GLOBAL PRODUCTION AND OPERATIONS MANAGEMENT

MASTER OF BUSINESS ADMINISTRATION
(INTERNATIONAL BUSINESS)

FIRST YEAR, SEMESTER-II, PAPER-VI

DIRECTOR, I/c.

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Global Production and Operations Management

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FOREWORD

Since its establishment in 1976, Acharya Nagarjuna University has been forging ahead in the path of progress and dynamism, offering a variety of courses and research contributions. I am extremely happy that by gaining 'A+' grade from the NAAC in the year 2024, Acharya Nagarjuna University is offering educational opportunities at the UG, PG levels apart from research degrees to students from over 221 affiliated colleges spread over the two districts of Guntur and Prakasam.

The University has also started the Centre for Distance Education in 2003-04 with the aim of taking higher education to the door step of all the sectors of the society. The centre will be a great help to those who cannot join in colleges, those who cannot afford the exorbitant fees as regular students, and even to housewives desirous of pursuing higher studies. Acharya Nagarjuna University has started offering B.Sc., B.A., B.B.A., and B.Com courses at the Degree level and M.A., M.Com., M.Sc., M.B.A., and L.L.M., courses at the PG level from the academic year 2003-2004 onwards.

To facilitate easier understanding by students studying through the distance mode, these self-instruction materials have been prepared by eminent and experienced teachers. The lessons have been drafted with great care and expertise in the stipulated time by these teachers. Constructive ideas and scholarly suggestions are welcome from students and teachers involved respectively. Such ideas will be incorporated for the greater efficacy of this distance mode of education. For clarification of doubts and feedback, weekly classes and contact classes will be arranged at the UG and PG levels respectively.

It is my aim that students getting higher education through the Centre for Distance Education should improve their qualification, have better employment opportunities and in turn be part of country's progress. It is my fond desire that in the years to come, the Centre for Distance Education will go from strength to strength in the form of new courses and by catering to larger number of people. My congratulations to all the Directors, Academic Coordinators, Editors and Lesson-writers of the Centre who have helped in these endeavors.

Prof. K. Gangadhara Rao
M.Tech., Ph.D.,
Vice-Chancellor I/c
Acharya Nagarjuna University.

MASTER OF BUSINESS ADMINISTRATION
(INTERNATIONAL BUSINESS)
FIRST YEAR, Semester-II, Paper-VI
204IB26: Global Production and Operations Management
SYLLABUS

Course objectives:

1. To enable the students to know about the concepts of production and making planning and forecasting demand.
2. To acquaint the students with the facility location and line balancing concepts and components.
3. To know about the aggregate sales and operation planning.
4. To enable the students to know the project management preparation.
5. To know about the maintenance planning and control.

Learning outcomes:

1. Defined the concepts of production and making planning and forecasting demand.
2. Elucidate about the facility location and line balancing concepts and components.
3. Expound regarding aggregate sales and operation planning.
4. Enumerate the project management preparation.
5. Explain the maintenance planning and control.

Unit I: System concept of production – Types of production system – Productivity – World class manufacturing- process planning and design- selection of process- value analysis/value engineering-make or buy decision- capacity planning and forecasting- Demand pattern-Forecasting model-selection of forecasting techniques-SMA-WMA-Simple exponential smoothing, Linear regression – Delphi method.

Unit II: Facility location; factors influencing plant location-break even analysis-facility layout-basic formats-classification- process layout, Product layout and Group technology layout- advantages and limitation- systematic layout planning (SLP) – Concept of CRAFT, ALDEP, CORELAP- Assembly Line – Line balancing concept-Concept of mass production. Material management and inventory control – Components of material management-Purchase model with instantaneous replenishment and without shortage – Manufacturing model without shortage – Material handling system- unit load concept- material handling principle-classification of material handling equipments.

Unit III: Aggregate sales and operation planning – Introduction – overview- Production planning environment. Material Requirement planning (MRP) - Product Structure/ Bill of material (BOM) – MRP System and overview- Production planning control- Planning phase-action phase- the control phase. Single machine scheduling (SMS); types of scheduling-concept of SMS- SPT rule to minimize mean flow time-minimizing weighted mean flow time –EDD rule to minimize maximum lateness-flow shop scheduling- Introduction to Johnson Problem – Extension of Johnson's rule.

Unit IV: Project management: CPM – PERT – GANTT chart/Time chart – work study-method study- time study – motion study. Quality control :Introduction- need to control quality- definition of a quality system- classification QC techniques- control charts for variables and attribute- Acceptance sampling – Operating characteristic curve – Single sampling plan.

Unit V: Maintenance planning and control - Maintenance Objectives –Types – Basic reasons for replacement- reliability – reliability improvement- reliability calculations-Modern production management tools- JIT manufacturing - Introduction to Six sigma concepts- TQM- Lean manufacturing.-Kaizen.

Practical component:

1. Doing practical methods through conducting seminars on concepts of production and making planning and forecasting demand.
2. Students will be participating in various workshops on facility location and line balancing concepts and components.
3. To know about the aggregate sales and operation planning they will participate in national and international conferences.
4. Participate in live projects to know the project management preparation.
5. They will participate in seminars to know the maintenance planning and control

Text Books

1.Paneerselvam.R , Production and Operation management, Prentice Hall, New delhi.
2. Operations management for competitive management, chase, Jacobs &Aquilano, Tata Mcgraw hill,11E

Reference Books:

1.William J.Stevenson: Production/Operations Management, Richard Irwin.
2. Joseph G. Monks: Operation Management – Theory And Problems

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LESSON- 1

INTRODUCTION TO PRODUCTION AND OPERATIONS MANAGEMENT

1. OBJECTIVES OF THE LESSON

- To explain the meaning, nature, and scope of Production and Operations Management.
- To provide a conceptual understanding of production systems and their components.
- To describe various types of production systems operating in global manufacturing.
- To understand the strategic role of production in achieving competitiveness in global markets.
- To introduce the evolution of production management into modern operations management.

2. STRUCTURE OF THE LESSON

1. Introduction
2. Meaning and Definition of Production and Operations Management
3. Evolution of Production and Operations Management
4. System Concept of Production
5. Components of a Production System
6. Role and Importance of Production Management
7. Types of Production Systems
8. Production Functions and Responsibilities of a Production Manager
9. Challenges in Modern Global Production Systems
10. Summary
11. Key Words
12. Self-Assessment Questions
13. Reference Books

3.1 Introduction

Production and Operations Management (POM) is one of the oldest and most essential functions of any business organization. Whether it is a manufacturing enterprise converting raw materials into finished goods or a service organization delivering intangible value to customers, production and operations constitute the heart of value creation. All other business functions—marketing, finance, human resources, accounting, logistics—exist to support the production function. Production is the process through which inputs such as materials, labour, machines, capital, technology, and information are transformed into goods and services required by consumers.

In today's globalized environment, production management is no longer confined to factory operations. It deals with complex supply chains, global sourcing of materials, international standards of quality, and competition based on productivity, cost leadership, and innovation. Firms compete not only on price but on delivery speed, customization, design, reliability, and sustainability. The success of multinational corporations like Toyota, Samsung, Apple, and Tata Motors is largely attributed to efficient production and operations strategies that integrate technology, quality, and customer expectations.

3.2 Meaning and Definition of Production and Operations Management

Production refers to the process of creating utility. In manufacturing industries, production involves converting raw materials into finished products using tools, equipment, processes, and labour. In service industries, production refers to delivering intangible value such as healthcare, education, banking, and transportation.

Operations Management is a broader term that includes production but extends beyond manufacturing. It deals with management of both manufacturing and service operations. Operations management ensures that all activities involving inputs, transformation, and output are conducted efficiently and effectively.

Several definitions explain POM:

- **Production Management** is the process of planning, organizing, directing, and controlling activities related to the creation of goods.
- **Operations Management** is the management of systems that design, operate, and improve the processes that create and deliver products and services.

Thus, POM involves decision-making regarding plant location, process design, capacity planning, material management, scheduling, quality control, maintenance, and continuous improvement. It ensures that organizational resources are used optimally to produce goods that meet customer expectations in terms of quantity, quality, time, and cost.

3.3 Evolution of Production and Operations Management

The evolution of POM spans several centuries, beginning with the era of artisans and craftsmen. In ancient times, production was simple, based on custom-made goods and limited

tools. Later, mass production began with the Industrial Revolution, which brought mechanization, factories, and division of labour.

a. Craft Production Era

Before the 18th century, goods were produced by skilled artisans in small workshops. Production volumes were low, and products were unique and customized. Although quality was high, costs were also high due to limited automation.

b. Industrial Revolution (1760–1840)

This era marked a drastic shift from manual labour to machine-based production. Steam engines, power looms, and mechanized tools were introduced, leading to mass production. Adam Smith's concept of division of labour improved productivity significantly.

c. Scientific Management (Early 20th Century)

Frederick Taylor introduced time study, method study, and wage incentive plans. The focus was on increasing efficiency and standardizing work. Henry Ford further revolutionized production with assembly-line techniques that enabled mass production of automobiles.

d. Human Relations Movement

In the 1930s–50s, Elton Mayo and others emphasized human factors, motivation, and employee satisfaction. The Hawthorne Studies revealed the importance of social and psychological elements in productivity.

e. Operations Research and Quantitative Techniques

During World War II, mathematical models and linear programming were used to optimize logistics and military operations. After the war, these tools were adopted by industries for decision-making.

f. Japanese Manufacturing Revolution (1950s–1980s)

Japan introduced path-breaking concepts such as *Just-in-Time (JIT), Total Quality Management (TQM), Kaizen, Lean Manufacturing,* and *Quality Circles*. Toyota Production System became a global benchmark.

g. Modern Digital Operations Management

Today's operations management integrates artificial intelligence, robotics, CAD/CAM, enterprise resource planning (ERP), supply chain management (SCM), and Industry 4.0 technologies. Modern production systems emphasize flexibility, sustainability, customization, and global supply networks.

3.4 System Concept of Production

Production is best understood as a system. A system is a set of interrelated components working together to achieve a common objective. In a production system, various elements such as machines, materials, manpower, money, methods, and information interact to convert inputs into outputs.

The production system operates on the principle of input–process–output, often referred to as the **transformation model**.

Inputs

Inputs include raw materials, components, labour, capital, energy, machines, and information. The availability and quality of inputs determine the efficiency of the production system.

Transformation Process

This is the core of production and includes operations such as machining, forming, assembling, chemical treatment, inspection, packaging, and material handling. The design of the transformation process determines costs, quality, and delivery schedules.

Outputs

Outputs are finished goods or services delivered to customers. The output should meet customer expectations regarding performance, durability, reliability, and aesthetics.

Feedback

Feedback loops provide information about defects, delays, customer complaints, or inefficiencies. This helps in corrective actions and continuous improvement.

Control Mechanisms

Production systems require scheduling, inventory control, capacity monitoring, and quality control to ensure the process runs smoothly.

The system concept helps managers integrate all elements of production and make effective decisions based on interdependencies.

3.5 Components of a Production System

A production system consists of the following major components:

1. Inputs

These include raw materials, machinery, equipment, human resources, energy, and information.

2. Transformation Process

Processes such as machining, assembling, transporting, and storing convert inputs into outputs.

3. Output

Finished products, semi-finished goods, or services provided to customers.

4. Control Subsystem

This ensures that production takes place according to planned schedules, specifications, and standards. It uses quality control, inspection, scheduling, and production monitoring.

5. Feedback Mechanism

Data on production efficiency, customer satisfaction, defects, and productivity is fed back to the control system.

6. Environment

The external environment such as competitors, government regulations, technological changes, suppliers, and economic conditions influences the production system.

3.6 Role and Importance of Production Management

Production management is essential because it determines the cost of products, their quality, and the ability of a firm to meet customer demands. It plays a transformative role in shaping the competitiveness of a business.

Enhancing Productivity

Efficient operations reduce waste, improve resource utilization, and increase output, leading to better profitability.

Quality Improvement

Through quality assurance, TQM, and continuous improvement, production management ensures high-quality products.

Cost Reduction

Optimal use of machines, labour, and materials lowers production costs and improves profit margins.

Customer Satisfaction

Timely delivery, consistent quality, and customization ensure higher customer satisfaction and loyalty.

Global Competitiveness

Production management enables firms to adopt world-class manufacturing practices that help them compete in global markets.

