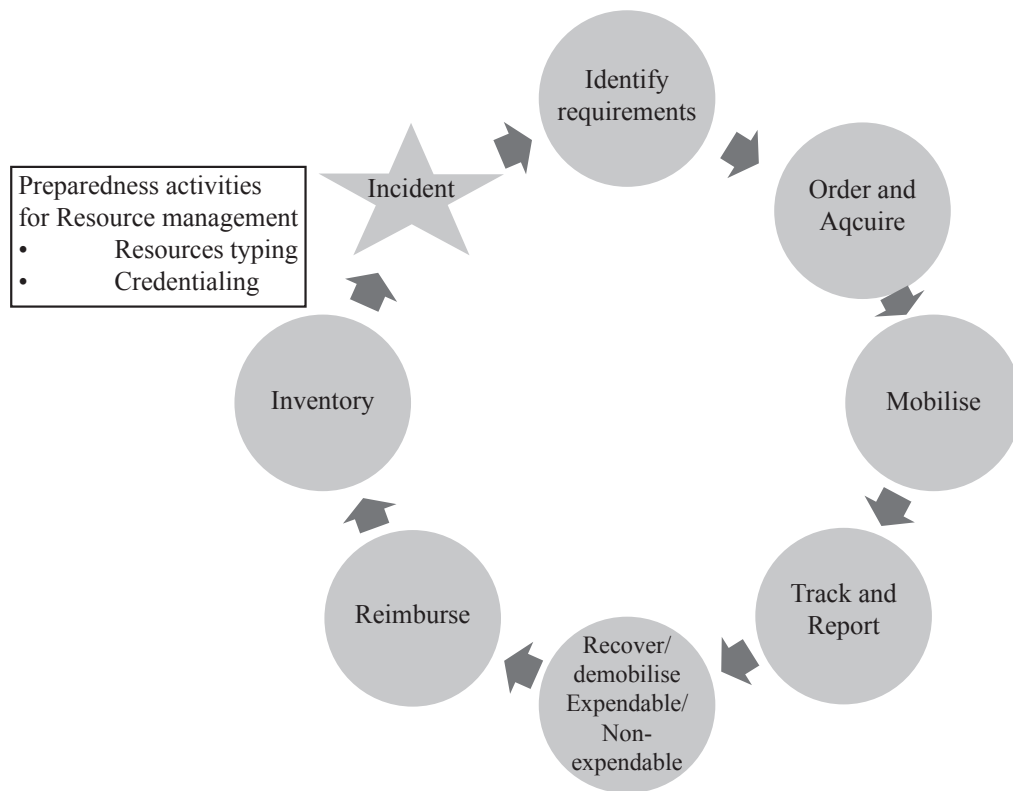


Fig. 6.10 Resource management as a process

Credentialing

The credentialing process entails the objective evaluation and documentation of an individual's current certification, license, or degree; training and experience; and competence or proficiency to meet nationally accepted standards, provide particular services and/or functions, or perform specific tasks under specific conditions during an incident.

6.9 Production Planning

Production planning is strongly related to the layout type of a considered production system. An experimental analysis of production systems to be found in industrial practice reveals many differences which have a significant impact on the type of planning models that may be applicable in a certain planning environment. There are numerous different layout types, e.g. fixed position layout, process layout (job shop production), product layout (flow lines), just-in-time production systems, and cellular layout, among others. In each type of production system specific planning problems emerge for which the literature provides an appropriate modelling and solution approach.

A wide variety of planning approaches are partly implemented for the solution of the production planning problems. The operations management literature provides in so called Advanced Planning Software systems (APS) for this. It is a common property of most of these approaches, such as aggregate production planning, master planning as well as lot sizing, that planning is based on forecasts of future demands. This is treated as deterministic data in the planning process. This could be interpreted as the external demand quantities and the flow times (including waiting times caused by bottlenecks or machine breakdowns) as well as the scrap rates which in some industries are significant, are treated as deterministic factors. In reality random influences take effect, planning concepts are required which are able to take the unavoidable uncertainty on all levels of planning and control of the value-adding processes into account.

From a theoretical point of view, this would mean to extend, say, a mixed-integer multi-level capacitated dynamic lot sizing model by including random variables in the model formulation. Such an approach are considered disappointing as for many production planning models including the deterministic version of the problem can be solved satisfactorily.

6.10 Planning in Inventory Control

For retailers, planning ahead is one of the most important aspects of inventory control management. This includes prepping activities like going into the market to buy the goods early enough to ensure delivery on time. Therefore buying requires advance planning to determine inventory needs for each time period and then making the commitments without procrastination. New items are for sale months before the actual calendar date for the beginning of the new season. It is vital to formulate buying plans early enough to allow for intelligent buying without any last minute panic purchases. The early offering for sale of new items is that the retailer regards the calendar date for the beginning of the new season as the merchandise date for the end of the old season.

For example, many retailers view March 21 as the end of the spring season, June 21 as the end of summer and December 21 as the end of winter. Exhaustion of the inventory Part of your purchasing plan must include accounting for the same. Before a decision can be made as to the level of inventory to order, one must determine how long the inventory you have in stock will last. For instance, a retail firm must formulate a plan to ensure the sale of the greatest number of units. A manufacturing business must formulate a plan to ensure enough inventories is on hand for production of a finished product.

6.11 Hierarchy of Planning

The inventory department is a very important department in any organisation. The hierarchy of planning inventory can be explained with the help of the following figure:

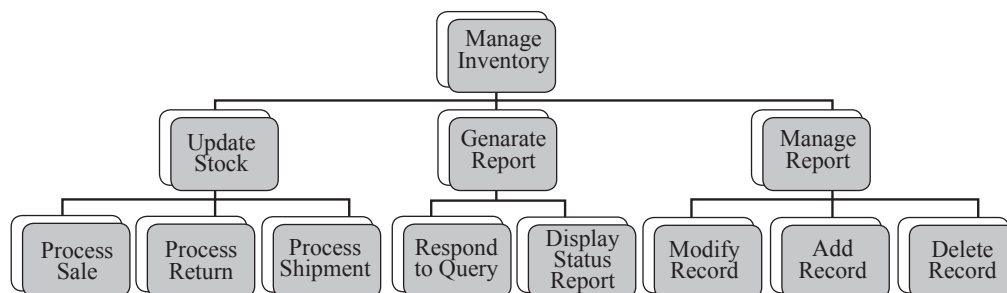


Fig. 6.11 Hierarchy in interactive inventory management

(Source: <http://www.hit.ac.il/staff/leonidm/information-systems/ch64.html#Heading6>)

6.12 Business Needs

The functions of business are to reduce purchasing and inventory costs.

- If a connection is brought about between inventory control, purchasing, and sales order processing with demand planning, it will further help in reducing costs, improve cash flow, and help ensure that you have the right stock available when you need it.
- Gaining visibility into inventory processes by effectively balancing availability with demand and track items and their possible expiration dates throughout the supply chain to help minimise on-hand inventory, optimise replenishment, and increase warehouse efficiency.
- To improve customer satisfaction, make more accurate order promises and intelligent last-minute exceptions with access to up-to-date inventory information.
- Respond quickly and knowledgeably to customer queries for improved customer service.
- Reduce time to market. With integrated order, inventory, and distribution processes, as well as item tracking capabilities, your business can reduce manual data entry and get your goods to market fast.

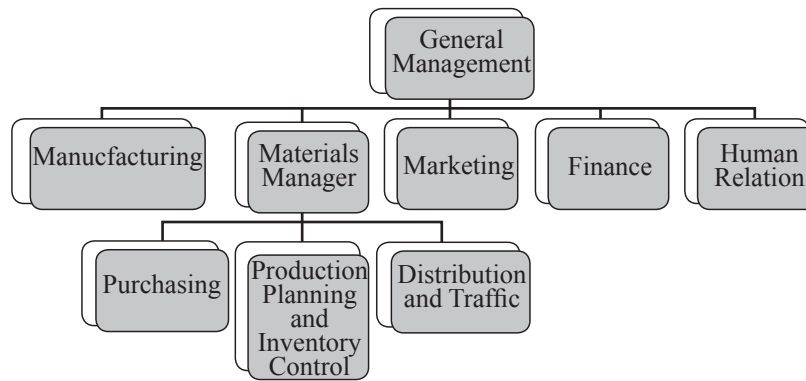


Fig. 6.12 Hierarchy in organisational structure

The output of an undertaking depends on successful implementation of activities which are followed in the process of building an effective organisational structure. These activities consist of assigning duties and responsibilities clearly. Various departments decide the requirements according to the qualifications of each position determining each task to be carried out.

6.13 An Effective Material Organisational Structure

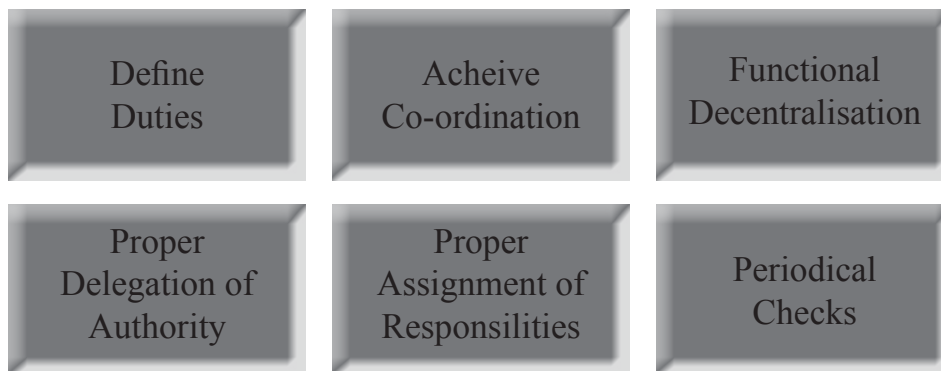


Fig. 6.13 Elements of an effective material management organisation

An effective material organisational structure should also be economic. In an organisational structure, the materials manager exercises a high degree of coordination and control over all the material activities. A single line of command runs through the organisational structure where activities constitute different stages of a single function.

An integrated form helps in rapid transfer of data through effective and informal communication channels ensuring cost savings and improvements in service levels. A central materials manager is on par with engineering and production and enjoys better support and coordination in the accomplishment of the materials function. This creates an atmosphere of trust and better relations between the user department and the materials management department.

6.14 Methods of Valuation of Inventory

Increased automation and item tracking capabilities help you improve inventory

accuracy and better match with the goods you have on hand with customer demand.