3.7 Types of Production Systems

Production systems are classified based on the nature of the product, volume of production, and degree of customization. The main types include:

1. Job Production

This system is used for custom-made products such as furniture, jewellery, and tailor-made garments. Each product is unique, and production volume is low.

2. Batch Production

Goods are produced in batches or groups. This system is suitable for industries such as bakeries, pharmaceuticals, and textile dyeing. It offers moderate flexibility and medium volume.

3. Mass Production

Large quantities of standardized products are produced on assembly lines. Examples include automobiles, mobile phones, and household appliances. Mass production requires high investment but provides economies of scale.

4. Continuous Production

Production is carried out uninterrupted, often 24×7. Industries such as oil refining, cement manufacturing, and chemical processing use continuous production systems.

Each system has advantages and limitations depending on product design, demand patterns, and cost structures.

3.8 Production Functions and Responsibilities of a Production Manager

The production manager plays a vital role in planning, coordinating, and controlling the production process. Major responsibilities include:

- Designing the production system
- Planning plant layout and location
- Forecasting demand and planning capacity
- Scheduling production activities
- Managing materials and inventory
- Ensuring quality control and reliability
- Implementing maintenance strategies
- Managing labour and ensuring safety
- Monitoring productivity and initiating improvements

The production manager must balance customer needs, resource availability, and organizational goals to achieve operational excellence.

3.9 Challenges in Modern Global Production Systems

Global production faces several challenges in the 21st century:

Technological Disruptions

Rapid advances in automation, robotics, and artificial intelligence require continuous investment.

Supply Chain Volatility

Global disruptions such as pandemics, wars, and trade restrictions affect sourcing and logistics.

Quality and Compliance

International markets demand adherence to stringent quality standards, safety norms, and environmental regulations.

Sustainability

Companies must adopt eco-friendly production processes, reduce carbon emissions, and follow ethical sourcing.

Customization vs. Cost Efficiency

Customers demand personalized products, yet firms must maintain cost competitiveness.

Handling these challenges requires a strategic approach that integrates technology, innovation, and workforce skill development.

4. SUMMARY

This lesson introduced the fundamental concepts of Production and Operations Management, highlighting its evolution from craft-based systems to modern digital manufacturing. The production system was explained using the input–process–output model, emphasizing the interdependence of various components. Different types of production systems—job, batch, mass, and continuous—were described, each suited to specific product and market requirements. The role of the production manager was discussed, along with the challenges faced by global operations in the modern world. Overall, POM serves as the foundation for organizational success by ensuring efficient resource utilization, high-quality output, and customer satisfaction.

5. KEY WORDS

- Production System
- Operations Management
- Transformation Process
- World-Class Manufacturing
- Productivity
- Mass Production
- Batch Processing
- Plant Layout
- Production Manager
- Continuous Production

6. SELF-ASSESSMENT QUESTIONS

A. Short Answer Questions

1. What is meant by production management?
2. Give two differences between job production and batch production.
3. What is the transformation process in a production system?
4. Write a short note on world-class manufacturing.
5. What are the components of a production system?

B. Essay Questions

1. Explain the evolution of Production and Operations Management from the craft system to modern Industry 4.0.
2. Discuss the system concept of production with a detailed explanation of inputs, processes, outputs, control, and feedback.
3. Describe the role and responsibilities of a production manager in a global manufacturing organization.
4. Elucidate the different types of production systems and compare their advantages and disadvantages.
5. Analyse the major challenges faced by modern production systems in the context of globalization and digital technologies.

7. REFERENCE BOOKS

1. Panneerselvam, R. *Production and Operations Management*, Prentice Hall India.
2. Chase, Jacobs & Aquilano. *Operations Management for Competitive Advantage*, Tata McGraw-Hill.
3. Stevenson, W. J. *Operations Management*, Richard Irwin.
4. Monks, J. G. *Operations Management – Theory and Problems*.
5. Buffa & Sarin, *Modern Production/Operations Management*.

LESSON -2

PRODUCTIVITY AND WORLD-CLASS MANUFACTURING

1. OBJECTIVES OF THE LESSON

- To understand the meaning, concept, and significance of productivity in production and operations management.
- To explain different types and measures of productivity used in industries.
- To describe the factors influencing productivity at organizational and national levels.
- To discuss contemporary productivity improvement methods in manufacturing and service sectors.
- To introduce the philosophy, principles, and practices of World-Class Manufacturing (WCM).
- To relate the role of productivity and WCM in achieving global competitiveness.

2. STRUCTURE OF THE LESSON

1. Introduction
2. Concept and Meaning of Productivity
3. Types of Productivity
4. Factors Affecting Productivity
5. Measurement of Productivity
6. Productivity Improvement Techniques
7. Concept of World-Class Manufacturing
8. Elements of World-Class Manufacturing
9. Benefits and Challenges of WCM
10. Summary
11. Key Words
12. Self-Assessment Questions
13. Reference Books

3.1 Introduction

Productivity is one of the most important performance indicators for any business or national economy. It reflects the relationship between the inputs used in a production system and the amount of output generated. A productive organization can manufacture more goods or deliver more services with the same amount of resources, thereby improving its competitiveness and profitability. Productivity gains reduce costs, enhance customer satisfaction, improve employee morale, and strengthen the organization's position in domestic and international markets.

The concept of productivity became highly significant during the Industrial Revolution, when machines replaced manual labour and output increased dramatically. Over time, managers realized that productivity is not only influenced by technology but also by the skills of workers, quality of raw materials, process design, maintenance, and innovation. Today, productivity is considered a strategic tool for achieving global competitiveness, especially for countries seeking to strengthen their manufacturing base.

In the globalized business environment, firms face unprecedented competition, forcing them to continuously improve their productivity levels. Companies such as Toyota, Samsung, and General Electric achieved global leadership by focusing on productivity-enhancing techniques like lean manufacturing, Just-in-Time systems, flexible automation, and employee involvement. Thus, productivity is not merely a technical measure but a philosophy that reflects the organization's commitment to excellence, efficiency, and continuous improvement.

3.2 Concept and Meaning of Productivity

Productivity refers to the ratio of output to inputs used in the production process. It measures how effectively an organization utilizes its resources. A higher productivity value indicates that fewer inputs are required to produce the same level of output or more output is produced with the same resources.

In simple terms:

Productivity = Output / Input

This basic definition applies across industries—manufacturing, agriculture, construction, and services. Productivity should not be confused with production. Production refers to the volume of goods or services produced, whereas productivity refers to the efficiency with which resources are used. For example, if a factory produces 500 units in 10 hours, productivity measures how efficiently labour, machines, materials, and time contributed to that production.

The importance of productivity lies in its impact on profitability, cost reduction, competitiveness, and national economic growth. Countries with higher productivity, such as Japan, Germany, South Korea, and the United States, enjoy higher income levels, better living standards, and stronger global positions.

3.3 Types of Productivity

There are several types of productivity measures, each focusing on a specific input or combination of inputs. These include:

a. Labour Productivity

Labour productivity measures the output per worker or per labour hour. It helps organizations understand the efficiency of their workforce.

Example:
If 10 workers produce 200 units per day, labour productivity is 20 units per worker.

Labour productivity is influenced by worker skills, training, motivation, tools, and workplace environment.

b. Capital Productivity

Capital productivity measures the output generated by machinery, equipment, and technology. Modern industries invest heavily in automation, robotics, and IT systems to improve capital productivity.

c. Material Productivity

This measures how efficiently raw materials are used in production. High material waste reduces productivity. Industries aim to reduce scrap, rework, and defective products.

d. Total Factor Productivity (TFP)

TFP is a comprehensive measure that considers multiple inputs—labour, capital, materials, energy, and technology. It reflects the overall efficiency of a system and is widely used in macroeconomic analysis.

e. Machine Productivity

Machine productivity indicates how effectively machines are utilized. High breakdowns, idle time, or poor scheduling reduce machine productivity.

3.4 Factors Affecting Productivity

Productivity is influenced by both internal and external factors.

1. Internal Factors

These are within the control of the organization:

- **Technology and automation**: Advanced machinery and digital tools improve efficiency.
- **Workforce skills and training**: Skilled labour performs tasks faster and with fewer errors.
- **Materials and quality**: High-quality materials reduce rework and waste.

- **Process design**: Efficient workflows reduce delays and bottlenecks.
- **Maintenance**: Preventive maintenance reduces downtime and increases equipment life.
- **Work environment**: Good lighting, ventilation, safety, and ergonomics enhance performance.
- **Management policies**: Fair incentives, delegation, and leadership style affect employee motivation.

2. External Factors

These affect productivity indirectly:

- Government industrial policies
- Tax structures
- Availability of power, transport, and infrastructure
- Market conditions
- Competition
- Global economic trends

Productivity improvement requires coordinated efforts at both micro (organizational) and macro (national) levels.

3.5 Measurement of Productivity

Measuring productivity is important for identifying inefficiencies, setting performance targets, and planning improvements. Productivity can be measured in several ways depending on the industry.

a. Single-Factor Productivity

Measures output relative to one input, such as labour or materials.

Example:

$$\text{Output} = 1000 \text{ units}$$

$$\text{Labour hours} = 250$$

Labour productivity = 1000 / 250 = 4 units per hour

b. Multifactor Productivity

Measures output relative to a combination of several inputs.

c. Total Factor Productivity

TFP = Output / (Labour + Capital + Material + Energy)

Accurate measurement requires reliable data on input costs, usage, and output levels.

3.6 Productivity Improvement Techniques

Improving productivity is a continuous and systematic effort. Major techniques include:

1. Work Study

Work study includes method study and work measurement. Method study evaluates the best way of performing a task, while work measurement determines the standard time required to complete it.

2. Automation and Technology Upgradation

Automation reduces human error and increases speed. Robots are widely used in automobile manufacturing for welding, painting, and assembly.

3. Quality Management

Improving quality reduces waste. Total Quality Management (TQM) and Six Sigma focus on defect reduction and customer satisfaction.

4. Lean Manufacturing

Lean eliminates waste in all forms—overproduction, waiting time, unnecessary motion, excess inventory, and defective goods.

5. Kaizen and Continuous Improvement

Kaizen encourages small, incremental improvements at all levels of the organization.

6. Better Maintenance

Preventive and predictive maintenance ensure continuous machine availability.

7. Employee Involvement

Employee empowerment and teamwork enhance productivity through ownership and motivation.

3.7 Concept of World-Class Manufacturing

World-Class Manufacturing (WCM) is a philosophy that enables companies to compete successfully on a global scale. It involves adopting best practices from leading manufacturers worldwide to achieve excellence in cost, quality, delivery, flexibility, and innovation.

WCM emerged from Japan’s manufacturing revolution, particularly from Toyota’s Production System (TPS). Companies adopting WCM strive for:

- Zero defects
- Zero waste

- Zero breakdowns
- Zero inventory
- High flexibility
- High customer focus

WCM demands a cultural transformation, involving top management commitment, employee involvement, and continuous improvement.

3.8 Elements of World-Class Manufacturing

The major elements of WCM include:

1. Just-in-Time (JIT)

JIT eliminates waste by producing only what is required, in the exact quantity, and at the right time.

2. Total Quality Management (TQM)

TQM ensures every employee participates in improving quality through systematic problem-solving.

3. Lean Manufacturing

Lean focuses on eliminating non-value-added activities.

4. Benchmarking

Comparing performance with the best organizations globally and adopting superior practices.

5. Employee Empowerment

Employees are trained, motivated, and involved in decision-making.

6. Flexible Manufacturing Systems (FMS)

These systems quickly adapt to product variations with minimal downtime.

7. Total Productive Maintenance (TPM)

TPM involves all employees in maintenance activities to ensure zero breakdowns.

8. Customer-Driven Production

Meeting and exceeding customer expectations is central to WCM.

3.9 Benefits and Challenges of World-Class Manufacturing

Benefits

- Improved quality and reduced defects
- Lower operational costs
- Faster response to customer demands
- Higher flexibility in production
- Stronger global competitiveness
- Improved employee morale and teamwork

Challenges

- High initial investment
- Need for cultural change
- Requirement of skilled workforce
- Resistance to change
- Complex coordination across departments

Despite challenges, WCM is essential for surviving in a highly competitive global environment.

4. SUMMARY

This lesson explained the concept of productivity, its importance, and various methods used to measure and improve it. Productivity influences the cost, quality, competitiveness, and long-term sustainability of organizations. Several factors—technological, human, material, and managerial—affect productivity. The lesson also introduced World-Class Manufacturing, a comprehensive management philosophy that focuses on global excellence through lean systems, continuous improvement, quality enhancement, and customer focus. Together, productivity and WCM enable organizations to compete effectively in both domestic and international markets.

5. KEY WORDS

Productivity
Labour Productivity
Total Factor Productivity
Lean Manufacturing
Kaizen
Just-in-Time
Total Quality Management
World-Class Manufacturing

6. SELF-ASSESSMENT QUESTIONS

Short Answer Questions

1. Define productivity.
2. What is labour productivity?
3. State any two internal factors affecting productivity.
4. What is the meaning of world-class manufacturing?
5. Write a short note on Kaizen.

Essay Questions

1. Explain the various types of productivity with suitable examples.
2. Discuss factors affecting productivity at organizational and national levels.
3. Describe different productivity improvement techniques used in industries.
4. Explain the concept and components of world-class manufacturing.
5. Evaluate the relevance of world-class manufacturing in today's competitive global environment.

7. REFERENCE BOOKS

1. Panneerselvam, R. *Production and Operations Management*, Prentice Hall India.
2. Chase, Jacobs & Aquilano. *Operations Management for Competitive Advantage*, McGraw-Hill.
3. Stevenson, W. J. *Operations Management*.
4. Monks, J. G. *Operations Management – Theory and Problems*.
5. Schonberger, R. *World-Class Manufacturing*.

LESSON -3

PROCESS PLANNING, PROCESS DESIGN & MAKE-OR-BUY DECISIONS

1. OBJECTIVES OF THE LESSON

- To explain the meaning and importance of process planning in production and operations management.
- To describe various stages and elements involved in designing a manufacturing or service process.
- To understand the principles and methods of selecting an appropriate production process.
- To discuss the concepts and applications of Value Analysis (VA) and Value Engineering (VE).
- To analyze the strategic and economic considerations involved in make-or-buy decisions.
- To highlight the role of process planning and design in improving productivity and competitiveness.

2. STRUCTURE OF THE LESSON

1. Introduction
2. Concept and Meaning of Process Planning
3. Objectives and Importance of Process Planning
4. Steps in Process Planning
5. Factors Influencing Process Selection
6. Concept and Meaning of Process Design
7. Process Design in Manufacturing and Services
8. Tools and Techniques Used in Process Design
9. Value Analysis and Value Engineering
10. Make-or-Buy Decisions: Concepts and Determinants
11. Strategic Implications of Make-or-Buy Decisions

12. Summary

13. Key Words

14. Self-Assessment Questions

15. Reference Books

3.1 Introduction

Process planning and design form the backbone of production and operations management. They determine how an organization converts raw materials into finished products or delivers services to customers. A well-designed process ensures that production activities are conducted efficiently, cost-effectively, and with consistent quality. Process planning involves identifying the sequence of operations, tools, machines, materials, and methods required to produce a product. It bridges the gap between product design and actual production.

In today's competitive global market, customers expect high quality, shorter lead time, customization, and cost-effective products. To meet these expectations, organizations must develop production processes that are flexible, technologically advanced, and optimized for speed and efficiency. Effective process planning reduces waste, lowers cost, improves productivity, and enhances competitiveness. Modern tools such as computer-aided process planning, flexible manufacturing systems, robotics, and automation have further transformed process design. The lesson explores these aspects in detail.

3.2 Concept and Meaning of Process Planning

Process planning refers to determining the most effective and economical method to produce a product or deliver a service. It establishes the route or pathway that a product must follow from raw material to finished good. It includes the selection of materials, machines, operations, sequence of operations, tools, jigs, fixtures, inspection methods, and quality control procedures.

In simple terms, **process planning converts product specifications into detailed manufacturing instructions.**

Process planning acts as a roadmap for the manufacturing floor and ensures uniformity, efficiency, and cost-effectiveness. It is a crucial link between product design and actual production.

3.3 Objectives and Importance of Process Planning

Process planning serves multiple objectives that contribute to the efficiency of production operations.

1. To determine the best manufacturing method

Choosing the right method ensures higher productivity and lower cost.

2. To select suitable tools and equipment

Proper tool selection minimizes machine breakdowns and enhances output quality.

3. To minimize manufacturing costs

Efficient processes reduce waste, rework, and idle time.

4. To standardize operations

Standardization results in consistent product quality.

5. To improve production efficiency

Well-planned processes reduce bottlenecks and ensure smooth workflow.

6. To facilitate training and supervision

Clear process instructions help new workers learn operations faster.

7. To enhance flexibility

Well-designed processes can adapt to technological changes and market variations.

3.4 Steps in Process Planning

Process planning involves a systematic sequence of activities:

1. Study of Product Design

The planner studies product drawings, specifications, tolerances, and customer requirements.

2. Selection of Raw Materials

Material properties such as strength, durability, machinability, and cost are considered.

3. Selection of Manufacturing Processes

The planner identifies whether casting, forging, machining, welding, injection moulding, or other methods will be used.

4. Determination of Operation Sequence

The correct order of operations is established. Example: cutting → shaping → drilling → inspection → assembly.

5. Selection of Machines and Tools

Machines are chosen based on speed, accuracy, and capacity requirements.

6. Determination of Standard Time

Work measurement techniques are used to set the time required for each operation.

7. Estimation of Costs

Material, labour, overhead, and machine costs are calculated.

8. Preparation of Process Sheet

The final process plan is documented for production personnel.

Effective process planning ensures that operations are aligned with organizational goals of quality, speed, and cost minimization.

3.5 Factors Influencing Process Selection

Selecting the right process is critical for achieving operational efficiency. The choice depends on several factors:

a. Nature of the Product

Simple products may require minimal processing, while complex products require advanced technology.

b. Production Volume

Mass production requires highly automated processes, while job production requires flexible processes.

c. Cost Considerations

Processes must be chosen to minimize total cost (material, labour, overhead, maintenance).

d. Flexibility Requirements

Companies producing customized goods need flexible systems.

e. Technology Availability

Access to tools, software, machines, and expertise affects process selection.

f. Quality Requirements

Industries such as aerospace and medical equipment require ultra-precision processes.

g. Layout and Facility Constraints

Space and infrastructure limit the use of certain processes.

All these factors have long-term implications for productivity and profitability.

3.6 Concept and Meaning of Process Design

Process design refers to developing efficient and effective production processes that convert inputs into outputs. It involves determining:

- How operations will be performed

- Which workflows will be adopted
- What equipment will be used
- How material and information will flow
- How quality will be controlled

Process design aims to achieve customer satisfaction by ensuring consistent quality, low cost, flexibility, and fast delivery.

Process Design in Manufacturing

Manufacturing process design involves decisions related to:

- Equipment selection
- Plant layout
- Automation level
- Machine capacity
- Workstation design
- Material handling systems

Process Design in Services

Service industries design processes relating to:

- Customer interaction
- Service layout (e.g., hospitals, banks, hotels)
- Waiting lines (queuing models)
- Scheduling
- Standardization of service delivery

Thus, process design is essential for both manufacturing and service operations.

3.7 Tools and Techniques Used in Process Design

Several tools assist in designing efficient processes:

1. Process Mapping

Graphical representation of the flow of materials and information.

2. Flow Charts

Show operational steps in sequence.

3. Value Stream Mapping

Identifies value-added and non-value-added steps.

4. Computer-Aided Process Planning (CAPP)

Automates the process planning task using software.

5. Time and Motion Study

Determines the best method and standard time for operations.

6. Simulation

Predicts the performance of different process scenarios.

7. Work Sampling

Estimates the proportion of time spent on various activities.

Using these tools reduces inefficiencies and supports continuous improvement.

3.8 Value Analysis and Value Engineering

Concept of Value

Value refers to the ratio of function to cost:

Value = Function / Cost

If function increases or cost decreases, value improves.

Value Analysis (VA)

Value Analysis is applied to existing products. It aims to reduce cost without affecting product performance.

Value Engineering (VE)

Value Engineering is applied during product design. It seeks to achieve the required function at the lowest cost even before production begins.

Benefits of VA/VE

- Reduction in manufacturing cost
- Improved product quality
- Enhanced reliability
- Elimination of unnecessary features
- Better use of materials and resources

VA/VE are powerful tools for achieving competitive advantage.

3.9 Make-or-Buy Decisions: Concepts and Determinants

Make-or-buy decision refers to the strategic choice between manufacturing a component in-house or purchasing it from an external supplier.

When to "Make" In-House:

- When quality control is critical.
- When organization has specialized technology.
- When capacity utilization is required.
- When intellectual property must be protected.
- When cost advantage exists.

When to "Buy" from Outside:

- When suppliers offer lower cost.
- When production volume is low.
- When specialized skills are required.
- When the firm wants to reduce burden of overheads.
- When flexibility and speed are important.

3.10 Strategic Implications of Make-or-Buy Decisions

Make-or-buy decisions have long-term effects on cost structure, quality, competitiveness, and flexibility.

Strategic implications include:

- Impact on supply chain structure
- Dependence on external suppliers
- Control over technology and quality
- Cost and profitability implications
- Effect on workforce and capacity planning
- Risk associated with outsourcing

Modern companies often adopt a hybrid strategy, making core components in-house and outsourcing non-core parts.

4. SUMMARY

This lesson explored the detailed concepts of process planning and process design, which are essential for efficient production. It explained how process planning converts product design into operational instructions and how process design determines the workflow, equipment, and technology needed to produce goods or services. The lesson highlighted the significance of value analysis and value engineering for improving product value and reducing cost. A detailed discussion was provided on make-or-buy decisions, which influence cost, quality, technology, and competitiveness. In a global marketplace, effective process planning and design play a critical role in achieving operational excellence.

5. KEY WORDS

Process	Planning
Process	Design
Value	Analysis
Value	Engineering
Make-or-Buy	Decision
Process	Selection
Flow	Chart
CAPP	
Workflow	

6. SELF-ASSESSMENT QUESTIONS

Short Answer Questions

1. What is process planning?
2. Define process design.
3. Mention any two factors affecting process selection.
4. What is value engineering?
5. What do you understand by a make-or-buy decision?

Essay Questions

1. Explain the steps involved in process planning with suitable examples.
2. Discuss the tools and techniques used for process design in manufacturing.
3. Describe value analysis and value engineering and explain their role in cost reduction.

4. What are make-or-buy decisions? Discuss their strategic implications.
5. Compare process design in manufacturing and service industries with examples.

7. REFERENCE BOOKS

1. Panneerselvam, R. *Production and Operations Management*, PHI.
2. Chase, Jacobs & Aquilano. *Operations Management for Competitive Advantage*.
3. Stevenson, W. J. *Operations Management*.
4. Monks, J. G. *Operations Management: Theory and Problems*.
5. Buffa & Sarin. *Modern Production/Operations Management*.

LESSON -4

FACILITY LOCATION

1. OBJECTIVES OF THE LESSON

- To explain the meaning and significance of facility location in production and operations management.
- To describe the various factors that influence the selection of a plant or service facility location.
- To discuss the types of location decisions and their importance in long-term strategic planning.
- To examine different quantitative and qualitative methods used in evaluating facility location options.
- To highlight the role of break-even analysis in comparing alternative plant locations.
- To illustrate the consequences of poor location decisions on cost, productivity, and competitiveness.

2. STRUCTURE OF THE LESSON

1. Introduction
2. Concept and Meaning of Facility Location
3. Types of Location Decisions
4. Importance of Facility Location
5. Factors Influencing Facility Location
6. Location Planning for Manufacturing vs. Services
7. Location Analysis Techniques
8. Break-Even Analysis for Facility Location
9. Challenges in Facility Location Decisions
10. Summary
11. Key Words
12. Self-Assessment Questions
13. Reference Books

3.1 Introduction

Facility location is one of the most critical long-term strategic decisions in production and operations management. It involves selecting the most suitable geographical site for establishing a factory, office, warehouse, retail store, hospital, or service centre. A well-chosen location increases operational efficiency, reduces costs, and provides access to markets and resources. Poor location decisions, on the other hand, can lead to increased transportation costs, high labour turnover, supply shortages, and reduced competitiveness.

Location decisions are not easily reversible. Once a plant or facility is established, relocating it requires significant financial investment, time, and administrative procedures. Therefore, organizations conduct detailed location analysis to identify the best possible site from several alternatives. Factors such as proximity to raw materials, availability of labour, infrastructure facilities, government policies, environmental factors, and market accessibility play a vital role in this analysis.