In order to assign a cost value to inventory, you must make some assumptions about the inventory on hand. Under the federal income tax laws, a company can only make these assumptions once per fiscal year. Tax treatment is often an organisation's chief concern regarding inventory valuation. There are five common inventory valuation methods:

- First-in, First-out (FIFO) inventory valuation assumes that the first goods purchased are the first to be used or sold regardless of the actual timing of their use or sale. This method is most closely tied to actual physical flow of goods in inventory.
- Last-in, First-out (LIFO) inventory valuation assumes that the most recently purchased/acquired goods are the first to be used or sold regardless of the actual timing of their use or sale. Since items you have just bought often cost more than those purchased in the past, this method best matches current costs with current revenues.
- Average Cost Method of inventory valuation identifies the value of inventory and cost of goods sold by calculating an average unit cost for all goods available for sale during a given period of time. This valuation method assumes that ending inventory consists of all goods available for sale.

Average Cost = Total Cost of Goods ÷ Total Quantity of Goods Available for Sale

Available for Sale Specific Cost Method (also Actual Cost Method) of inventory valuation assumes that the organisation can track the actual cost of an item into, through, and out of the facility. That ability allows you to charge the actual cost of a given item to production or sales. Specific costing is generally used only by companies with sophisticated computer systems or reserved for high-value items such as artwork or custom-made items.

Standard Cost Method of inventory valuation is often used by manufacturing companies to give all of their departments a uniform value for an item throughout a given year. This method is a “best guess” approach based on known costs and expenses such as historical costs and any predictable changes coming up in the foreseeable future. It is not used to calculate actual net profit or for income tax purposes. Rather, it is a working tool more than a formal accounting approach.

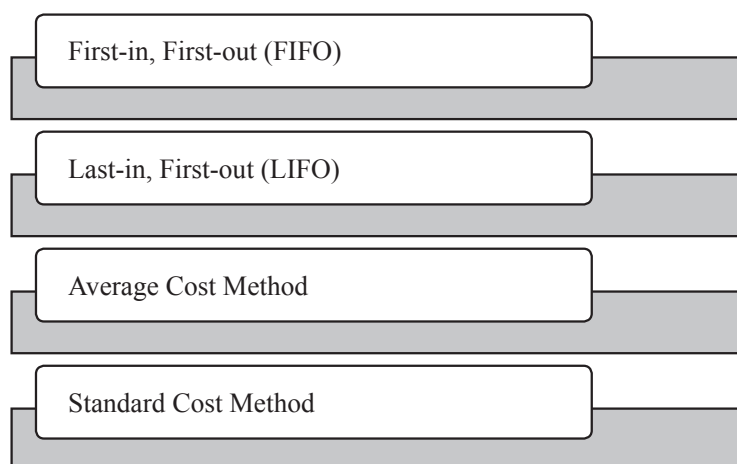


Fig. 6.14 Methods of valuation of inventory methods

6.15 Ratio Analysis in Business

Ratio is an expression of number of items which is contained within another. The business world uses Ratios in selecting parts of an organisation’s financial statements .It compares one set of financial conditions to another. A company’s financial statements contain important aspects of the business. By reviewing these aspects, determination of an organisation’s economic well-being can be achieved. Division of one by the other is one way of reviewing these financial conditions. For example, if you had \$200 cash and \$100 worth of debts, you could divide the cash (assets) by the debt (liabilities) getting a ratio of 2 to 1. In other words, you have twice as many assets as you have in liabilities. Ratios are useful tools to explain trends and also help in summarising business results. Often third parties, such as banks use ratios to determine a company’s credit worthiness. A ratio holds little meaning but however when it is compared to other industry and/or company-specific figures or standards, ratios can be powerful in helping to analyse your company’s current and historical results. Companies in the same industry often have similar liquidity ratios or benchmarks, as they often have similar cost structures. Your company’s ratios can be compared to:

- Prior period(s)
- Company goals or budget projections
- Companies in your industry
- Companies in other industries
- Companies in different geographic regions

The following can list three ratios that are useful when assessing inventory in an organisation.

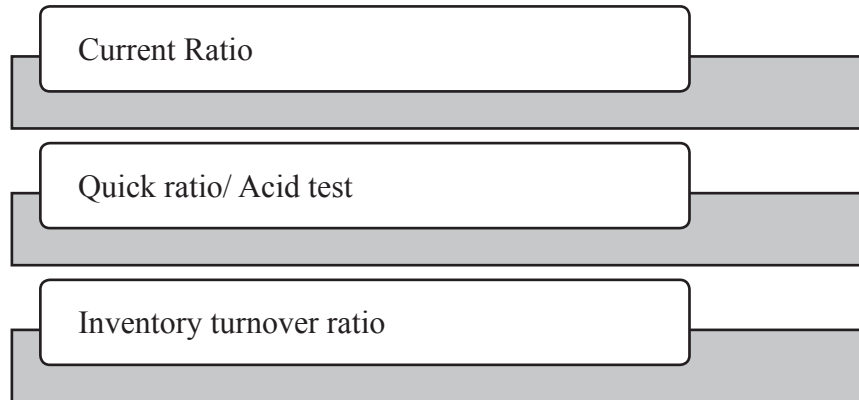


Fig. 6.15 Ratio assessment of Inventory in an organisation

Current Ratio: The current ratio assesses the organisation's overall liquidity which indicates a company's ability to meet its short-term obligations. The current ratio indicates how much of assets we have against liabilities that the organisation owes. In other words, it measures whether or not a company will be able to pay its bills. The current ratio is calculated as follows:

$$\text{Current Ratio} = \text{Current Assets} \div \text{Current Liabilities}$$

Current Assets refers to those assets which are in form of cash or that are easily convertible to cash within one year, such as accounts receivable, securities, and inventory. Current Liabilities refers to liabilities that are due and payable within twelve months, such as accounts payable, notes payable and short-term portion of long-term debt. Standards for the current ratio vary from industry to industry. Companies that carry inventory also have higher current ratios. Manufacturing companies are included in this latter group where in they inventory in the form of finished goods have ready for sale and also they carry inventory of goods that are not yet ready for sale. The longer it takes a company to manufacture the inventory will have higher the current ratio and the more inventory it must keep on hand. A low current ratio may signal either that a company has liquidity problems or has trouble meeting its short and long-term obligations. In other words, the organisation might be suffering from a lack of cash flow to cover operating and other expenses. As a result, accounts payable may be building at a faster rate than receivables.

This is sometimes used in conjunction with other factors to determine the overall financial health of an organisation as an indication. In fact, some companies will have good cash flow can sustain lower-than-average current ratios because they move their inventory quickly and/or are quick to collect from their customers. A high current ratio is not necessarily desirable. It might indicate that the company is holding high-risk inventory or just maybe doing a bad job of managing its assets. For example, fashion retailers may have costly inventory, but they might also have significant trouble getting rid of the inventory— if at all the wrong clothing line were to be selected. The fact that makes it a high-risk company, forcing creditors to require a bigger financial cushion. Further, if a high current ratio is a result of a very large cash account can be used as an indicator that the company is not reinvesting its cash appropriately. The liquidity problems might still exist even if the current ratio looks fine as other factors must be taken into consideration. Since ratios look at quantity, not quality, it is important to look at what the current assets consist of to determine if they are made up of slow-moving inventory.

Quick Ratio or Acid Test: The quick ratio compares the organisation's most liquid current assets to its current liabilities. The quick ratio is calculated as follows:

$$\text{Quick Ratio} = (\text{Current Assets} - \text{Inventories}) \div \text{Current Liabilities}$$

In other words, the company has at less in liquid assets (likely in the form of accounts receivable) than liabilities. Industries that have significant cash sales (such as grocery stores) tend to be even lower. As with the current ratio, a low quick ratio could be an indicator of cash flow problems, while a high ratio may indicate poor asset management as cash may be properly reinvested or accounts receivable levels are out of control. An organisation's ability to promptly collect its accounts receivable has a significant impact on this ratio. It has more collection results in more liquidity.

Inventory Turnover Ratio: The inventory turnover ratio measures how many times inventory is replaced over a period of time on an average. In simple terms, an inventory turn occurs every time an item is received, is used or sold, and then is replaced. If an SKU (**Store Keeping Unit**) came in twice during the year, was used/sold, and then replenished, that would be two turns per year. If this happened once per month, it would be twelve turns per year, and so forth. Since the ability to move inventory quickly Inventory turnover is considered quite an important measure since it directly impacts the company's liquidity. Inventory turnover is calculated as follows:

$$\text{Inventory Turnover Ratio} = \text{Cost of Goods Sold} \div \text{Average Inventory}$$

Essentially, when a product is sold, it is subtracted from inventory and transferred to cost of goods sold. Therefore, this ratio indicates how quickly inventory is moving for accounting purposes. It does not necessarily reflect how many times actual physical items were handled within the facility itself. This is true because the cost of goods sold number may include items you sold but never physically handled. For example, items that we purchase and then have drop-shipped directly at our customer's site aren't ever handled within our facility. A more accurate measure of how many times actual physical inventory turned within the site would be:

$$\text{Inventory Turnover Ratio} = \text{Cost of Goods Sold} \div \text{Average Inventory}$$

If the inventory has shown an increase or decrease significantly during the year, then the average inventory for the year may be distorted and not accurately reflect your turnover ratio going forward.

Also, if the company uses the LIFO method of accounting, the ratio may be inflated because LIFO undervalues the inventory sometimes. Unlike the current ratio and quick ratio, the inventory turnover ratio does not abide to any standard range. Organisations with highly perishable products can have inventory turns of 30 times a year or more. Companies that retain large amounts of inventory or that require a long time to build their inventory might have turns of only two or three times a year. In general, the overall trend in business today is to reduce carrying costs by limiting the amount of inventory in stock at any given time. As a result, both individual inventory turnovers and industry averages in this area have increased in recent years. It is important to understand, however, that many factors can cause a low inventory turnover ratio. The company may be holding the wrong type of inventory, its quality may be suffering, or it may have sales/marketing issues.

6.16 Inventory on the Income Statement

The income statement is a report that identifies a company's revenues (sales), expenses, and resulting profits. While the balance sheet gives you a financial picture of a company on a specific date (June 30, for example), the income statement covers a given period of time (June 1 through June 30). The cost of goods sold is the item on the income statement that reflects the cost of inventory flowing out of a business. The business makes money by using or selling inventory. That inventory costs the businessman money while acquiring it Cost of goods sold (on the income statement) represents the value of goods (inventory) sold during the accounting period. The value of goods that are not sold is represented by the ending inventory amount on the balance sheet calculated as:

$$\text{Ending Inventory} = \text{Beginning Inventory} + \text{Purchases Inventory} - \text{Cost of Goods Sold}$$

This information is also useful because it can be used to show how a company “officially” accounts for inventory. The cost of purchases can be arrived without knowing the actual costs by turning around the equation as follows:

$$\text{Purchases} = \text{Ending inventory} - \text{Beginning Inventory} + \text{Cost of goods sold}$$

The costs of goods are sold if you know what your purchases are by making the following calculation:

$$\text{Cost of goods sold} = \text{Beginning Inventory} + \text{Purchases} - \text{Ending Inventory}$$

6.16.1 Inventory on the Balance sheet

The balance sheet shows the financial position of a company on a specific date. It provides details for the basic accounting equation: $\text{Assets} = \text{Liabilities} + \text{Equity}$. In other words, assets are a company’s resources while liabilities and equity are how those resources are paid for

- Assets represent a company’s resources. Assets can be in the form of cash or other items that have monetary value—including inventory. Assets are made up of (a) current assets (assets that are in the form of cash or that are easily convertible to cash within one year such as accounts receivable, securities, and inventory), (b) longer-term assets such as investments and fixed assets (property/plant/equipment), or (c) intangible assets (patents, copyrights, and goodwill).
- Liabilities represent amounts owed to creditors (debt, accounts payable, and lease-term obligations).
- Equity represents ownership or rights to the assets of the company (common stock, additional paid-in capital, and retained earnings).

Inventory is among a company’s current assets as it can be sold within one year. This information is used to calculate financial ratios that help assess the financial health of the company. The balance sheet is one important place that inventory plays a role in the financial analysis of the company. It also shows up on the income statement in the form of cost of goods sold.

Summary

- Inventory refers to stocks of anything necessary to do business. These stocks represent a large portion of the business investment and must be well managed in order to maximise profits
- One of the most significant aspects of inventory control is to have the items in stock at the moment they are required. This includes going into the market to buy the goods early enough to ensure delivery at the proper time.
- Raw materials are inventory items that are used in the manufacturer's conversion process to produce components, subassemblies, or finished products. These inventory items may be commodities or extracted materials that the firm or its subsidiary has produced or extracted
- Work-in-process (WIP) is made up of all the materials, parts (components), assemblies, and subassemblies that are being processed or are waiting to be processed within the system.
- A finished good is a completed part that is ready for a customer order. Therefore, finished goods inventory is the stock of completed products. These goods have been inspected and have passed final inspection requirements so that they can be transferred out of work-in-process and into finished goods inventory.
- Maintenance, repair, and operating supplies, or MRO goods, are items that are used to support and maintain the production process and its infrastructure. These goods are usually consumed as a result of the production process but are not directly a part of the finished product
- Transit inventories are the ones that need to transport items or material from one location to another, and from the fact that there is some transportation time involved in getting from one location to another.
- Some inventory used to protect against the uncertainties of supply and demand, as well as unpredictable events such as poor delivery reliability or poor quality of a supplier's products
- Some firms will purchase and hold inventory that is in excess of their current need in expectation of a possible future event. Such events may include a price increase, a seasonal increase in demand, or even an impending labour strike. This tactic is commonly used by retailers, who routinely build up inventory months before the demand for their products will be unusually high
- Maintenance, repair, and operating supplies, or MRO goods, are items that are used to support and maintain the production process and its infrastructure
- First-in, First-out (FIFO) inventory valuation assumes that the first goods purchased are the first to be used or sold regardless of the actual timing of their use or sale
- Last-in, First-out (LIFO) inventory valuation assumes that the most recently purchased/acquired goods are the first to be used or sold regardless of the actual timing of their use or sale.
- Average Cost Method of inventory valuation identifies the value of inventory and cost of goods sold by calculating an average unit cost for all goods available for sale during a given period of time.
- Standard Cost Method of inventory valuation is often used by manufacturing companies to give all of their departments a uniform value for an item throughout a given year.
- The current ratio assesses the organisation's overall liquidity and indicates a company's ability to meet its short-term obligations
- Quick Ratio or Acid Test. The quick ratio compares the organisation's most liquid current assets to its current liabilities.
- The inventory turnover ratio measures, on average, how many times inventory is replaced over a period of time.

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Recommended Reading

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Self Assessment

1. _____ is a list of goods and materials or those goods and materials held available in stock by a business
 - a. Inventory
 - b. Supplies
 - c. Commodities
 - d. Products
2. Some inventory used to protect against the uncertainties of supply and demand are called _____
 - a. MRO inventory
 - b. Buffer inventory
 - c. Anticipation inventory
 - d. Transit Inventory
3. _____ are items that are used to support and maintain the production process and its infrastructure
 - a. Finished Goods
 - b. Raw Material
 - c. Maintenance, repair, and operating supplies(MRO goods)
 - d. Work in Progress goods
4. _____ is that inventory valuation assumes that the first goods purchased are the first to be used or sold regardless of the actual timing of their use or sale
 - a. Last-in, First-out (LIFO)
 - b. Average Cost Method
 - c. Standard Cost Method
 - d. First-in, First-out (FIFO)
5. _____ of inventory valuation is often used by manufacturing companies to give all of their departments a uniform value for an item throughout a given year.
 - a. Standard Cost Method
 - b. First-in, First-out (FIFO)
 - c. Last-in, First-out (LIFO)
 - d. Average Cost Method
6. _____ compares the organisation's most liquid current assets to its current liabilities
 - a. Last-in, First-out (LIFO)
 - b. Average Cost Method
 - c. Standard Cost Method
 - d. The Quick ratio test
7. _____ of inventory valuation identifies the value of inventory and cost of goods sold by calculating an average unit cost for all goods available for sale during a given period of time.
 - a. Average Cost Method
 - b. Standard Cost Method
 - c. First-in, First-out (FIFO)
 - d. Last-in, First-out (LIFO)

8. _____ are the ones that need to transport items or material from one location to another, and from the fact that there is some transportation time involved in getting from one location to another.
- MRO inventory
 - Buffer inventory
 - Anticipation inventory
 - Transit Inventory
9. _____ measures, on average, how many times inventory is replaced over a period of time.
- The inventory turnover ratio
 - The Quick ratio
 - The Current ratio
 - Last-in, First-out (LIFO)
10. _____ assesses the organisation's overall liquidity and indicates a company's ability to meet its short-term obligations
- The inventory turnover ratio
 - The Current ratio
 - Last-in, First-out (LIFO)
 - The Quick ratio

Chapter VII

Quality Management

Aim

The aim of this chapter is to:

- explicate the concept of quality management in operations management
- explain the terms: 'quality' and 'quality management'
- enlist different types of costs in quality management

Objectives

The objectives of this chapter are to:

- explain the tools of quality control
- elucidate the quality standards in quality management
- explicate the total quality management in operations management

Learning outcome

At the end of this chapter, you will be able to:

- understand the reasons for failure of quality management in various fields
- identify the importance of quality standards in management education and try to apply it
- describe 'Total Quality Management'

7.1 Introduction

Successful companies understand the powerful impact customer-defined quality can have on their business. For this reason many competitive firms continually increase their quality standards. For example, both the Ford Motor Company and the Honda Motor Company have recently announced that they are making customer satisfaction their number one priority. The slow economy of 2003 impacted sales in the auto industry. Both firms believe that the way to rebound is through improvements in quality, and each has outlined specific changes to their operations. Ford is focusing on tightening already strict standards in their production process and implementing a quality program called Six-Sigma. Honda, on the other hand, is focused on improving customer-driven product design. Although both firms have been leaders in implementing high quality standards, they believe that customer satisfaction is still what matters most.

7.2 Definition of Total Quality Management

Total Quality Management (TQM) is an integrated effort designed to improve quality performance at every level of the organisation. Customer-defined Quality is defined by the customers is called Customer-defined Quality.

7.2.1 Defining Quality

Conformance to Specifications

How well a product or service meets the targets and tolerances determined by its designers.

Fitness for Use

It is the quality that evaluates how well the product performs for its intended use.

Value for Price Paid

Quality is defined in terms of product or service usefulness for the price paid.

Support Services

Quality defined in terms of the support provided after the product or service is purchased.

Psychological Criteria

It is the quality that focuses on judgmental evaluations of what constitutes product or service excellence.

- **TQM** is an integrated organisational effort designed to improve quality at every level.
- In this chapter you will learn about the philosophy of TQM, its impact on organisations, and its impact on your life.
- You will learn that TQM is about meeting quality expectations as defined by the customer; this is called customer-defined quality.
- However, defining quality is not as easy as it may seem, because different people have different ideas of what constitutes high quality. Let's begin by looking at different ways in which quality can be defined.

7.3 Cost of Quality

- The reason quality has gained such prominence is that organisations have gained an understanding of the high cost of poor quality. Quality affects all aspects of the organisation and has dramatic cost implications.
- The most obvious consequence occurs when poor quality creates unhappy customers and eventually leads to loss of business. However, quality has many other costs, which can be divided into two categories.
- The first category consists of costs necessary for achieving high quality, which are called quality control costs.
- These are of two types: Prevention Costs and Appraisal Costs.
- The second category consists of the cost consequences of poor quality, which are called Quality Failure costs.
- These include External Failure Costs and Internal Failure Costs. These costs of quality are shown in Table 7.1
- The first two costs are incurred in the hope of preventing the second two.
- Prevention costs are all costs incurred in the process of preventing poor quality from occurring. They include quality planning costs, such as the costs of developing and implementing a quality plan.
- Also included are the costs of product and process design, from collecting customer information to designing processes that achieve conformance to specifications.
- Employee training in quality measurement is included as part of this cost, as well as the costs of maintaining records of information and data related to quality.
- Appraisal costs are incurred in the process of uncovering defects. They include the cost of quality inspections, product testing, and performing audits to make sure that quality standards are being met.
- Also included in this category are the costs of worker time spent measuring quality and the cost of equipment used for quality appraisal.
- Internal Failure Costs are associated with discovering poor product quality before the product reaches the customer site. One type of internal failure cost is rework, which is the cost of correcting the defective item.
- Sometimes the item is so defective that it cannot be corrected and must be thrown away. This is called scrap, and its costs include all the material, labor, and machine cost spent in producing the defective product.
- Other types of internal failure costs include the cost of machine downtime due to failures in the process and the costs of discounting defective items for salvage value.
- External Failure Costs are associated with quality problems that occur at the customer site.
- These costs can be particularly damaging because customer faith and loyalty can be difficult to regain.
- They include everything from customer complaints, product returns, and repairs, to warranty claims, recalls, and even litigation costs resulting from product liability issues.
- A final component of this cost is lost sales and lost customers. For example, manufacturers of lunch meats and hot dogs whose products have been recalled due to bacterial contamination have had to struggle to regain consumer confidence.
- Other examples include auto manufacturers whose products have been recalled due to major malfunctions such as problematic braking systems and airlines that have experienced a crash with many fatalities.
- External failure can sometimes put a company out of business almost overnight.
- Companies that consider quality important invest heavily in prevention and appraisal costs in order to prevent internal and external failure costs.
- The earlier defects are found, the less costly they are to correct. For example, detecting and correcting defects during product design and product production is considerably less expensive than when the defects are found at the customer site as shown in fig. 7.1

- External Failure Costs tend to be particularly high for service organisations. The reason is that with a service the customer spends much time in the service delivery system, and there are fewer opportunities to correct defects than there are in manufacturing. Examples of external failure in services include an airline that has overbooked flights, long delays in airline service, and lost luggage.