In an era of globalization, multinational corporations strategically select plant locations across countries to take advantage of lower production costs, tax benefits, access to skilled labour, and closeness to international markets. Examples include global electronics companies establishing plants in China, Vietnam, and India, and automobile companies setting up manufacturing clusters in Mexico, Eastern Europe, and Southeast Asia. Thus, facility location is a strategic decision that has far-reaching implications for competitiveness and efficiency.

3.2 Concept and Meaning of Facility Location

Facility location refers to the process of identifying the most suitable geographical site for establishing an organization's operations. It involves determining where to situate the plant or service unit so that operations are efficient and cost-effective.

In manufacturing, facility location determines the physical site of the factory, warehouse, or distribution centre. In service organizations, it determines where the service facility such as a hospital, bank, retail store, or educational institution should be located to conveniently serve customers.

Facility location decisions answer questions such as:

- Where should we locate our manufacturing plant?
- Should we locate near raw material sources or near markets?
- Which region or state offers better incentives and labour availability?
- What is the cost of land, power, taxes, and transportation?
- What facilities and services does the region provide?

The objective of facility location is to identify a site that minimizes cost and maximizes customer service and productivity.

3.3 Types of Location Decisions

Location decisions can be classified into the following types:

1. New Location

When a company begins operations for the first time or expands by setting up a new facility, it must choose a fresh site.

2. Relocation

Sometimes companies shift from one site to another due to unfavourable conditions such as rising costs, lack of skilled labour, or inadequate infrastructure.

3. Expansion at Existing Location

Instead of moving, an organization may expand by adding more buildings, machinery, or departments.

4. Multi-Plant Location

Large organizations may open multiple plants in different regions to reduce costs and reach customers faster.

5. Global Location

Companies may choose international locations to benefit from foreign markets, tax concessions, low-wage labour, or availability of raw materials.

Each type of location decision requires careful evaluation of internal and external factors.

3.4 Importance of Facility Location

Facility location has long-term consequences for cost and performance. A good location provides the following benefits:

a. Cost Reduction

Transportation cost, labour cost, and rent vary from place to place. Selecting a cost-efficient site reduces overall production expenses.

b. Availability of Labour

Locating in regions with skilled labour ensures high productivity and lower training costs.

c. Market Proximity

Being closer to customers reduces delivery time and transportation expenses.

d. Access to Inputs

Raw materials and suppliers are easily accessible at some locations, making operations smoother.

e. Better Infrastructure

Facilities such as power supply, water, roads, ports, and telecommunication are crucial for smooth operations.

f. Competitive Advantage

Strategically located facilities help companies respond faster to market demands and outperform competitors.

g. Favourable Government Policies

Tax incentives, subsidies, and relaxed regulations help organizations reduce costs.

Thus, choosing the right facility location is essential for achieving operational excellence.

3.5 Factors Influencing Facility Location

Facility location decisions are influenced by various factors, which vary according to the nature of the business. These include:

1. Raw Material Availability

Industries such as steel, cement, and food processing depend heavily on raw materials. Locating near raw material sources reduces transportation cost.

2. Labour Availability

Availability of skilled, semi-skilled, and unskilled labour is crucial.

3. Transportation Facilities

Good road, rail, air, and port facilities reduce logistic delays and costs.

4. Infrastructure

Reliable power, water supply, waste disposal, and telecommunication are necessary.

5. Market Proximity

Industries producing perishable goods prefer locations near markets.

6. Government Policies

Tax exemptions, subsidies, industrial estates, and relaxed labour laws attract industries.

7. Climate and Environmental Conditions

Some industries require specific climatic conditions. Also, pollution control norms restrict certain industries.

8. Community and Social Factors

Local attitudes, lifestyle, and living standards influence worker availability and productivity.

9. Cost of Land and Construction

Land prices and rental costs vary across regions.

10. Safety and Risk Factors

Regions prone to floods, earthquakes, or political instability may not be suitable.

A combination of these factors is evaluated before finalizing the location.

3.6 Location Planning for Manufacturing vs. Services

Manufacturing Location Decisions

Manufacturing facilities focus on:

- Control of production cost
- Proximity to raw materials
- Large land area
- Infrastructure
- Access to suppliers
- Transportation costs
- Skilled labour

Since manufacturing plants do not require close customer contact, they can be located in remote areas if resources and infrastructure are available.

Service Location Decisions

Service facilities depend on:

- Customer accessibility
- Visibility and convenience
- Traffic patterns
- Population density
- Competition
- Local demand

Examples:

- Banks prefer commercial areas
- Hospitals choose central locations

- Retail outlets need high footfall

Thus, manufacturing focuses on cost and logistics, while services focus on customer convenience.

3.7 Location Analysis Techniques

Organizations use several methods to evaluate alternative locations.

1. Factor Rating Method

Factors are assigned weights and scores. The location with the highest total score is selected.

2. Cost-Benefit Analysis

All costs (land, labour, transport) are compared across alternative sites.

3. Centre-of-Gravity Method

Used for locating warehouses and distribution centres based on transportation cost minimization.

4. Break-Even Analysis

Used to compare costs at different locations and determine where profits will be maximized.

5. Trade-Off Analysis

Evaluates trade-offs between cost, accessibility, labour, and infrastructure.

6. Geographic Information Systems (GIS)

GIS helps analyze population density, traffic, distances, and environmental factors.

Each technique provides a different perspective for decision-making.

3.8 Break-Even Analysis for Facility Location

Break-even analysis is a quantitative tool that compares fixed and variable costs across alternative locations. It helps identify which location will be more profitable under different levels of production.

Steps:

1. Identify fixed and variable costs for each location.
2. Determine expected selling price and production volume.
3. Plot total revenue and total cost lines.
4. The break-even point indicates where total cost equals total revenue.
5. The location with the lowest break-even point or highest profit is chosen.

Break-even analysis is particularly useful when locations differ significantly in land price, labour cost, or operational expenses.

3.9 Challenges in Facility Location Decisions

Organizations face several challenges:

a. Uncertainty

Future demand, labour availability, and government policies may change.

b. Global Competition

Companies must evaluate international locations, which adds complexity.

c. Environmental Regulations

Strict pollution norms may restrict certain industries.

d. Land Acquisition Issues

Legal and social conflicts may arise in land acquisition.

e. High Fixed Costs

Relocation or expansion requires large investments.

f. Community Resistance

Communities may oppose hazardous or polluting industries.

Despite these challenges, a systematic approach helps organizations make optimal location decisions.

4. SUMMARY

Facility location is a strategic decision that determines the geographical placement of a company's production or service operations. It has a long-term impact on cost, productivity, customer service, and competitiveness. Several factors such as labour availability, infrastructure, raw materials, transportation, market proximity, government policies, and environmental conditions influence location decisions. Organizations use various analytical techniques such as factor rating, cost-benefit analysis, centre-of-gravity method, and break-even analysis to evaluate alternative sites. Effective location planning helps organizations minimize cost, ensure timely delivery, and achieve operational efficiency.

5. KEY WORDS

Facility Location
Plant Location

Factor Rating
Break-Even Analysis
Infrastructure
Market Proximity
Global Location
Cost-Benefit Analysis

6. SELF-ASSESSMENT QUESTIONS

Short Answer Questions

1. Define facility location.
2. Mention any two factors influencing plant location.
3. What is break-even analysis?
4. Differentiate between manufacturing and service location decisions.
5. What is a factor rating method?

Essay Questions

1. Discuss the importance of facility location in production and operations management.
2. Explain various factors influencing facility location decisions.
3. Describe different location analysis techniques used by organizations.
4. Illustrate how break-even analysis assists in selecting the best plant location.
5. Compare global location decisions with domestic location decisions.

7. REFERENCE BOOKS

1. Panneerselvam, R. *Production and Operations Management*, PHI.
2. Stevenson, W. J. *Operations Management*, McGraw-Hill.
3. Chase, Jacobs & Aquilano. *Operations Management for Competitive Advantage*.
4. Buffa & Sarin. *Modern Production/Operations Management*.
5. Heizer, J. & Render, B. *Operations Management*.

LESSON -5

FACILITY LAYOUT AND LINE BALANCING

1. OBJECTIVES OF THE LESSON

- To understand the meaning and significance of facility layout in production and service organizations.
- To describe various types of facility layouts and their suitability for different industries.
- To explain the procedure and principles behind systematic layout planning (SLP).
- To introduce computer-aided layout tools such as CRAFT, ALDEP, and CORELAP.
- To explain the concept of assembly lines and the need for line balancing.
- To discuss the role of line balancing in improving productivity, reducing idle time, and achieving smooth workflow.
- To highlight the relationship between layout planning, material flow, and operational efficiency.

2. STRUCTURE OF THE LESSON

1. Introduction
2. Concept and Meaning of Facility Layout
3. Objectives of Facility Layout
4. Importance of Effective Layout Planning
5. Types of Facility Layout
6. Process Layout
7. Product Layout
8. Group Technology (Cellular) Layout
9. Principles of Good Layout
10. Systematic Layout Planning (SLP)
11. Computer-Aided Layout Techniques: CRAFT, ALDEP, CORELAP
12. Concept of Assembly Line
13. Line Balancing: Meaning and Purpose
14. Methods of Line Balancing
15. Mass Production and its Relevance

16. Summary
17. Key Words
18. Self-Assessment Questions
19. Reference Books

3.1 Introduction

Facility layout refers to the physical arrangement of machines, equipment, workstations, storage areas, material handling systems, and service departments within a plant or service facility. Effective layout planning is essential for achieving smooth workflow, minimizing material movement, reducing production costs, and ensuring worker safety. Layout decisions directly influence the efficiency of operations, the speed of production, and the overall productivity of the system.

In manufacturing, layout planning ensures that raw materials move through processes in a logical sequence with minimal delays. In service organizations such as hospitals, banks, and restaurants, layout design ensures customer convenience, employee efficiency, and smooth service delivery.

Similarly, assembly lines are widely used in mass production industries such as automotive manufacturing, electronics, and household appliances. Line balancing ensures that work is evenly distributed across all stations, eliminating bottlenecks and idle time. Together, facility layout and line balancing form the backbone of efficient production systems.

3.2 Concept and Meaning of Facility Layout

Facility layout refers to the arrangement of physical facilities such as machines, tools, storage areas, and workstations in a plant. The purpose is to ensure the most efficient flow of materials, people, and information throughout the production process.

A good layout reduces material handling cost, minimizes delays, ensures safety, and improves employee morale. Poor layout results in congestion, unnecessary movement, higher cost, and lower productivity.

Facility layout is required when:

- A new plant is built
- A new product is introduced
- The volume of production changes
- The existing layout becomes inefficient
- New technology is introduced

3.3 Objectives of Facility Layout

The major objectives of effective facility layout include:

1. Minimizing Material Handling

Reducing movement of materials lowers cost and increases efficiency.

2. Efficient Use of Space

Optimal utilization of floor area reduces construction and rental cost.

3. Smooth Workflow

Logical sequence of operations reduces bottlenecks and delays.

4. Worker Safety and Comfort

Proper design reduces accidents and improves morale.

5. Increased Flexibility

Layouts should adapt easily to product and process changes.

6. Better Supervision

Clear visibility across work areas helps supervisors monitor activities effectively.

7. Improved Productivity

Efficient layout reduces idle time and increases output.

3.4 Importance of Effective Layout Planning

Effective layout planning contributes to:

- Lower production and operating cost
- Improved product quality
- Reduced cycle time
- Better employee morale
- Higher capacity utilization
- Reduced inventory and waiting time
- Enhanced customer satisfaction in services

Given its importance, layout planning is one of the most critical decisions in production management.

3.5 Types of Facility Layout

There are three primary types of layout used in industries:

1. **Process Layout (Functional Layout)**
2. **Product Layout (Line Layout)**
3. **Group Technology / Cellular Layout**

Each type has distinct features, advantages, and limitations.

3.6 Process Layout

A process layout groups similar machines or processes together. It is suitable for industries where products are manufactured in small batches or customized according to customer requirements.

Characteristics:

- Machines performing similar operations are grouped (e.g., drilling machines in one area).
- Material moves between departments depending on the product route.
- High flexibility for different products.
- Work-in-progress inventory is usually high.

Examples:

- Machine shops
- Hospitals (similar wards grouped)
- Universities (departments grouped by subjects)

Advantages:

- High flexibility
- Better utilization of machines
- Customization is possible

Limitations:

- Complex material handling
- Higher production time
- Low production planning efficiency

3.7 Product Layout

In product layout, machines and workstations are arranged according to the sequence of operations required for a specific product. It is suitable for mass production of standardized products.