Prevention Cost	Cost of preparing and implementing Quality
Appraisal Cost	Costs of testing, evaluating, and inspecting quality
Internal failure	Costs of scrap, rework, and material losses.
External failure	Costs of failure at customer site, including returns, repairs, and recalls.

Table 7.1 Cost of quality

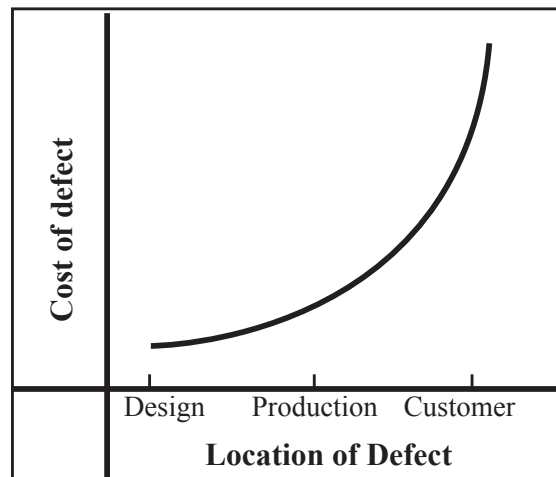


Fig. 7.1 Cost of defects

7.4 Continuous Improvement (Kaizen)

- Another concept of the TQM philosophy is the focus on Continuous Improvement.
- Traditional systems operated on the assumption that once a company achieved a certain level of quality, it was successful and needed no further improvements.
- We tend to think of improvement in terms of plateaus that are to be achieved, such as passing a certification test or reducing the number of defects to a certain level.
- Traditionally, change for American managers involves large magnitudes, such as major organisational restructuring.
- The Japanese, on the other hand, believe that the best and most lasting changes come from gradual improvements.
- To use an analogy, they believe that it is better to take frequent small doses of medicine than to take one large dose.
- Continuous improvement, called 'Kaizen' by the Japanese, requires that the company continually strive to be better through learning and problem solving. Because we can never achieve perfection, we must always evaluate our performance and take measures to improve it.
- Now let's look at two approaches that can help companies with continuous improvement: the Plan – Do – Study – Act (PDSA) cycle and benchmarking.

7.4.1 Plan to Study Cycle

The Plan – Do – Study – Act (PDSA) cycle describes the activities a company needs to perform in order to incorporate continuous improvement in its operation. This cycle, shown in Fig. 5-6 is also referred to as the Shewhart cycle or the Deming wheel. The circular nature of this cycle shows that continuous improvement is a never-ending process. Let's look at the specific steps in the cycle.

Plan

1. The first step in the PDSA cycle is to plan.
2. Managers must evaluate the current process and make plans based on any problems they find.
3. They need to document all current procedures, collect data, and identify problems.
4. This information should then be studied and used to develop a plan for improvement as well as specific measures to evaluate performance.

Do

The next step in the cycle is implementing the plan (do). During the implementation process managers should document all changes made and collect data for evaluation.

Study

The third step is to study the data collected in the previous phase. The data are evaluated to see whether the plan is achieving the goals established in the plan phase.

Act

- The last phase of the cycle is to act based on the results of the first three phases.
- The best way to accomplish this is to communicate the results to other members in the company and then implement the new procedure if it has been successful.
- Note that this is a cycle; the next step is to plan again. After we have acted, we need to continue evaluating the process, planning, and repeating the cycle again.

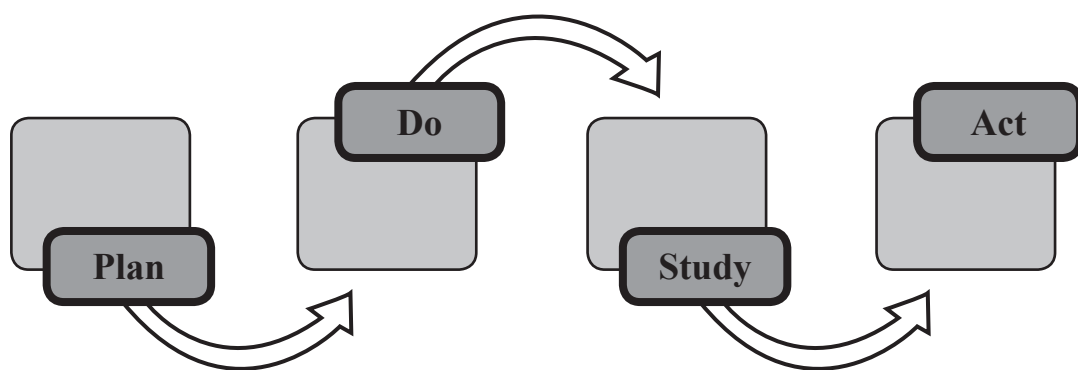


Fig. 7.2 PDSA cycle

7.4.2 Benchmarking

- Another way companies implement continuous improvement is by studying business practices of companies considered “best in class.” This is called as benchmarking.
- The ability to learn and study how others do things is an important part of continuous improvement.
- The benchmark company does not have to be in the same business, as long as it excels at something that the company doing the study wishes to emulate.
- For example, many companies have used Lands’ End to benchmark catalog distribution and order filling, because Lands’ End is considered a leader in this area. Similarly, many companies have used American Express to benchmark conflict resolution.

7.5 Employee Empowerment

- Part of the TQM philosophy is to empower all employees to seek out quality problems and correct them.
- With the old concept of quality, employees were afraid to identify problems for fear that they would be reprimanded. Often poor quality was passed onto someone else, in order to make it “someone else’s problem.”
- The new concept of quality, TQM, provides incentives for employees to identify quality problems. Employees are rewarded for uncovering quality problems, not punished.
- In TQM, the role of employees is very different from what it was in traditional systems.
- Workers are empowered to make decisions relative to quality in the production process. They are considered a vital element of the effort to achieve high quality.
- Their contributions are highly valued, and their suggestions are implemented. In order to perform this function, employees are given continual and extensive training in quality measurement tools.
- To further stress the role of employees in quality, TQM differentiates between external and internal customers.
- External customers are those that purchase the company’s goods and services. Internal customers are employees of the organisation who receive goods or services from others in the company.
- For example, the packaging department of an organisation is an internal customer of the assembly department. Just as a defective item would not be passed to an external customer, a defective item should not be passed to an internal customer.

7.5.1 Team Approach

- TQM stresses that quality is an organisational effort. To facilitate the solving of quality problems, it places great emphasis on teamwork. The use of teams is based on the old adage that “two heads are better than one.”
- Using techniques such as brainstorming, discussion, and quality control tools, teams work regularly to correct problems. The contributions of teams are considered vital to the success of the company. For this reason, companies set aside time in the workday for team meetings.
- Teams vary in their degree of structure and formality, and different types of teams solve different types of problems.
- One of the most common types of teams is the quality circle, a team of volunteer production employees and their supervisors whose purpose is to solve quality problems.
- The circle is usually composed of eight to ten members, and decisions are made through group consensus. The teams usually meet weekly during work hours in a place designated for this purpose.
- They follow a preset process for analysing and solving quality problems. Open discussion is promoted, and criticism is not allowed. Although the functioning of quality circles is friendly and casual, it is serious business.
- Quality circles are not mere “gab sessions.” Rather, they do important work for the company and have been very successful in many firms.

7.6 Tools of Quality Control

- You can see that TQM places a great deal of responsibility on all workers. If employees are to identify and correct quality problems, they need proper training.
- They need to understand how to assess quality by using a variety of quality control tools, how to interpret findings, and how to correct problems.
- In this section we look at seven different quality tools. These are often called the seven tools of quality control and are shown in Fig.7.3.

- They are easy to understand, yet extremely useful in identifying and analysing quality problems. Sometimes workers use only one tool at a time, but often a combination of tools is most helpful.

7.6.1 Cause-and-Effect Diagrams

- Cause-and-effect diagrams are charts that identify potential causes for particular quality problems. They are often called fishbone diagrams because they look like the bones of a fish.
- A general cause-and-effect diagram is shown in Fig.7.3. The “head” of the fish is the quality problem, such as damaged zippers on a garment or broken valves on a tire.
- The diagram is drawn so that the “spine” of the fish connects the “head” to the possible cause of the problem. These causes could be related to the machines, workers, measurement, suppliers, materials, and many other aspects of the production process.
- Each of these possible causes can then have smaller “bones” that address specific issues that relate to each cause.
- For example, a problem with machines could be due to a need for adjustment, old equipment, or tooling problems. Similarly, a problem with workers could be related to lack of training, poor supervision, or fatigue.
- Cause-and-effect diagrams are problem-solving tools commonly used by quality control teams.
- Specific causes of problems can be explored through brainstorming. The development of a cause-and-effect diagram requires the team to think through all the possible causes of poor quality

7.6.2 Flowcharts

- A flowchart is a schematic diagram of the sequence of steps involved in an operation or process.
- It provides a visual tool that is easy to use and understand. By seeing the steps involved in an operation or process, everyone develops a clear picture of how the operation works and where problems could arise.

7.6.3 Checklists

- A checklist is a list of common defects and the number of observed occurrences of these defects. It is a simple yet effective fact-finding tool that allows the worker to collect specific information regarding the defects observed.
- The checklist in Fig.7.3 shows four defects and the number of times they have been observed. It is clear that the biggest problem is ripped material.
- This means that the plant needs to focus on this specific problem — for example, by going to the source of supply or seeing whether the material rips during a particular production process.
- A checklist can also be used to focus on other dimensions, such as location or time. For example, if a defect is being observed frequently, a checklist can be developed that measures the number of occurrences per shift, per machine, or per operator.
- In this fashion we can isolate the location of the particular defect and then focus on correcting the problem.

7.6.4 Control Charts

- Control charts are a very important quality control tool. We will study the use of control charts at great length in the next chapter.
- These charts are used to evaluate whether a process is operating within expectations relative to some measured value such as weight, width, or volume.
- For example, we could measure the weight of a sack of flour, the width of a tire, or the volume of a bottle of soft drink. When the production process is operating within expectations, we say that it is “in control.”

- To evaluate whether or not a process is in control, we regularly measure the variable of interest and plot it on a control chart. The chart has a line down the center representing the average value of the variable we are measuring.
- Above and below the center line are two lines, called the Upper Control Limit (UCL) and the Lower Control Limit (LCL). As long as the observed values fall within the upper and lower control limits, the process is in control and there is no problem with quality. When a measured observation falls outside of these limits, there is a problem.