Characteristics:

- Linear arrangement of machines
- Continuous flow of materials
- Low material handling cost
- High degree of automation

Examples:

- Automobile assembly lines
- Electronics manufacturing
- Bottling plants

Advantages:

- High efficiency
- Low material handling cost
- Easy supervision
- Lower work-in-progress inventory

Limitations:

- Low flexibility
- High initial investment
- Breakdown at one station affects the entire line

3.8 Group Technology (Cellular) Layout

Group Technology (GT) layout combines the advantages of both process and product layouts. It groups parts with similar characteristics into families and arranges their machines into cells.

Characteristics:

- Product families processed in cells
- Reduced movement within the cell

Advantages:

- Reduced setup time
- Lower material movement
- Improved quality

Limitations:

- Requires detailed analysis of part characteristics
- High initial cost

3.9 Principles of Good Layout

Some important principles include:

- Minimum movement of materials
- Straight-line flow
- Space for future expansion
- Smooth and continuous flow
- Safety and comfort for workers
- Efficient utilization of machines and labour

3.10 Systematic Layout Planning (SLP)

Systematic Layout Planning is a step-by-step approach used to design efficient layouts. Developed by Richard Muther, SLP uses a flow-based analysis to determine the best arrangement of facilities.

Steps in SLP:

1. Identify input data (products, volume, routing).
2. Determine activity relationships.
3. Develop relationship diagrams.
4. Create layout alternatives.
5. Evaluate alternatives based on cost and feasibility.
6. Select the best layout.

SLP provides a structured and logical framework for layout planning.

3.11 Computer-Aided Layout Tools: CRAFT, ALDEP, CORELAP

1. CRAFT (Computerized Relative Allocation of Facilities Technique)

This tool improves an initial layout by making iterative changes to reduce material handling cost.

2. ALDEP (Automated Layout Design Program)

Generates layout alternatives based on closeness ratings and material flow.

3. CORELAP (Computerized Relationship Layout Planning)

Focuses on relationship data (closeness ratings) to develop block layouts.

These tools help reduce time and errors in layout planning.

3.12 Concept of Assembly Line

An assembly line is a series of sequential workstations where specific operations are performed to assemble a product. Each station performs a small portion of the total task, and the product moves from one station to another.

Examples:

- Automobile manufacturing
- Smartphone assembly
- Home appliances

Assembly lines are ideal for mass production of standardized goods.

3.13 Line Balancing: Meaning and Purpose

Line balancing refers to assigning tasks to workstations in such a way that each workstation has approximately equal workload. The aim is to minimize idle time and ensure smooth production flow.

Objectives of Line Balancing:

- Reduce bottlenecks
- Increase production rate
- Minimize workstation idle time
- Improve labour and machine utilization
- Reduce cost per unit

Good line balancing improves overall plant productivity.

3.14 Methods of Line Balancing

1. Heuristic Methods

Simple rules such as:

- Largest Candidate Rule
- Kilbridge and Wester Method
- Ranked Positional Weight Method

2. Analytical Methods

These involve mathematical optimization but are more complex.

3.15 Mass Production and its Relevance

Mass production involves producing large volumes of standardized goods using highly automated equipment and assembly lines. It is relevant when:

- Demand is stable
- Products are standardized
- Large-scale production reduces cost

Mass production is used in industries such as automobiles, FMCG, electronics, and textiles.

4. SUMMARY

This lesson covered in detail the concepts of facility layout, its importance, and various types used in industries. Process, product, and group technology layouts suit different production environments depending on product variety and volume. Systematic Layout Planning provides a structured approach to designing efficient layouts. Computer-aided tools such as CRAFT, ALDEP, and CORELAP support faster and more accurate layout decisions. The lesson also explained assembly lines used in mass production systems and the importance of line balancing in improving productivity, reducing idle time, and achieving efficient workflow.

5. KEY WORDS

Facility Layout
Process Layout
Product Layout
Group Technology Layout
Systematic Layout Planning
CRAFT
ALDEP
CORELAP
Assembly Line
Line Balancing

6. SELF-ASSESSMENT QUESTIONS

Short Answer Questions

1. Define facility layout.
2. What is a process layout?
3. Mention two advantages of product layout.
4. What is an assembly line?
5. What is line balancing?

Essay Questions

1. Explain the different types of facility layouts with suitable examples.
2. Discuss the principles and objectives of good layout planning.
3. Describe Systematic Layout Planning (SLP) and explain its steps.
4. Explain line balancing and its importance in assembly line production.
5. Compare process layout and product layout in detail.

7. REFERENCE BOOKS

1. Panneerselvam, R. *Production and Operations Management*, PHI.
2. Stevenson, W. J. *Operations Management*, McGraw-Hill.
3. Chase, Jacobs & Aquilano. *Operations Management for Competitive Advantage*.
4. Buffa & Sarin. *Modern Production/Operations Management*.
5. Heizer & Render. *Operations Management*.

LESSON-6

MATERIALS MANAGEMENT AND INVENTORY CONTROL

1. OBJECTIVES OF THE LESSON

- To understand the concept, scope, and significance of materials management in production systems.
- To explain the components and functions of materials management.
- To describe the concept, need, and role of inventory in an organization.
- To understand various inventory models including purchase and manufacturing models.
- To discuss concepts like Economic Order Quantity (EOQ), instantaneous replenishment, and no-shortage models.
- To explain the principles and types of material handling systems.
- To highlight the importance of unit load concepts and classification of material handling equipment.

2. STRUCTURE OF THE LESSON

1. Introduction
2. Concept and Meaning of Materials Management
3. Scope and Functions of Materials Management
4. Objectives and Importance of Materials Management
5. Concept and Need for Inventory
6. Types of Inventory
7. Inventory Costs
8. Inventory Control Techniques
9. Economic Order Quantity (EOQ)
10. Purchase Model (Instantaneous Replenishment, No Shortage)
11. Manufacturing Model (No Shortage)
12. Concept of Material Handling
13. Material Handling Principles

14. Unit Load Concept
15. Classification of Material Handling Equipment
16. Summary
17. Key Words
18. Self-Assessment Questions
19. Reference Books

3.1 Introduction

Materials management plays a vital role in ensuring the smooth functioning of production and operations. It is concerned with the planning, sourcing, purchasing, moving, storing, and controlling of materials in an optimum manner. For any manufacturing industry, materials constitute a major portion of total production cost—usually between 50% to 70%. Therefore, effective management of materials helps reduce cost, avoid shortages, and improve production efficiency.

Inventory control, a major component of materials management, ensures that materials are available when needed and in the right quantity. Poor inventory management leads to production delays, increased carrying costs, and financial strain. On the other hand, too much inventory results in storage issues, wastage, and blocking of working capital.

Today's globally integrated supply chains demand advanced materials management strategies supported by modern tools such as ERP systems, Just-in-Time practices, automated storage systems, and barcoding technologies. This lesson explores these concepts in depth.

3.2 Concept and Meaning of Materials Management

Materials management refers to the process of planning, organizing, and controlling the flow of materials from their purchase to delivery to the finished goods stage. It ensures the availability of materials of the right quality, in the right quantity, at the right place, at the right time, and at the right cost.

It encompasses several activities such as:

- Forecasting material requirements
- Purchasing
- Receiving and inspection
- Inventory control
- Material handling
- Warehousing
- Disposal of scrap and surplus materials

Materials management is a strategic function because the performance of production systems depends heavily on the timely and efficient supply of materials.

3.3 Scope and Functions of Materials Management

Materials management covers a broad range of activities that ensure smooth production operations. The key functions include:

1. Materials Planning

Estimating the quantitative and qualitative requirements of materials based on production schedules.

2. Purchasing

Selecting suppliers, negotiating prices, and acquiring materials.

3. Inventory Control

Ensuring optimal inventory levels to avoid shortages or overstocking.

4. Receiving and Inspection

Checking materials for quality and quantity before storing.

5. Warehousing

Storing materials in an orderly and safe manner.

6. Material Handling

Moving materials from one place to another efficiently.

7. Standardization and Simplification

Reducing the variety of materials to improve efficiency.

8. Scrap and Surplus Disposal

Selling unused or waste materials profitably.

3.4 Objectives and Importance of Materials Management

Objectives:

- To ensure continuous supply of materials
- To minimize material cost
- To improve production efficiency
- To maintain optimal inventory levels

- To reduce wastage and pilferage
- To improve supplier relationships
- To enhance overall productivity

Importance:

- Reduces cost of production
- Improves working capital utilization
- Increases efficiency of purchase and storage
- Enhances customer satisfaction through timely delivery
- Reduces stockouts and production delays

Materials management has become increasingly important in modern industries that rely on global sourcing and just-in-time production systems.

3.5 Concept and Need for Inventory

Inventory refers to the stock of raw materials, components, work-in-progress, and finished goods stored for future use. Inventory acts as a buffer between supply and demand.

The need for inventory arises due to:

- Uncertainty in demand
- Unpredictable lead times
- Discounts from bulk purchases
- Maintaining continuous production
- Seasonal or cyclical variations

Without adequate inventory, production may stop, causing losses and customer dissatisfaction.

3.6 Types of Inventory

1. Raw Materials

Basic materials used in production.

2. Work-in-Progress (WIP)

Partially completed goods.

3. Finished Goods

Completed products ready for sale.

4. Maintenance, Repair, and Operating (MRO) Supplies

Items needed for support functions like tools and lubricants.

5. Pipeline Inventory

Inventory in transit between locations.

3.7 Inventory Costs

Inventory involves three main categories of costs:

1. Purchase or Production Cost

Cost of buying or manufacturing the product.

2. Ordering Cost

Cost incurred in placing and receiving orders such as paperwork, transportation, and administrative expenses.

3. Carrying (Holding) Cost

Includes:

- Storage cost
- Insurance cost
- Cost of capital
- Obsolescence cost
- Depreciation

4. Shortage Cost

Cost incurred due to stockouts, loss of sales, or production delays.

Minimizing total inventory cost is the objective of inventory control.

3.8 Inventory Control Techniques

Inventory control involves regulating inventory levels using various techniques:

1. ABC Analysis

Categorizes items into A (high value), B (medium value), and C (low value) for selective control.

2. VED Analysis

Classifies items into Vital, Essential, and Desirable (mainly used in hospitals).

3. FSN Analysis

Categories items based on movement frequency: Fast-moving, Slow-moving, Non-moving.

4. HML Analysis

Based on price—High, Medium, and Low.

5. Economic Order Quantity (EOQ)

Determines the most economical order quantity.

6. Just-in-Time (JIT)

Aiming for zero inventory through synchronization.

7. Two-Bin System

Simple method for replenishment.

These tools support efficient materials management by minimizing stockouts and reducing carrying costs.

3.9 Economic Order Quantity (EOQ)

EOQ is a widely used inventory model that determines the optimal order quantity that minimizes total cost (ordering + holding cost).
The classical EOQ formula assumes instantaneous replenishment and no shortages.

$$EOQ = \sqrt{(2DS / H)}$$

Where:

D = annual demand
S = ordering cost per order
H = holding cost per unit per year

The EOQ model helps organizations balance ordering frequency with carrying cost.

3.10 Purchase Model (Instantaneous Replenishment, No Shortage)

In this model, inventory is replenished instantly when an order is placed. There is no shortage allowed, and stock reaches its maximum level immediately after receipt.

Characteristics:

- Useful for items purchased from outside suppliers
- Constant demand
- Lead time known and predictable
- No backorders allowed

- Order arrives as a single lot

This model helps organizations determine the point at which new orders must be placed to avoid shortages.

3.11 Manufacturing Model (No Shortage)

Also known as the **Production Order Quantity Model**, this applies to items manufactured in-house rather than purchased.

Characteristics:

- Production rate (P) is higher than demand rate (D)
- Replenishment is gradual
- Inventory builds up slowly
- No shortages allowed

This model better reflects actual production systems where inventory accumulates gradually as items are produced.

3.12 Concept of Material Handling

Material handling involves the movement, protection, storage, and control of materials throughout the manufacturing process. It includes equipment like cranes, conveyors, forklifts, pallet trucks, and automated guided vehicles (AGVs).

Effective material handling improves productivity, reduces cost, and enhances safety.

3.13 Material Handling Principles

Some key principles include:

1. Planning Principle

Material handling must be part of the plant layout and overall production plan.

2. System Principle

Material handling should be integrated with receiving, storage, and shipping.