7.6.5 Scatter Diagrams

- Scatter diagrams are graphs that show how two variables are related to one another. They are particularly useful in detecting the amount of correlation, or the degree of linear relationship, between two variables.
- For example, increased production speed and number of defects could be correlated positively; as production speed increases, so does the number of defects.
- Two variables could also be correlated negatively, so that an increase in one of the variables is associated with a decrease in the other.
- For example, increased worker training might be associated with a decrease in the number of defects observed.
- The greater the degree of correlation the more linear are the observations in the scatter diagram. On the other hand, the more scattered the observations in the diagram, the less correlation exists between the variables.
- Of course, other types of relationships can also be observed on a scatter diagram, such as an inverted.
- This may be the case when one is observing the relationship between two variables such as oven temperature and number of defects, since temperatures below and above the ideal could lead to defects.

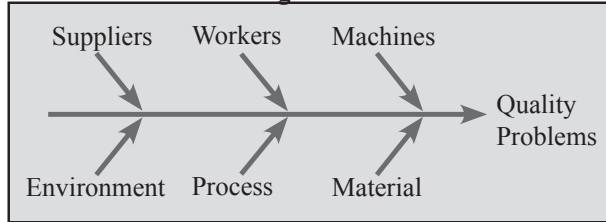
7.6.6 Pareto Analysis

- Pareto analysis is a technique used to identify quality problems based on their degree of importance.
- The logic behind Pareto analysis is that only a few quality problems are important, whereas many others are not critical. The technique was named after Vilfredo Pareto, a nineteenth-century Italian economist who determined that only a small percentage of people controlled most of the wealth.
- This concept has often been called the 70 – 20 rule and has been extended to many areas.
- In quality management the logic behind Pareto's principle is that most quality problems are a result of only a few causes. The trick is to identify these causes.
- One way to use Pareto analysis is to develop a chart that ranks the causes of poor quality in decreasing order based on the percentage of defects each has caused.
- For example, a tally can be made of the number of defects that result from different causes, such as operator error, defective parts, or inaccurate machine calibrations.
- Percentages of defects can be computed from the tally and placed in a chart like those shown in Fig.7.3. We generally tend to find that a few causes account for most of the defects.

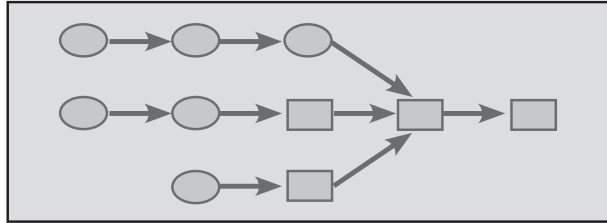
7.6.7 Histograms

- A histogram is a chart that shows the frequency distribution of observed values of a variable.
- We can see from the plot what type of distribution a particular variable displays, such as whether it has a normal distribution and whether the distribution is symmetrical.

1. Cause and Effect Diagram



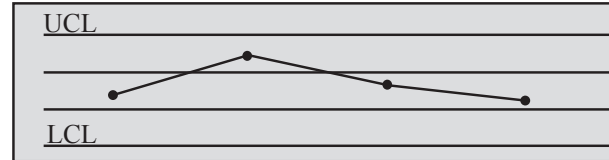
2. Flowchart



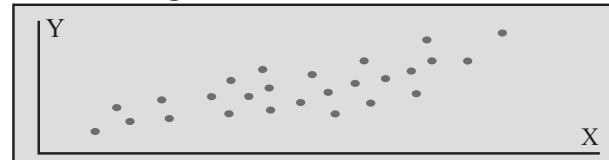
3. Checklist

Detect type	No. of Defects	Total
Broken Zipper	✓✓✓	3
Ripped material	✓✓✓✓✓✓✓	7
Missing buttons	✓✓✓	3
Faded colour	✓✓	2

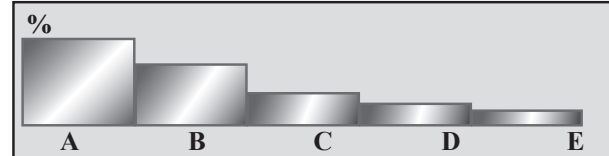
4. Control Chart



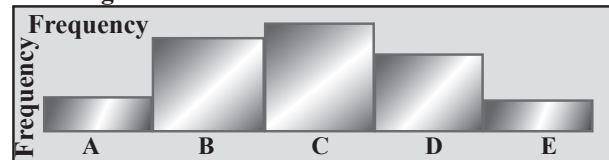
5. Scatter Diagram



6. Pareto Chart



7. Histogram



The seven tools of quality control

Fig. 7.3 Seven tools of quality control

7.7 Process Management

- According to TQM a quality product comes from a quality process. This means that quality should be built into the process.
- Quality at the source is the belief that it is far better to uncover the source of quality problems and correct it than to discard defective items after production.
- If the source of the problem is not corrected, the problem will continue. For example, if you are baking cookies you might find that some of the cookies are burned. Simply throwing away the burned cookies will not correct the problem.
- You will continue to have burned cookies and will lose money when you throw them away. It will be far more effective to see where the problem is and correct it. For example, the temperature setting may be too high; the pan may be curved, placing some cookies closer to the heating element; or the oven may not be distributing heat evenly.
- Quality at the source exemplifies the difference between the old and new concepts of quality. The old concept focused on inspecting goods after they were produced or after a particular stage of production.
- If an inspection revealed defects, the defective products were either discarded or sent back for reworking. All this cost the company money, and these costs were passed on to the customer.
- The new concept of quality focuses on identifying quality problems at the source and correcting them.

7.8 Quality Standards

Various quality standards are discussed below.

7.8.1 ISO 9000 Standards

- Increases in international trade during the 1970s created a need for the development of universal standards of quality. Universal standards were seen as necessary in order for companies to be able to objectively document their quality practices around the world.
- Then in 1977 the International Organisation for Standardisation (ISO) published its first set of standards for quality management called ISO 9000.
- The International Organisation for Standardisation (ISO) is an international organisation whose purpose is to establish agreement on international quality standards.
- It currently has members from 91 countries, including the United States. To develop and promote international quality standards, ISO 9000 has been created.
- ISO 9000 consists of a set of standards and a certification process for companies. By receiving ISO 9000 certification, companies demonstrate that they have met the standards specified by the ISO.
- The standards are applicable to all types of companies and have gained global acceptance.
- In many industries ISO certification has become a requirement for doing business. Also, ISO 9000 standards have been adopted by the European Community as a standard for companies doing business in Europe.
- In December 2000 the first major changes to ISO 9000 were made, introducing the following three new standards:
 - ISO 9000:2000 Quality Management Systems Fundamentals and Standards: Provides the terminology and definitions used in the standards. It is the starting point for understanding the system of standards.
 - ISO 9001:2000 Quality Management Systems Requirements: This is the standard used for the certification of a firm's quality management system. It is used to demonstrate the conformity of quality management systems to meet customer requirements.
 - ISO 9004:2000 Quality Management Systems Guidelines for Performance: Provides guidelines for establishing a quality management system. It focuses not only on meeting customer requirements but also on improving performance.

7.8.2 ISO 14000 Standards

- The need for standardisation of quality created an impetus for the development of other standards. In 1996 the International Standards Organisation introduced standards for evaluating a company's environmental responsibility. These standards, termed ISO 14000, focus on three major areas:
- Management systems standards measure systems development and integration of environmental responsibility into the overall business.
- Operations standards include the measurement of consumption of natural resources and energy.
- Environmental systems standards measure emissions, effluents, and other waste systems.

7.9 Reason for TQM Failure

- The most important factor in the success or failure of TQM efforts is the genuineness of the organisation's commitment. Often companies look at TQM as another business change that must be implemented due to market pressure without really changing the values of their organisation.
- Recall that TQM is a complete philosophy that has to be embraced with true belief, not mere lip service. Looking at TQM as a short-term financial investment is a sure recipe for failure.
- Another mistake is the view that the responsibility for quality and elimination of waste lies with employees other than top management. It is a "let the workers do it" mentality.
- A third common mistake is over- or under-reliance on statistical process control (SPC) methods.
- SPC is not a substitute for continuous improvement, teamwork, and a change in the organisation's belief system. However, SPC is a necessary tool for identifying quality problems. Some common causes for TQM failure are;
 - Lack of a genuine quality culture
 - Lack of top management support and commitment
 - Over- and under-reliance on statistical process control (SPC) methods.
- Companies that have attained the benefits of TQM have created a quality culture.
- These companies have developed processes for identifying customer-defined quality.
- In addition, they have a systematic method for listening to their customers, collecting and analysing data pertaining to customer problems, and making changes based on customer feedback.

Summary

- Total quality management (TQM) is different from the old concept of quality because its focus is on serving customers, identifying the causes of quality problems, and building quality into the production process.
- There are four categories of quality costs. The first two are prevention and appraisal costs, which are incurred by a company in attempting to improve quality. The last two costs are internal and external failure costs, which are the costs of quality failures that the company wishes to prevent.
- Seven features of TQM combine to create the TQM philosophy: customer focus, continuous improvement, employee empowerment, use of quality tools, product design, process management, and managing supplier quality.
- Quality function deployment (QFD) is a tool used to translate customer needs into specific engineering requirements. Seven problem-solving tools are used in managing quality. Often called the seven tools of quality control, they are cause-and-effect diagrams, flowcharts, checklists, scatter diagrams, Pareto analysis, control charts, and histograms.
- Reliability is the probability that the product will function as expected. The reliability of a product is computed as the product of the reliabilities of the individual components.
- Companies are evaluated in seven areas, including quality leadership and performance results. These criteria have become a standard for many companies that seek to improve quality.
- ISO 9000 is a certification based on a set of quality standards established by the International Organisation for Standardisation. Its goal is to ensure that quality is built into production processes. ISO 9000 focuses mainly on quality of conformance.