3. Unit Load Principle

Materials should be moved as a single load rather than individually.

4. Gravity Principle

Use gravity to reduce manual effort and energy.

5. Safety Principle

Ensure worker safety during material movement.

6. Flexibility Principle

Material handling systems must adapt to changes.

3.14 Unit Load Concept

The unit load concept refers to combining several items into a single load to be moved as one entity. Examples include:

- Pallets
- Containers
- Crates
- Boxes
- Bulk carriers

Advantages:

- Lower cost per unit
- Faster movement
- Reduced damage
- Easier loading and unloading

3.15 Classification of Material Handling Equipment

Material handling equipment can be classified into:

1. Conveyors

Used for continuous movement—belt conveyors, roller conveyors.

2. Industrial Trucks

Forklifts, pallet trucks, and platform trucks.

3. Cranes and Hoists

Used for lifting heavy materials.

4. Automated Systems

AGVs, robotics, automated storage and retrieval systems (AS/RS).

5. Storage Systems

Racks, shelves, bins, and warehouses.

The selection of equipment depends on load characteristics, movement needs, and cost.

4. SUMMARY

This lesson provided a detailed understanding of materials management and inventory control. It highlighted the scope, objectives, and importance of materials management in ensuring cost-effective and efficient production. Different types of inventory, inventory costs, and control techniques were explained. EOQ, purchase models, and manufacturing models were discussed as essential tools for inventory optimization. The lesson also elaborated on material handling, its principles, and equipment classification. Overall, materials management plays a crucial role in reducing cost, improving productivity, and ensuring timely availability of materials.

5. KEY WORDS

Materials	Management
Inventory	
EOQ	
Inventory	Control
Material	Handling
Unit	Load
Purchase	Model
Manufacturing	Model
MRO Supplies	

6. SELF-ASSESSMENT QUESTIONS

Short Answer Questions

1. What is materials management?
2. Name any two types of inventory.
3. What is EOQ?
4. What is the unit load concept?
5. What is the difference between purchase model and manufacturing model?

Essay Questions

1. Discuss the scope and functions of materials management.
2. Explain the need, types, and costs of inventory in detail.

3. Describe Economic Order Quantity (EOQ) and its applications.
4. Explain the purchase and manufacturing inventory models.
5. Discuss material handling principles and classify material handling equipment.

7. REFERENCE BOOKS

1. Panneerselvam, R. *Production and Operations Management*, PHI.
2. Stevenson, W. J. *Operations Management*.
3. Chase, Jacobs & Aquilano. *Operations Management for Competitive Advantage*.
4. Monks, J. G. *Operations Management*.
5. Buffa & Sarin. *Modern Production/Operations Management*.

LESSON- 7

AGGREGATE SALES AND OPERATIONS PLANNING

1. OBJECTIVES OF THE LESSON

- To explain the meaning and purpose of Aggregate Sales and Operations Planning (S&OP).
- To understand the role of aggregate planning in balancing demand and supply.
- To describe the production planning environment and its components.
- To examine strategies and approaches used to develop aggregate plans.
- To highlight the importance of S&OP in achieving organizational goals.
- To explain how aggregate planning supports capacity planning, inventory control, and workforce management.
- To relate aggregate planning to real-world manufacturing and service operations.

2. STRUCTURE OF THE LESSON

1. Introduction
2. Meaning and Concept of Aggregate Sales and Operations Planning
3. Objectives of Aggregate Planning
4. The Production Planning Environment
5. Inputs to Aggregate Planning
6. Aggregate Planning Strategies
7. Approaches to Aggregate Planning
8. Demand Options in Aggregate Planning
9. Supply Options in Aggregate Planning
10. Aggregate Planning Methods
11. Role of Aggregate Planning in Operations Management
12. Applications in Manufacturing and Services
13. Challenges in Aggregate Planning

14. Summary

15. Key Words

16. Self-Assessment Questions

17. Reference Books

3.1 Introduction

Aggregate Sales and Operations Planning (S&OP) is a vital process in operations management. It involves developing, analyzing, and maintaining a preliminary plan for the company's overall operations. The plan typically spans a medium-term horizon of 3 to 18 months. Aggregate planning helps synchronize the company's production capacity with expected customer demand, ensuring that resources such as labour, materials, and machinery are used efficiently.

In today's competitive business environment, fluctuations in demand, supply chain uncertainties, seasonal variations, and global competition make aggregate planning an essential tool. It provides organizations with the ability to balance supply and demand, stabilize employment, optimize inventory, and reduce operational costs. Effective aggregate planning integrates marketing, operations, finance, and HR to create a unified organizational strategy.

3.2 Meaning and Concept of Aggregate Sales and Operations Planning

Aggregate Sales and Operations Planning is the process of determining the quantity and timing of production for the intermediate future. It aims to ensure that the organization can meet demand while minimizing cost.

The term "aggregate" refers to the grouping of products into families rather than individual SKUs (Stock Keeping Units). This simplifies planning and provides a broader perspective.

Definition:

Aggregate planning is a medium-range capacity planning process that determines the best way to meet forecasted demand by adjusting production rate, workforce levels, inventory, and other controllable variables.

Key features:

- Concerned with total output rather than individual product styles
- Balances demand and supply at the aggregate level
- Focuses on medium-term planning
- Involves trade-offs between cost, capacity, and service levels

Effective S&OP results in an integrated plan that aligns the organization's operational capabilities with market expectations.

3.3 Objectives of Aggregate Planning

Aggregate planning aims to achieve multiple objectives that contribute to operational and financial efficiency:

1. To Meet Forecasted Demand

Ensuring that all customer orders are fulfilled on time.

2. To Minimize Cost

Minimizing total cost, including inventory, labour, production, and backorder costs.

3. To Maintain Stable Workforce

Avoiding frequent hiring and layoffs to enhance productivity and morale.

4. To Minimize Inventory Levels

Maintaining optimal inventory to reduce holding costs.

5. To Utilize Resources Efficiently

Ensuring effective use of labour, machines, and material handling systems.

6. To Ensure Smooth Production Flow

Reducing fluctuations in production levels to avoid bottlenecks and idle time.

3.4 The Production Planning Environment

The production planning environment includes all aspects that influence the aggregate planning process. It is shaped by:

1. Organizational Policies

Policies regarding overtime, subcontracting, inventory levels, and workforce variations.

2. Production System

Whether the company uses a make-to-order or make-to-stock system.

3. Product Characteristics

Products that are highly seasonal or perishable require careful planning.

4. Capacity Constraints

Available machinery, labour skills, plant layout, and material availability.

5. Demand Characteristics

Demand patterns such as seasonal demand, cyclical variations, or uncertain demand.

6. Organizational Structure

Coordination between marketing, operations, finance, and HR.

The production planning environment ensures that aggregate planning is realistic, achievable, and aligned with strategic goals.

3.5 Inputs to Aggregate Planning

Aggregate planning requires three major inputs:

1. Demand Forecasts

Forecasts of anticipated customer demand over the planning period.

2. Capacity Constraints

Information on available workforce, equipment, facilities, and material supply.

3. Organizational Policies

Policies regarding overtime, outsourcing, inventory, workforce size, and minimum service levels.

These inputs help planners determine feasible production alternatives that minimize cost while meeting demand.

3.6 Aggregate Planning Strategies

There are two fundamental strategies for aggregate planning:

1. Chase Strategy

Production is adjusted to match demand exactly.

Characteristics:

- Workforce level varies with demand
- Inventory levels remain low
- Suitable for industries with flexible labour

Examples:

- Food processing
- Garment manufacturing during festivals
- Bakeries

2. Level Strategy

Production remains constant, while inventory is allowed to fluctuate.

Characteristics:

- Stable workforce
- Inventory used to absorb demand changes
- Suitable for long-term, stable demand

Examples:

- Automobile production
- Consumer electronics

Most companies use a combination of the two strategies, known as the **mixed strategy**, to achieve a cost-effective and stable plan.

3.7 Approaches to Aggregate Planning

1. Graphical and Charting Methods

Simple and easy to use. Uses graphs to show demand, production, and capacity.

2. Mathematical Techniques

Include linear programming, transportation method, and simulation.

3. Heuristic Approaches

Use trial-and-error methods based on practical experience.

4. Computer-Aided Tools

Modern ERP systems such as SAP, Oracle, and Microsoft Dynamics support aggregate planning.

3.8 Demand Options in Aggregate Planning

Organizations can use demand-side approaches to influence or manage customer demand.

1. Pricing

Adjusting prices to influence demand during peak and off-peak seasons.

2. Promotion

Marketing campaigns to stimulate demand.

3. Backordering

Delaying fulfillment until the product is available.

4. New Demand Creation

Developing complementary products to stabilize demand.

5. Reservations

Service firms (hotels, airlines) regulate demand through reservations.

3.9 Supply Options in Aggregate Planning

Supply-side options involve adjusting internal operations to match demand.

1. Hiring or Laying Off Workers

Increasing workforce size during high demand.

2. Overtime and Undertime

Using overtime to increase production temporarily.

3. Subcontracting

Outsourcing production to external suppliers.

4. Changing Inventory Levels

Building up inventory during low demand to meet future demand.

5. Part-Time Workers

Used in industries such as retail and hospitality.

6. Cross-Training Workers

Improves flexibility and reduces dependence on hiring.

3.10 Aggregate Planning Methods

1. Cut-and-Try Method

Trial-and-error approach used by small businesses.

2. Transportation Method

Compared cost of different plans using a transportation matrix.

3. Linear Programming

Optimizes cost while meeting constraints.

4. Simulation Models

Used to test different scenarios without affecting actual operations.

5. Computerized Planning Systems

ERP systems automate demand forecasting, capacity planning, and resource allocation.

3.11 Role of Aggregate Planning in Operations Management

Aggregate planning plays a vital role by:

- Providing a link between strategic planning and short-term scheduling
- Reducing fluctuations in production rates
- Ensuring efficient use of capacity
- Minimizing total cost
- Reducing stockouts and backorders
- Improving customer service
- Coordinating different departments

It integrates marketing forecasts with operational capabilities.

3.12 Applications in Manufacturing and Services

Manufacturing:

- Automotive companies use aggregate planning to balance production and demand.
- FMCG companies plan for seasonal peaks.

Services:

- Hospitals plan bed capacity, staff, and equipment.
- Airlines use yield management and reservation systems.
- Hotels plan staffing for peak tourist seasons.

Aggregate planning is essential for all industries facing variable demand.

3.13 Challenges in Aggregate Planning

Organizations face several challenges:

1. Demand Uncertainty

Unpredictable demand complicates planning.

2. Supply Chain Disruptions

Material shortages or supplier delays impact production.

3. Labour Constraints

Shortage of skilled labour affects capacity.

4. Inaccurate Forecasts

Poor forecasts lead to inefficient plans.

5. Cost Variability

Fluctuating costs affect budget planning.

Despite these challenges, aggregate planning is a powerful tool for achieving stability and efficiency.

4. SUMMARY

This lesson explained the concept, importance, and strategies of aggregate sales and operations planning. It highlighted how aggregate planning acts as a bridge between long-term strategic decisions and short-term scheduling. The lesson discussed chase, level, and mixed strategies, demand and supply options, and mathematical methods used in aggregate planning. Applications in manufacturing and services illustrated the importance of S&OP in balancing demand and supply, minimizing cost, and ensuring smooth operations.

5. KEY WORDS

Aggregate Planning
Sales and Operations Planning (S&OP)
Chase Strategy
Level Strategy
Demand Management
Capacity Planning
ERP Systems

6. SELF-ASSESSMENT QUESTIONS

Short Answer Questions

1. Define aggregate planning.
2. What is the chase strategy?

3. Mention any two demand options in aggregate planning.
4. What is level scheduling?
5. What are the key inputs to aggregate planning?

Essay Questions

1. Explain the objectives and importance of aggregate planning.
2. Discuss the production planning environment and its influence on aggregate planning.
3. Describe demand and supply options available for aggregate planning.
4. Compare chase, level, and mixed strategies with examples.
5. Explain mathematical and graphical methods used in aggregate planning.

7. REFERENCE BOOKS

1. Panneerselvam, R. *Production and Operations Management*, PHI.
2. Stevenson, W. J. *Operations Management*, McGraw-Hill.
3. Chase, Jacobs & Aquilano. *Operations Management for Competitive Advantage*.
4. Buffa & Sarin. *Modern Production/Operations Management*.
5. Heizer & Render, *Operations Management*.