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Self Assessment

1. The category consists of costs necessary for achieving high quality, which are called _____ costs.
 - a. quality control costs
 - b. prevention costs
 - c. appraisal costs
 - d. quality failure costs
2. _____ includes quality planning costs, such as the costs of developing and implementing a quality plan.
 - a. Appraisal costs
 - b. Internal failure costs
 - c. Prevention costs
 - d. External failure costs
3. The _____ is the first step of Shewhart cycle.
 - a. Plan
 - b. Do
 - c. Study
 - d. Act
4. _____ is an integrated organisational effort designed to improve quality at every level.
 - a. TPM
 - b. TQM
 - c. Kaizen
 - d. Kanban
5. In 1977 the International Organisation for Standardisation (ISO) published its first set of standards for quality management called _____.
 - a. ISO
 - b. ISO 9001
 - c. ISO 9000
 - d. ISO 14000
6. In 1996 the International Standards Organisation introduced standards for evaluating a company's environmental responsibility called as _____.
 - a. ISO
 - b. ISO 9000
 - c. ISO 14000
 - d. ISO 9001

7. Which of the following phases explains the data are evaluated to see whether the plan is achieving the goals established in the plan phase?
 - a. Plan
 - b. Do
 - c. Study
 - d. Act

8. _____ is the sequence of steps involved in an operation or process.
 - a. Checklist
 - b. Flowchart
 - c. Control charts
 - d. Cause and effect diagrams

9. Technique used to identify quality problems based on their degree of importance is known as _____.
 - a. Parreto analysis
 - b. Statistical process control
 - c. Histogram
 - d. Scatter diagrams

10. In which type of diagrams or charts are the upper control limit and the lower control limit reflected?
 - a. Scatter charts
 - b. Histograms
 - c. Control charts
 - d. Statistical Process control

Chapter VIII

JIT and Lean Production

Aim

The aim of this chapter is to:

- elucidate the concept of Just-In-Time
- explain the lean manufacturing system
- explicate six sigma

Objectives

The objectives of this chapter are to:

- explain JIT, lean manufacturing and six sigma in production system
- elucidate the principles of JIT, lean manufacturing and six sigma
- enlist the benefits of JIT, Lean system and Six sigma

Learning outcome

At the end of this chapter, you will be able to:

- understand the difference between quality management tools
- identify the importance of JIT, lean manufacturing in operations management
- enlist the benefits and major pitfalls of existing manufacturing system

8.1 Introduction

- The primary goal for the company is customer's satisfaction and if company cannot reach perfection in this area then all the processes are worthless.
- All parts of the value chain and everything in the enterprise must be healthy for realisation of competitive business processes.
- If the company wants strong and long lasting value chain all the links within the chain must be prepared to overpass all existing problems.
- One of the most important links inside that value chain is definitely logistics. Logistics is concerned with the physical distribution and storage of products and services.
- During the 20th century several approaches of implementation of logistics were developed. Surely, one the most famous and most important logistics concept is the Just-In-Time concept.

8.2 History and Philosophy of Just-In-Time (JIT)

Problems before JIT system were that companies cannot properly calculate their material flows. Also, there were problems with warehouses because there were situations that in one moment warehouses are full with stocks, and in other they are almost empty. Because of these problems it was really difficult for engineers and managers to deal with logistics.

JIT, however, is not new. The technique was first used by the Ford Motor Company during 1920s, but the technique was subsequently adopted and publicised by Toyota Motor Corporation of Japan as part of its Toyota production System (TPS). In 1954 Japanese giant Toyota implemented this concept in order to reduce wasteful overstocking in car production.

Just-in-time (JIT) inventory systems are not just a simple method that a company has to buy in to; it has a whole philosophy that the company must follow. The ideas in this philosophy come from many different disciplines including; statistics, industrial engineering, production management and behavioral science. In the JIT inventory philosophy there are views with respect to how inventory is looked upon, what it says about the management within the company, and the main principle behind JIT. Firstly, inventory is seen as incurring costs instead of adding value, contrary to traditional thinking. Under the philosophy, businesses are encouraged to eliminate.

8.3 Just-In-Time Concept

Since the emergence of this term it was difficult for sciences and business people to define it. Even today many companies think that they are using JIT concept, but actually, they are not realising that JIT must be integrated in company philosophy and no just dead letters. Just in Time (JIT) production is a manufacturing philosophy, which eliminates waste associated with time, labor, and storage space.

Basics of the concept are that the company produces only what is needed, when it is needed and in the quantity that is needed. The company produces only what the customer requests, to actual orders, not to forecast. JIT can also be defined as producing the necessary units, with the required quality, in the necessary quantities, at the last safe moment. It means that company can manage with their own resources and allocate them very easily.

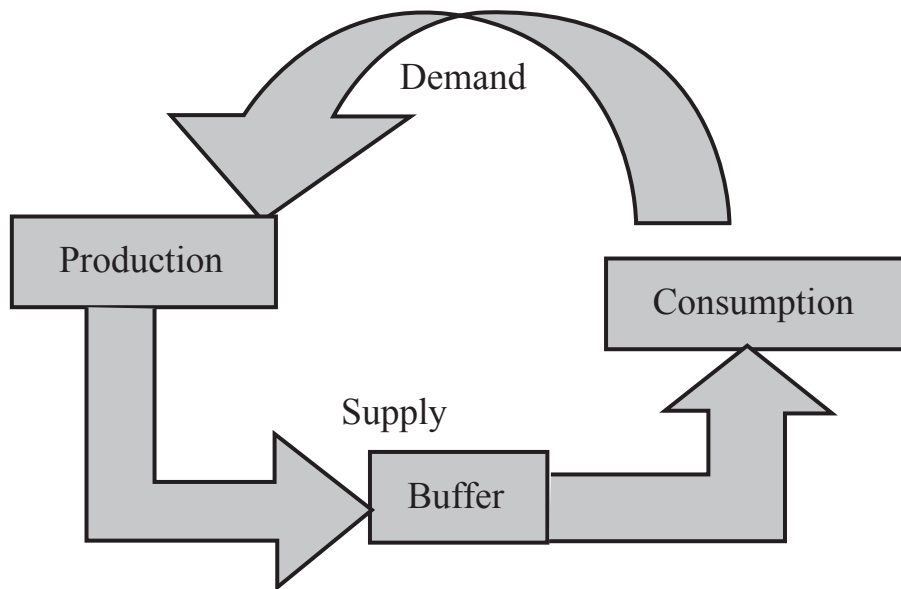


Fig. 8.1 Drawing of the JIT concept

8.4 Benefits and Problems

Benefits that JIT concept can provide to the company are huge and very diverse. The main benefits of JIT are listed below:

- Reduced set up times in warehouse - the company in this case can focus on other processes that might need improvement;
- Improved flows of goods in/through/out warehouse employees will be able to process goods faster;
- Employees who possess multi-skills are utilised more efficiently the company can use workers in situations when they are needed, when there is a shortage of workers and a high demand for a particular product;
- Better consistency of scheduling and consistency of employee work hours if there is no demand for a product at the time, workers don't have to be working. This can save the company money by not having to pay workers for a job not completed or could have them focus on other jobs around the warehouse that would not necessarily be done on a normal day;
- Increased emphasis on supplier relationships - having a trusting supplier relationship is important for the company because it is possible to rely on goods being there when they are needed;
- Supplies continue around the clock keeping workers productive and businesses focused on turnover - employees will work hard to meet the company goals.
- Also, the benefits of JIT include: better quality products, higher productivity and lower production costs. For better understanding of JIT benefits, Table 9.1 shows comparing between flexible systems (based on Just-In-Time systems) and buffered/rigid systems.
- It is certain that JIT concept can improve business performance and efficiency. Employee morale is likely increased and that is one most important benefit that comes from using the foregoing concept. Of course, we must not forget that now the company is allowed to remain competitive.

	Lean Flexible System (Just-In-Time System)	Buffered/Rigid System (Just-In-Case system)
Production System	Customer orders pulls product through the factory	The system pushes the product through the factory
Production Lot Size	Small batches are made with reduced setup time	Large batches are made due to high setup time
Process Design	Concurrent engineering design is applied	Process designed after product has been designed
Inventory Turnover	High turnover with minimum inventory level	Low turnover due to high inventory level
Suppliers	Fewer number and they are helped informed and kept close	Suppliers are kept at arms length
Employees	Multi skilled, flexible and work well in teams	Specialised and with strict work rules
Decision-making	Empowerment of workers enables quick response	Centralised at management level
Quality	Everyone's responsibility	Q.C. inspectors job
System Improvement	Emphasis is on small but continuous improvement	"If it isn't broke, dont fix it" attitude.

Table 8.1 Comparison between flexible systems and buffered/rigid systems

- There are several problems, which are connected within JIT concept.
- The major problem with JIT operation is that it leaves the supplier and downstream consumers open to supply shocks.
- With shipments coming in sometimes several times per day, the company is especially susceptible to an interruption in the flow. For that reason, some companies are careful to use two or more suppliers for most of their assemblies.
- The hidden costs are present and they include labor union leverage, problems with flexible manufacturing systems (FMS), problems developing for the flexible workforce, difficulties with supplying commodities using JIT, increased expenses for suppliers.

8.5 Implementation of JIT

How a company will implement the JIT concept depends on many factors. For example, if a company has more than 100,000 workers and production in different places, then the implementation of JIT needs to be done in interaction with all departments. It is obvious that for large companies more time will be spent. On the other hand, smaller companies have the opportunity to implement the JIT concept much faster because their organisation structure is not so complicated. But it does not mean that smaller companies are better in JIT implementation. There are several general guideline steps for easier JIT implementation.

The following algorithm shows what the company has to do if it wants to implement the JIT concept. (refer to fig. 8.2)

1. Top management must accept idea of the JIT.

Without their permission it is not possible to move on with the whole process. They are responsible for ensuring financial resources for the project. Perhaps the most difficult thing for engineers is to convince managers that the company under consideration really needs implementation of the JIT concept in order to improve business processes. Convincing managers to allow evaluation of JIT is not only a problem that comes from human.

2. Second step for a company is success which is connected with the fact that employees also have to understand significance of the new concept. Very important in this step is to explain to workers that JIT is not some kind of bad monster and not something unimportant for their work. It is desirable to hold a series of training sessions to familiarise employees with the fundamentals of the JIT concept. When we succeed once to explain to our human resources the importance of the new concept and if they become cognizant about it, now it is possible to continue.

3. The third step would be the setup of ERP (Enterprise Resource Planning).

ERP is a system which integrates all data and processes of an organisation into a single unified system.

It is impossible nowadays to run successful production without strong support of an information system.

So, it means that ERP requests the software and hardware systems with a secure and huge data base which is able to collect all information about resources.

With a centralised data base it is much easier to manage all enterprise resources. It is especially important for logistics because, as we mentioned before, logistics can be considered as a tool for getting resources, like products, services, and people, where they are needed and when they are desired.

If the ERP system is well established, the next step would be to test our own system.

Now all preconditions of the JIT implementation are considered and we are trying to figure out: are there any difficulties to start with implementation. In this step one question comes up: "Is the system ready for JIT implementation?". When the answer is NO, it is recommendable to go back and do changes. If the answer is YES, everything is prepared for the implementation process. Apropos the technical and physical parts of the implementation, maybe the most important thing which is worth of mentioning is that during the process the organisation must not rush.

4. The last step is testing and control. For successful existence and developing of the JIT system there must be continuous control. Without control things can sway from the right direction. Of course, feedback loops also exist and they are very important for the whole process.

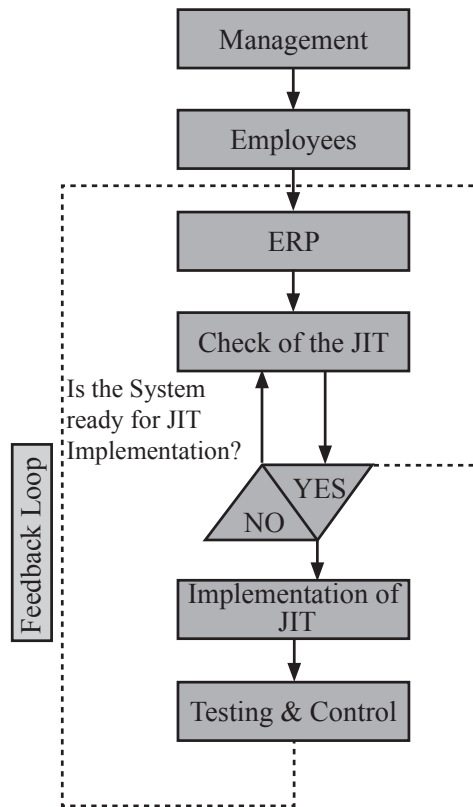


Fig. 8.2 Algorithm of JIT implementation

8.6 Lean Manufacturing

Lean is about doing more with less. (less time, inventory, space, labor, money) Lean manufacturing a shorthand commitment to eliminating waste, simplifying procedures and speeding up production Lean manufacturing is also known as Toyota Production System (TPS). The systematic elimination of wastes like, overproduction, waiting, transportation, inventory, motion, over processing, defective units and the implementation of the concepts of continuous flow and customer pull.

The five areas of Lean manufacturing or production are:

- cost
- quality
- delivery
- safety
- morale

Just as a mass production is recognised as the production system of the 20th century lean production is viewed as the production system of the 21st century.

8.6.1 Lean Production Overview

- Non-value added activities or waste are eliminated through continuous improvement efforts.
- Focus on continuous improvement of processes – rather than results - of the entire value chain.
- The lean manufacturing mindset: concept, way of thinking – not techniques; culture – not the latest management tool.

- Continuous product flow is achieved through physical rearrangement and system structure and control mechanisms.
- Single-piece flow / small lot production: achieved through equipment set up time reduction; attention to machine maintenance; and orderly, clean work place.
- Pull reduction / Just-in-Time inventory control.

8.6.2 Basic Elements of Lean Manufacturing

- The basic elements are waste elimination, continuous one piece workflow, and customer pull.
- When these elements are focused in the areas of cost, quality and delivery, this forms the basis for a lean production system.
- The lean production concept was to a large extent inspired by the Kaizen the Japanese strategy of continuous improvement.
- Employee empowerment and promotion among them of a way of thinking oriented at improving processes, imitation of customer relationships, fast product development and manufacturing, and collaboration with suppliers are the key strategies of leading lean companies.

8.6.3 Characteristics of a Lean Manufacturing

- Integrated single piece continuous workflow.
- Close integration of the whole value chain from raw material to finished product through partnership oriented relations with suppliers and distributors.
- Just-in-time processing: a part moves to a production operation, is processed immediately, and moves immediately to the next operation.
- Short order-to-ship cycles times; small batch production capability that is synchronised to shipping schedules
- Production is based on orders rather than forecasts; production planning is driven by customer demand or "pull" and not to suit machine loading or inflexible work flows on the shop floor.
- Minimal inventories at each stage of the production process.
- Quick changeovers of machines and equipment allow different products to be produced with one-piece flow in small batches.
- Layout is based on product flow.
- Total quality control. Active involvement by workers in trouble shooting and problem solving to improve quality and eliminate wastes.
- Defect prevention rather than inspection and rework by building quality in the process and implementing real time quality feedback procedures.
- Team-based work organisations with multi skilled operators empowered to make decisions and improve operations with few indirect staff.

8.7 Key Feature of Lean Production

Following are the key features of lean production

- Reduced Setup Cost and Times (for semi-versatile machinery such as big stamping presses) – from months to hours thus making small-lot production economically viable; achieved by organising procedures, using carts, and training workers to do their own setups,
- Small-Lot Production – allowing higher flexibility and pull production (or just-in-time manufacturing)

- Employee Involvement and Empowerment – organising workers by forming teams and giving them training and responsibility to do many specialised tasks, for housekeeping, quality inspection, minor equipment repair and rework; allowing also them time to meet to discuss problems and find ways to improve the process
- Quality at the Source – total quality management (TQM) and control; assigning workers, not inspectors, the responsibility to discover a defect and to immediately fix it; if the defect cannot be readily fixed, any worker can halt the entire line by pulling a cord (called jidoka)
- Pull Production, or Just-In-Time (JIT) – the method wherein the quantity of work performed at each stage of the process is dictated solely by the demand for materials from the immediate next stage; thus reducing waste and lead times, and eliminating inventory holding costs
- Continuous Equipment Maintenance – as pull production reduces inventories, equipment breakdowns must also be reduced; thus empowered operators are assigned primary responsibility for basic maintenance since they are in the best position to detect signs of malfunction
- Multi- Skilled Workforce – as employees are empowered to do many jobs, they must be provided with adequate training
- Supplier Involvement – the manufacturer treats its supplier as a long-term partner; they often must be trained in ways to reduce setup times, inventories, defects, machine breakdowns, etc. in order to enable them to take responsibility for delivering the best possible parts/services to the manufacturer in a timely manner.

8.8 Benefits of Lean Production

Establishment and mastering of a lean production system would allow you to achieve the following benefits:

- Waste reduction by 80%
- Production cost reduction by 50%
- Manufacturing cycle times decreased by 50%
- Labor reduction by 50% while maintaining or increasing throughput
- Inventory reduction by 80% while increasing customer service levels
- Capacity in current facilities increase by 50%
- Higher quality
- Higher profits
- Higher system flexibility in reacting to changes in requirements improved
- More strategic focus
- Improved cash flow through increasing shipping and billing frequencies

However, by continually focusing on waste reduction, there are truly no end to the benefits that can be achieved.

8.9 Five Elements to Enabling Approach

1. Specify Value: Value is defined by the ultimate customer's needs through tools such as value management, quality function deployment and simulation.
2. Identify and Map the Value Stream: The value stream identifies all those steps required to make a product. Identifying value stream, the way value is realised, establishes when and how decisions are to be made. The key technique behind value stream is process mapping for a very specific reason: that of understanding how value is built into the building product from client's point of view.
3. Flows: Flows are characterised by time, cost and value. Resources (labor, material and construction equipment) and information flows are the basic units of analysis.
4. Pull: At a strategic level, pull identifies the real need to deliver the product to the customer as soon as he needs it.

5. Perfection: To achieve perfection means constantly considering what is being done; how it is being done and harnessing the expertise and knowledge of all those involved in the processes to improve and change it. With continuous improvement done and with waste eliminated along the flow process, perfection is the ultimate sweet reward that companies can achieve.

8.10 13 Tips to Transition Company into Lean Enterprise

1. Begin with action in the technical system and then follow quickly with cultural change.
2. Learn by doing first and training second.
3. Start with value stream pilots to demonstrate lean as a system and provide a "go see model".
4. Use value stream mapping to develop future state visions and help "learn to see".
5. Use Kaizen workshops to teach and make rapid changes.
6. Organise over value streams.
7. Make it mandatory.
8. A crisis may prompt a lean movement, but may not be necessary to turn the company around.
9. Be opportunistic in identifying opportunities for big financial impacts.
10. Realign metrics with value streams perspective.
11. Build on your company's roots to develop your own way.
12. Hire or develop lean leaders and develop a succession system.
13. Use experts for teaching and getting quick results.

8.11 Six-Sigma

Six-Sigma is a long-term, forward-thinking initiative designed to fundamentally change the way corporations do business. It is first and foremost "a business process that enables companies to increase profits dramatically by streamlining operations, improving quality, and eliminating defects or mistakes in everything a company does. While traditional quality programs have focused on detecting and correcting defects, Six Sigma encompasses something broader: It provides specific methods to re-create the process itself so that defects are never produced in the first place."

8.11.1 Objectives of Six-Sigma

Following are the objectives of six-sigma

- to satisfy the customer
- to lift internal performance
- to enable better performance by better design
- to improve the quality of purchased supplies
- to reduce the costs

8.11.2 Integrating Six Sigma with Business Process Management

- Six-Sigma is frequently implemented in a traditional departmental paradigm without much reliance on business process thinking.
- It is little wonder that many thoughtful Six Sigma practitioners complain of the difficulty in identifying the best opportunities to apply Six Sigma techniques, and of the fact that there are frequently overlapping and redundant Six Sigma projects.
- The practice of piecemeal thinking with respect to various improvement initiatives is a serious issue and the failure of integrating business process thinking with Six Sigma methods, results in firms incurring such significant opportunity costs that it is downright tragic.

- Integrating Six Sigma with business process management principles will help you realise significant opportunities versus the traditional methods of implementing a Six Sigma program.

Just consider the few examples cited below:

- By asking and answering the question 'Which business process would have to be improved by how much, by when, in order for us to realise our strategic objectives your firm would have greater clarity on where to apply Six Sigma techniques and for what results.
- By structuring, the entire improvement initiative according to business processes there would be fewer overlapping initiatives and more cross-departmental collaboration.
- Since process ownership relies on managing by influence as opposed to authority, process owners would collaboratively sponsor projects and project progress would be monitored by a 'Steering Team' of executives thereby reducing the frequency of project collapse which sometimes observed when Six Sigma is deployed on a traditional basis due to tribal warfare.
- Because of the big picture view, leadership could decide, based on the size of the performance gap that needs to be bridged and the firm's appetite/capability to absorb change, when to deploy DFSS (design for six sigma) methodology – or better yet, process redesign techniques – as opposed to the traditional DMAIC (define, measure, analyse, improve, control).
- The application of business process thinking in conjunction with Six Sigma would inject greater sensitivity to the human side of change and help address one of the pervasive criticisms of the Six Sigma in that it is less effective in solving historically "soft" issues.
- On the other hand, process improvement methods would benefit from the rigor of Six Sigma measurement techniques and its disciplined training regime.