LESSON -8

MATERIAL REQUIREMENT PLANNING (MRP) & PRODUCTION PLANNING AND CONTROL (PPC)

1. OBJECTIVES OF THE LESSON

- To understand the concept, purpose, and structure of Material Requirement Planning (MRP).
- To explain the role of Bill of Materials (BOM), Master Production Schedule (MPS), and inventory status in MRP.
- To describe the steps and logic of the MRP system.
- To understand the concept and functions of Production Planning and Control (PPC).
- To explain the phases of PPC—planning, action, and control.
- To highlight the importance of MRP and PPC in modern production systems.
- To analyze how MRP and PPC contribute to efficiency, cost reduction, and timely delivery.

2. STRUCTURE OF THE LESSON

1. Introduction
2. Concept and Meaning of Material Requirement Planning (MRP)
3. Objectives and Importance of MRP
4. Inputs to the MRP System
5. Master Production Schedule (MPS)
6. Bill of Materials (BOM)
7. Inventory Status File
8. MRP Logic and Process
9. Benefits and Limitations of MRP
10. Concept and Meaning of Production Planning and Control (PPC)
11. Objectives and Scope of PPC

12. Phases of PPC: Planning, Action, and Control
13. Functions of Production Planning and Control
14. PPC in Modern Production Systems
15. Challenges in Implementing MRP and PPC
16. Summary
17. Key Words
18. Self-Assessment Questions
19. Reference Books

3.1 Introduction

In today's competitive manufacturing environment, organizations must ensure that materials are available exactly when needed to prevent production delays and to reduce inventory carrying costs. Material Requirement Planning (MRP) is a powerful inventory management and production planning tool designed to ensure timely availability of materials for production while minimizing inventory levels. MRP converts the demand for final products into demand for components and raw materials.

Production Planning and Control (PPC) complements MRP by ensuring that production is planned, scheduled, executed, and monitored in a coordinated manner. PPC aims to optimize resource utilization, ensure smooth workflow, and maintain production efficiency. Together, MRP and PPC form the backbone of modern manufacturing systems.

3.2 Concept and Meaning of Material Requirement Planning (MRP)

Material Requirement Planning (MRP) is a computer-based planning tool used to determine the quantity and timing of materials required for production. It ensures that material components are available for production as per the schedule while maintaining minimum inventory levels.

MRP is particularly useful for companies that produce products with multiple components, subassemblies, and raw materials. It works backward from the demand for finished goods to determine the requirements for raw materials.

Definition:

MRP is a systematic approach that uses the demand for final products to calculate the dependent demand for components and materials.

Dependent demand items are those whose demand depends on the demand for finished goods. Examples include bolts, screws, electronic parts, and subassemblies.

3.3 Objectives and Importance of MRP

Objectives of MRP:

- To ensure availability of materials for production
- To maintain minimum inventory levels
- To plan manufacturing activities and delivery schedules
- To reduce production delays and shortages
- To improve customer service by ensuring timely delivery

Importance of MRP:

- Enhances efficiency by synchronizing materials with production schedules
- Reduces inventory carrying cost
- Helps in accurate production scheduling
- Improves coordination among departments
- Supports decision-making and resource optimization

MRP is considered the foundation of modern manufacturing systems.

3.4 Inputs to the MRP System

MRP requires three major inputs:

1. Master Production Schedule (MPS)

Specifies what items are to be produced, how many, and when.

2. Bill of Materials (BOM)

Lists all components, parts, and raw materials required to make one unit of final product.

3. Inventory Status File

Contains information about current stock levels, scheduled receipts, and lead times.

Together, these inputs allow MRP to calculate material needs accurately.

3.5 Master Production Schedule (MPS)

The Master Production Schedule is a detailed plan that outlines:

- What products need to be produced
- In what quantities

- At what time

MPS is derived from customer orders, sales forecasts, and production capacity. It drives the entire MRP system.

Characteristics of MPS:

- Focuses on end items
- Covers medium-term planning
- Considers capacity and labour constraints
- Helps plan production and purchasing activities

A realistic MPS ensures that the production schedule is achievable and aligns with customer demand.

3.6 Bill of Materials (BOM)

A Bill of Materials is a structured list of components, parts, raw materials, and subassemblies used to manufacture one finished product. It provides complete information about:

- Part name
- Part number
- Quantity required
- Level in the product structure
- Description

Types of BOM Structures:

1. Single-Level BOM

Lists only direct components needed to produce the final product.

2. Multi-Level BOM

Shows hierarchical relationships among components.

3. Indented BOM

Represents components using an indented format to indicate levels.

4. Modular BOM

Used for modular products where components can be swapped.

BOM accuracy is crucial because errors result in production delays and shortages.

3.7 Inventory Status File

This file contains essential information about:

- Inventory on hand
- Scheduled receipts
- Lead times for procurement
- Safety stock levels
- Lot size constraints

The MRP system uses this file to determine whether new material needs to be ordered or existing inventory is sufficient.

3.8 MRP Logic and Process

MRP uses a backward scheduling process:

Step 1: Gross Requirements

These are total needs for finished products based on the Master Production Schedule.

Step 2: Scheduled Receipts

These include materials already ordered but not yet received.

Step 3: Net Requirements

Net requirement = Gross requirements – Available inventory – Scheduled receipts

Step 4: Planned Order Receipts

These are quantities planned to be received to meet net requirements.

Step 5: Planned Order Releases

These determine when an order should be placed, considering lead time.

MRP generates time-phased schedules for all components.

3.9 Benefits and Limitations of MRP

Benefits:

- Reduces inventory levels
- Eliminates production stoppages
- Improves customer service

- Enhances coordination between departments
- Helps in capacity planning
- Supports decision-making

Limitations:

- Requires accurate data input
- Complex to implement
- Assumes fixed lead times
- Dependent on computer systems
- Not suitable for all industries

Despite limitations, MRP remains one of the most widely used planning tools in manufacturing.

3.10 Concept and Meaning of Production Planning and Control (PPC)

Production Planning and Control (PPC) is the process of planning, coordinating, and controlling production activities. PPC ensures that materials, equipment, and labour are available when required, and production proceeds smoothly.

Definition:

PPC is a managerial function that plans, organizes, directs, and controls production to ensure efficient utilization of resources and timely delivery of products.

3.11 Objectives and Scope of PPC

Objectives:

- Ensure timely availability of materials and resources
- Achieve continuous production
- Minimize production costs
- Maintain product quality
- Utilize resources efficiently
- Meet customer delivery schedules

Scope:

PPC covers a wide range of activities, including routing, scheduling, dispatching, loading, follow-up, and control.

3.12 Phases of PPC: Planning, Action, and Control

1. Planning Phase

Involves determining:

- What to produce
- How much to produce
- How to produce
- When to produce
- Required resources

2. Action Phase

Involves execution through:

- Dispatching work orders
- Distributing materials
- Guiding workers
- Managing operations

3. Control Phase

Ensures production progresses as planned by:

- Monitoring performance
- Identifying deviations
- Taking corrective measures
- Adjusting schedules

PPC ensures coordination across departments.

3.13 Functions of Production Planning and Control

Major functions of PPC include:

1. Routing

Determines the path that materials follow.

2. Scheduling

Establishes timelines for each operation.

3. Loading

Assigns jobs to machines based on capacity.

4. Dispatching

Issues instructions for the start of work.

5. Expediting/Follow-up

Ensures progress and removes bottlenecks.

6. Inspection

Verifies quality of output.

7. Evaluation

Assesses performance based on standards.

3.14 PPC in Modern Production Systems

Modern production environments use advanced technologies to enhance PPC:

- Enterprise Resource Planning (ERP)
- Just-in-Time (JIT)
- Lean manufacturing
- Robotics and automation
- Real-time data tracking
- Advanced scheduling tools

These tools improve accuracy and reduce lead times.

3.15 Challenges in Implementing MRP and PPC

Organizations face several challenges:

- Inaccurate BOM or inventory data
- Long and unpredictable lead times
- Lack of coordination among departments
- Resistance from employees
- High cost of implementation
- Poor capacity planning

Proper training, accurate data, and strong coordination are essential for success.

4. SUMMARY

This lesson explained the concepts and functions of Material Requirement Planning (MRP) and Production Planning and Control (PPC). MRP ensures timely availability of materials by converting demand for final products into demand for components. PPC ensures that production activities are well-planned, scheduled, executed, and controlled. It plays a crucial role in coordinating resources, maintaining quality, and ensuring timely delivery. Together, MRP and PPC enhance production efficiency, reduce cost, and support organizational competitiveness.

5. KEY WORDS

Material	Requirement	Planning
Bill	of	Materials
Master	Production	Schedule
PPC		
Routing		
Scheduling		
Planned	Order	Releases
Inventory Status File		

6. SELF-ASSESSMENT QUESTIONS

Short Answer Questions

1. What is MRP?
2. What is the role of BOM in MRP?
3. Define Master Production Schedule.
4. What are the three phases of PPC?
5. What is routing?

Essay Questions

1. Explain the concept, importance, and objectives of MRP.
2. Describe the inputs to MRP and explain their significance.
3. Discuss the logic and operation of the MRP system.
4. Explain the functions of Production Planning and Control.
5. What are the challenges in implementing MRP and PPC?

7. REFERENCE BOOKS

1. Panneerselvam, R. *Production and Operations Management*, PHI.
2. Stevenson, W. J. *Operations Management*, McGraw-Hill.
3. Chase, Jacobs & Aquilano. *Operations Management for Competitive Advantage*.
4. Buffa & Sarin. *Modern Production/Operations Management*.
5. Heizer & Render. *Operations Management*.

LESSON- 9

SCHEDULING TECHNIQUES – SINGLE MACHINE SCHEDULING, FLOW SHOP SCHEDULING & JOHNSON'S RULE

1. OBJECTIVES OF THE LESSON

- To explain the concept, meaning, and importance of scheduling in production and operations management.
- To understand different types of scheduling problems in manufacturing systems.
- To describe Single Machine Scheduling (SMS) and the rules used for minimizing flow time and maximum lateness.
- To discuss flow shop scheduling and the significance of sequencing operations across multiple machines.
- To explain Johnson's Rule for two-machine flow shop scheduling.
- To apply sequencing rules such as SPT, EDD, and weighted SPT for decision-making.
- To highlight the relevance of scheduling methods in improving productivity, minimizing delays, and optimizing resource utilization.

2. STRUCTURE OF THE LESSON

1. Introduction
2. Concept and Meaning of Scheduling
3. Objectives and Importance of Scheduling
4. Types of Scheduling Problems
5. Single Machine Scheduling (SMS)
6. Performance Measures in SMS
7. Scheduling Rules: SPT, EDD, Weighted SPT
8. Flow Shop Scheduling
9. Johnson's Rule for Two-Machine Flow Shop
10. Extension of Johnson's Rule
11. Comparison of Job Shop, Flow Shop, and Single Machine Scheduling

12. Challenges in Scheduling

13. Summary

14. Key Words

15. Self-Assessment Questions

16. Reference Books

3.1 Introduction

Scheduling is a key aspect of production management. It determines the allocation of scarce resources—such as machines, labour, and tools—to various jobs over a specific time horizon. The main goal of scheduling is to ensure that jobs are processed efficiently, delivery deadlines are met, and costs are minimized.

In manufacturing systems, poor scheduling often leads to bottlenecks, increased waiting time, higher work-in-progress inventory, and customer dissatisfaction. Effective scheduling, on the other hand, enhances productivity, ensures timely delivery, maximizes machine utilization, and reduces operational costs. Modern production systems rely heavily on scheduling techniques to plan daily operations.

Scheduling plays an equally important role in service industries such as hospitals, airlines, call centers, and retail stores, where resources must be allocated optimally to serve customers.

3.2 Concept and Meaning of Scheduling

Scheduling refers to the assignment of jobs or tasks to resources (machines, labour, workstations) and the determination of their start and finish times. It provides a timetable for performing operations.

Definition:

Scheduling is the process of deciding the time order in which jobs are to be processed on machines to achieve organizational objectives such as minimizing completion time, lateness, idle time, or cost.

Scheduling answers the following questions:

- What job should be done first?
- On which machine should it be done?
- When should the job begin and end?
- What is the sequence of processing?

3.3 Objectives and Importance of Scheduling

Objectives of Scheduling:

1. Minimize production time
2. Optimize machine and labour utilization
3. Reduce waiting time and idle time
4. Minimize work-in-progress inventory
5. Meet delivery deadlines
6. Improve customer satisfaction
7. Increase productivity and reduce cost

Importance:

- Ensures smooth workflow
- Coordinates different operations
- Prevents bottlenecks
- Enhances operational efficiency
- Supports better planning and control

Scheduling is critical in industries with multiple jobs competing for limited resources.