8.11.3 Six Main Benefits of the Sigma Breakthrough Strategy

Remarkable improvements in:

- Processes
- Products and services
- Investor relations
- Design methodology
- Supplier relationships
- Training and recruitment

8.11.4 Difference between TQM and Six Sigma

- Total Quality Management (TQM) programs focus on improvement in individual operations with unrelated processes; as a consequence, it takes many years before all operations within a given process are improved.
- Six Sigma focuses on making improvements in all operations within a process, producing results more rapidly and effectively

8.11.5 Critical Success Factors of an Organisation for Successful TPS-Lean Six Sigma Implementation

- Active commitment and involvement from Senior Executives
- Improvement goals integrated into the OBSC and Project BSC
- Deployment of the communications plan
- Project selection, prioritisation, tracking and reviewing process
- Extensive education and training

- An atmosphere of trust, commitment, teamwork, creativity, and learning within project teams
- Sustainable project results
- Technical support and training (Master Black Belts, Black Belts, Green Belts)
- Full-time vs. part-time resources
- Human resource management and Human Capital embedded in the project
- Alignment of personal ambition of project members and project ambition (Project BSC)
- Alignment of personal ambition of employees and shared organisational ambition (OBSC)
- Project BSC is related to the OBSC and Personal BSC
- Incentives, recognition, reward and celebration
- Supplier involvement Management accountability for quality improvement

Summary

- If the company wants to have a JIT concept it does not mean that everything must be done very fast. The most important thing for the company is to have good organised resource allocation.
- Also, the management and employees must have on their mind that this concept can help the organisation to solve many problems in logistics.
- It is true that implementation and development of JIT is a long-lasting and expensive process, but if the company can manage with these difficulties it is possible to achieve high levels of workflow.
- The JIT concept is only one part in the value chain that brings the satisfaction to the customers. It means that the JIT concept cannot solve existing problems in other organisation processes. Everything in enterprises is needed to be healthy, through the hierarchy of employees and all workflow processes. Synergy is the only thing that can improve business results. And in the bottom line, the JIT concept is just one link in the whole chain, but very important.
- Reduced set up times in warehouse - the company in this case can focus on other processes that might need improvement.
- Improved flows of goods in/through/out warehouse employees will be able to process goods faster.
- Employees who possess multi-skills are utilised more efficiently the company can use workers in situations when they are needed, when there is a shortage of workers and a high demand for a particular product.
- Better consistency of scheduling and consistency of employee work hours if there is no demand for a product at the time, workers don't have to be working. This can save the company money by not having to pay workers for a job not completed or could have them focus on other jobs around the
- Warehouse that would not necessarily be done on a normal day;
- Increased emphasis on supplier relationships - having a trusting supplier relationship is important for the company because it is possible to rely on goods being there when they are needed;
- Supplies continue around the clock keeping workers productive and businesses focused on turnover - employees will work hard to meet the company goals.
- Lean is about doing more with less. (Less time, inventory, space, labor, money)
- Lean manufacturing a shorthand commitment to eliminating waste, simplifying procedures and speeding up production
- The five areas of Lean manufacturing or production are: Cost, Quality, Delivery, Safety and Morale.
- Five Elements to Enabling Approach ARE: Specify value, Identify and map the value stream, Flows, Pull and Perfection

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Self Assessment

1. _____ production is a manufacturing philosophy, which eliminates waste associated with time, labor, and storage space.
 - a. Lean manufacturing
 - b. Just-In-Time
 - c. Toyota Production System
 - d. Total Production Management

2. _____ technique was first used by the Ford Motor Company during 1920s, but the technique was subsequently adopted and publicised by Toyota Motor Corporation of Japan as part of its Toyota production System (TPS).
 - a. JIT
 - b. Lean Manufacturing
 - c. Total Quality Management
 - d. Total Production Management

3. In which of the following systems, the concurrent engineering design is applied to process design?
 - a. Lean flexible system
 - b. Rigid system
 - c. Buffered system
 - d. Traditional System

4. In Just-In-Case system, the system shows low turnover due to _____ inventory.
 - a. low level
 - b. high level
 - c. complex
 - d. rigid

5. Integrated single piece continuous workflow is one of the important characteristic of _____.
 - a. JIT
 - b. Total quality
 - c. Lean manufacturing
 - d. Six sigma

6. Which of the following is defining a shorthand commitment to eliminating waste, simplifying procedures and speeding up production?
 - a. JIT
 - b. Six Sigma
 - c. Flexible Manufacturing
 - d. Lean Manufacturing

7. Which of the following systems shows continuous remarkable improvements in Processes, Products and services, Investor relations, Design methodology, Supplier relationships, Training and recruitment?
 - a. Lean Manufacturing
 - b. JIT
 - c. Toyota Production
 - d. Six Sigma
8. At a strategic level, what identifies the real need to deliver the product to the customer as soon as he needs it?
 - a. Push strategy
 - b. Pull strategy
 - c. Perfection
 - d. Relational
9. In process of implantation of JIT in manufacturing, the ERP system is established only after_____.
 - a. understanding the process
 - b. understanding the new concept
 - c. understanding the work allocation
 - d. understanding the wastes
10. In which of the following systems are the small batches are made with reduced setup time?
 - a. Just-In-Case
 - b. Just-In-Time
 - c. Lean Manufacturing
 - d. Six Sigma

Case Study I

JIT in TOYOTA

The Just in Time, JIT is a set of techniques that was first adopted and publicised by Toyota Motor Corporation of Japan as part of its Toyota Production System (TPS).

History of JIT

The technique was first used by the Ford Motor Company during 1920s, but the technique was subsequently adopted and publicised by Toyota Motor Corporation of Japan as part of its Toyota production System (TPS). In 1954 Japanese giant Toyota implemented this concept in order to reduce wasteful overstocking in car production.

JIT Implementation

Back in Japan, Sakichi customised the Ford production system to suit Japanese market. He also devised a system wherein each process in the assembly line of production would produce only the number of parts needed at the next step on the production line, which made logistics management easier as material was procured according to consumption. This system was referred to as Just-in-Time (JIT) within the Toyota Group.

The JIT production was defined as 'producing only necessary units in a necessary quantity at a necessary time resulting in decreased excess inventories and excess workforce, thereby increasing productivity.'

Benefits of JIT

- Reduced set up times in warehouse – TOYOTA in this case focused on other processes that might need improvement
- Improved flows of goods in/through/out warehouse employees was able to process goods faster
- Employees who possessed multi-skills were utilised more efficiently
- Better consistency of scheduling and consistency of employee work hours if there is no demand for a product at the time

Questions

1. Explain the Just in Time technique.

Answer

The Just in Time, JIT is a set of techniques that was first adopted and publicised by Toyota Motor Corporation of Japan as part of its Toyota Production System (TPS). The JIT production was defined as 'producing only necessary units in a necessary quantity at a necessary time resulting in decreased excess inventories and excess workforce, thereby increasing productivity.'

2. Why was JIT technique implemented?

Answer

In 1954 Japanese giant Toyota implemented this concept in order to reduce wasteful overstocking in car production.

3. How was JIT implemented in Toyota?

Answer

Back in Japan, Sakichi customised the Ford production system to suit Japanese market. He also devised a system wherein each process in the assembly line of production would produce only the number of parts needed at the next step on the production line, which made logistics management easier as material was procured according to consumption. This system was referred to as Just-in-Time (JIT) within the Toyota Group.

4. What were the benefits of JIT?

Answer

The benefits of JIT are as follows:

- Reduced set up times in warehouse – TOYOTA in this case focused on other processes that might need improvement.
- Improved flows of goods in/through/out warehouse employees was able to process goods faster.
- Employees who possessed multi-skills were utilised more efficiently.
- Better consistency of scheduling and consistency of employee work hours if there is no demand for a product at the time.

Case Study II

Ford Production System- A Lean Manufacturing

Introduction

Ford has established several innovative automobile manufacturing techniques from its beginning. In the mid 1990s, Ford modernised its manufacturing operations in its efforts to induce more flexibility and enhance the efficiency of its automobile production systems. The restructuring effort was known as Ford Production System (FPS). Ford was established by Henry Ford on June 16, 1903, with an initial investment of \$100,000.

Ford Production System

In January 1995, Ford employed a company-wide re-engineering initiative called Ford 2000. One of the major objectives of Ford 2000 program was to develop and implement a new manufacturing system called the Ford Production System (FPS). According to Ford's website, "The vision of FPS is a lean, flexible and disciplined common production system, defined by a set of principles and processes, that employs groups of capable and empowered people, learning and working safely together, in the production and delivery of products that consistently exceed customers' expectations in quality, cost and time."

LEAN Production

Lean production aimed at bringing together human, material and mechanical resources at the right time and place to accomplish a task. It strived to eliminate every kind of waste including wastage of time, labor, scrap material, defective parts, etc.

Benefits of LEAN Production

- Production cost reduction by 50%
- Manufacturing cycle times decreased by 50%
- Labor reduction by 50% while maintaining or increasing throughput
- Inventory reduction by 80% while increasing customer service levels
- Capacity in current facilities increase by 50%

Questions

1. How was the Ford production system established?
2. What was the vision of FPS?
3. What do you mean by Lean Production?
4. What are the benefits of Lean Production?

Case Study III

Six Sigma at GE

Introduction

By 2001, with revenues of \$ 125.91 billion and net earnings of \$ 13.68 billion, the US-based General Electric Company (GE) was easily the largest diversified company in the world. Out of the company's 24 different businesses, some were so large that they could independently feature in the Fortune 500 list of companies.

Six sigma

Six Sigma is a long-term, forward-thinking initiative designed to fundamentally change the way corporations do business. It is first and foremost "a business process that enables companies to increase profits dramatically by streamlining operations, improving quality, and eliminating defects or mistakes in everything a company does. Six Sigma is a well-structured, data-driven methodology for eliminating defects, waste, or quality control problems in all kinds of business activities.

Implementation of six sigma

According to analysts, the groundwork for the implementation of Six Sigma at GE had begun in 1988 in the form of an initiative known as the 'Work Out' program. The Work Out program gave each employee an opportunity to influence and improve GE's operations.

Objectives

- To lift internal performance
- To enable better performance by better design
- To improve the quality of purchased supplies
- To reduce the costs

Benefits

Analysts felt that the implementation of Six Sigma enabled Welch to transform an old-economy industrial giant into a competitive and growing company. No other corporation seemed to have integrated Six Sigma in to its operations as widely as GE. Within five years of its implementation of Six Sigma at GE produced annual benefits of more than \$2.5 billion for GE worldwide. Analysts remarked that Six Sigma was an indisputable success at GE whether in terms of customer satisfaction, improvement in internal performance, or in the improvement of shareowner value.

Questions

1. What is Six Sigma?
2. What are the objectives of Six Sigma?
3. How was GE benefited by Six Sigma?
4. How was Six Sigma implemented?

Self Assessment Answers

Chapter I

1. c
2. a
3. d
4. b
5. b
6. b
7. a
8. c
9. d
10. b

Chapter II

1. b
2. b
3. c
4. a
5. c
6. b
7. d
8. b
9. d
10. b

Chapter III

1. c
2. d
3. b
4. b
5. c
6. b
7. a
8. c
9. b
10. c

Chapter IV

1. c
2. b
3. c
4. a
5. b
6. c
7. b
8. d
9. b
10. c

Chapter V

1. a
2. b
3. d
4. a
5. c
6. b
7. d
8. c
9. a
10. b

Chapter VI

1. a
2. b
3. c
4. d
5. a
6. d
7. a
8. d
9. a
10. b

Chapter VII

1. a
2. c
3. a
4. b
5. c
6. c
7. c
8. b
9. a
10. c

Chapter VIII

1. b
2. a
3. a
4. b
5. c
6. d
7. d
8. b
9. b
10. b