3.4 Types of Scheduling Problems

1. Single Machine Scheduling

All jobs are processed on one machine.

2. Parallel Machine Scheduling

Jobs are processed on parallel identical or different machines.

3. Flow Shop Scheduling

Jobs follow the same sequence of machines (e.g., M1 → M2 → M3).

4. Job Shop Scheduling

Jobs follow different routes and sequences.

5. Open Shop Scheduling

Jobs can be processed in any order.

6. Assembly Line Scheduling

Used in mass production for sequential operations.

Each type has different complexity and performance criteria.

3.5 Single Machine Scheduling (SMS)

Single Machine Scheduling deals with sequencing a set of jobs to be processed on a single machine. This is the simplest form of scheduling but forms the foundation for more complex systems.

Jobs differ in:

- Processing time
- Due dates
- Priority
- Weight (importance)

Key Questions in SMS:

- How to minimize mean flow time?
- How to minimize the maximum lateness?
- How to meet due dates effectively?

3.6 Performance Measures in SMS

Several performance measures are used:

1. Flow Time (Ti)

Total time a job spends in the system:
Flow time = Completion time – Arrival time

2. Mean Flow Time

Average of all job flow times.

3. Lateness (Li)

Li = Completion time – Due date

4. Tardiness (Ti)

Ti = max(0, Lateness)

5. Makespan

Time taken to complete all jobs.

6. Idle Time

Time the machine remains idle due to poor scheduling.

The aim is to minimize flow time, lateness, and tardiness.

3.7 Scheduling Rules: SPT, EDD, Weighted SPT

1. Shortest Processing Time (SPT)

SPT schedules jobs in ascending order of processing time.

Advantages:

- Minimizes mean flow time
- Reduces waiting time
- Improves machine utilization

This is widely used in industries where minimizing flow time is critical.

2. Earliest Due Date (EDD)

Jobs are scheduled in order of increasing due dates.

Advantages:

- Minimizes maximum lateness
- Useful in industries where meeting deadlines is essential

EDD is used in printing, publishing, and custom manufacturing.

3. Weighted SPT (WSPT)

Used when jobs have different priorities (weights).
WSPT = Processing Time / Weight

Jobs with higher weight (importance) are scheduled first.

3.8 Flow Shop Scheduling

Flow shop scheduling involves sequencing jobs that must pass through the same sequence of machines. Each job follows the same route.

Examples:

- Automobile assembly
- Chemical processing

- Printed circuit board manufacturing

Flow shop scheduling focuses on:

- Minimizing makespan
- Reducing idle time
- Avoiding bottlenecks
- Improving production throughput

Flow shop scheduling can be simple (2-machine) or complex (multi-machine).

3.9 Johnson's Rule for Two-Machine Flow Shop Scheduling

Johnson's Rule offers an optimal solution for two-machine flow shop problems where each job must be processed on Machine 1 and then Machine 2.

Objective:

Minimize makespan (total time to complete all jobs).

Applicability:

- Two machines only
- Each job processed first on M1, then on M2
- Processing times known and deterministic
- No preemption

Steps in Johnson's Rule:

1. Select the job with the shortest processing time among all jobs.
2. If the shortest time is on M1 → Schedule the job as early as possible.
3. If the shortest time is on M2 → Schedule the job as late as possible.
4. Remove the job from the list and repeat the process.

Johnson's rule results in an optimal job sequence that minimizes makespan and machine idle time.

Example (Conceptual):

Suppose five jobs need to be scheduled on two machines M1 and M2.
Determine the job sequence that minimizes makespan.

Using Johnson's Rule, jobs are arranged optimally based on their processing times.

3.10 Extension of Johnson's Rule

For three machines (M1, M2, M3), Johnson's rule can be used only if:

- Processing times on M2 are greater than or equal to times on M1, and
- Processing times on M2 are greater than or equal to times on M3

OR

- Times on M2 are less than or equal to times on M1 and M3

In such cases, the three-machine problem can be reduced to a two-machine equivalent by forming:

- Machine A = M1 + M2
- Machine B = M2 + M3

Then Johnson's rule is applied.

Multi-machine scheduling is more complex and often solved using heuristic or meta-heuristic techniques.

3.11 Comparison of Job Shop, Flow Shop, and Single Machine Scheduling

Single Machine Scheduling:

- Simplest system
- One machine only
- Few constraints
- Primary focus on sequencing tasks

Flow Shop Scheduling:

- Multiple machines
- Fixed routing
- Jobs follow the same sequence
- Used in repetitive production

Job Shop Scheduling:

- Complex routing
- Every job has its own sequence

- Used in customized or batch production
- Difficult to optimize

Flow shop scheduling lies between the simplicity of SMS and the complexity of job shop scheduling.

3.12 Challenges in Scheduling

Organizations face several difficulties:

1. Variability in Processing Times

Actual processing times may differ from estimates.

2. Machine Breakdowns

Unexpected failures disrupt schedules.

3. Rush Orders

Urgent jobs may disrupt existing plans.

4. Labour Shortages

Skilled labour availability affects performance.

5. Complexity in Multi-Machine Systems

Scheduling complexity increases exponentially with job and machine numbers.

6. Balancing Trade-Offs

Managing lateness, makespan, idle time, and inventory simultaneously is difficult.

Despite challenges, scheduling rules and tools provide systematic approaches to improve performance.

4. SUMMARY

This lesson explained the concepts and techniques of scheduling in production systems. Scheduling ensures optimal allocation of jobs to machines to minimize flow time, lateness, and cost. The lesson covered Single Machine Scheduling, performance measures, and sequencing rules such as SPT, EDD, and Weighted SPT. Flow shop scheduling was discussed, highlighting Johnson's Rule as an effective method for minimizing makespan in two-machine flow shops. The lesson also compared different scheduling systems and explored real-world challenges. Proper scheduling enhances productivity, reduces delay, and ensures efficient utilization of resources.

5. KEY WORDS

Scheduling
Single Machine Scheduling
SPT
EDD
Flow Shop Scheduling
Johnson's Rule
Makespan
Sequencing
Tardiness

6. SELF-ASSESSMENT QUESTIONS

Short Answer Questions

1. What is scheduling?
2. Define flow time.
3. What does SPT stand for?
4. What is Johnson's Rule?
5. What is makespan?

Essay Questions

1. Explain the importance and objectives of scheduling in production systems.
2. Describe different scheduling rules used in Single Machine Scheduling.
3. Discuss flow shop scheduling with suitable examples.
4. Explain Johnson's Rule for two-machine flow shop problems with steps.
5. Compare job shop, flow shop, and single machine scheduling.

7. REFERENCE BOOKS

1. Panneerselvam, R. *Production and Operations Management*, PHI.
2. Stevenson, W. J. *Operations Management*, McGraw-Hill.
3. Chase, Jacobs & Aquilano. *Operations Management for Competitive Advantage*.
4. Buffa & Sarin. *Modern Production/Operations Management*.
5. Baker, K. R. *Introduction to Sequencing and Scheduling*.

LESSON- 10

PROJECT MANAGEMENT – CPM, PERT, GANTT CHART & WORK STUDY (METHOD STUDY, TIME STUDY)

1. OBJECTIVES OF THE LESSON

- To explain the meaning and importance of project management in production and operations.
- To describe the concepts, components, and applications of CPM (Critical Path Method).
- To explain PERT (Program Evaluation and Review Technique) and its use in managing uncertain project times.
- To illustrate the use of Gantt charts for project scheduling and monitoring.
- To introduce the concept and significance of work study.
- To differentiate between method study, time study, and motion study.
- To highlight the role of project management and work study in improving productivity and organizational efficiency.

2. STRUCTURE OF THE LESSON

1. Introduction
2. Concept and Meaning of Project Management
3. Characteristics of Projects
4. Importance of Project Management
5. CPM (Critical Path Method)
6. Steps in CPM
7. CPM Calculations and Network Analysis
8. Float (Slack) and Its Types
9. PERT (Program Evaluation and Review Technique)
10. Comparison of CPM and PERT
11. Gantt or Time Chart
12. Work Study: Concept and Importance

13. Method Study: Procedure
14. Time Study: Procedure and Tools
15. Motion Study: Concept and Objectives
16. Summary
17. Key Words
18. Self-Assessment Questions
19. Reference Books

3.1 Introduction

Project management is an important managerial function that involves planning, organizing, coordinating, and controlling resources to achieve specific objectives within a defined timeframe and budget. Projects are unique, non-routine, and time-bound activities. Examples include construction projects, new product development, software implementation, factory layout redesign, and research studies.

In operations management, several projects require systematic planning. Tools such as CPM, PERT, and Gantt charts help plan activities, allocate resources, estimate timelines, and control project progress. Work study techniques such as method study and time study improve productivity by analyzing and optimizing human effort and work processes.

3.2 Concept and Meaning of Project Management

Project management involves applying knowledge, skills, tools, and techniques to project activities to meet project requirements. It includes initiation, planning, execution, monitoring, and closure.

Key aspects:

- Clear objectives
- Defined start and end
- Limited resources
- Unique deliverables
- Cross-functional coordination

Project management ensures that activities are completed on schedule, within budget, and with the desired quality.

3.3 Characteristics of Projects

- **Unique**: No two projects are exactly alike.

- **Temporary**: Defined beginning and end.
- **Goal-Oriented**: Measurable deliverables.
- **Complex**: Interdependent activities.
- **Resource-Constrained**: Manpower, money, machines, materials.
- **Risk-Prone**: Uncertainties in time, cost, and performance.

These characteristics make project management essential for success.

3.4 Importance of Project Management

Project management is important because:

- It improves planning and scheduling.
- It ensures effective resource utilization.
- It minimizes delays and cost overruns.
- It improves coordination and communication.
- It manages risks and uncertainties.
- It enhances project success rate.

Project management tools support decision-making and execution.

3.5 CPM (Critical Path Method)

The Critical Path Method (CPM), developed by DuPont, is a deterministic project scheduling technique used when activity times are known and predictable. It identifies the critical path—the longest sequence of activities that determines project duration.

Key Concepts:

- **Activity**: A task requiring time and resources.
- **Event (Node)**: Completion of one or more activities.
- **Network**: Diagram connecting activities in sequence.
- **Critical Path**: The longest path with zero slack.
- **Slack (Float)**: Allowable delay without affecting project time.

CPM helps determine project completion time, identify bottlenecks, and allocate resources effectively.

3.6 Steps in CPM

1. Identify project activities.
2. Determine sequence (precedence relationships).
3. Draw a network diagram (nodes and arrows).
4. Estimate activity times.
5. Perform forward pass to calculate earliest times.
6. Perform backward pass to calculate latest times.
7. Identify critical path.
8. Calculate slack/float for non-critical activities.

These steps provide a structured approach to scheduling and controlling projects.

3.7 CPM Calculations and Network Analysis

Forward Pass Calculation:

Determines the earliest start (ES) and earliest finish (EF) times.

- ES (first activity) = 0
- EF = ES + activity duration

Backward Pass Calculation:

Determines latest start (LS) and latest finish (LF) times.

- LF (last activity) = project duration
- LS = LF – activity duration

Critical Path:

- Activities where ES = LS and EF = LF
- Zero slack

Slack (Float):

Slack = LS – ES
Slack = LF – EF

Critical activities have zero slack, meaning any delay will delay the entire project.

3.8 Float and Its Types

1. Total Float

Maximum time an activity can be delayed without delaying project completion.

2. Free Float

Time an activity can be delayed without delaying the early start of its successor.

3. Independent Float

Amount of delay allowed without affecting preceding or succeeding activities.

Understanding float helps managers allocate resources and monitor risks.

3.9 PERT (Program Evaluation and Review Technique)

PERT was developed by the U.S. Navy for the Polaris missile program. It is used when activity times are uncertain.

Characteristics of PERT:

- Probabilistic time estimates
- Useful for R&D projects
- Incorporates uncertainty and risk

Three Time Estimates in PERT:

1. **Optimistic Time (O)**: Shortest possible time
2. **Most Likely Time (M)**: Realistic time
3. **Pessimistic Time (P)**: Longest possible time

Expected Time (TE):

$TE = (O + 4M + P) / 6$

Variance:

$Var = [(P – O) / 6]^2$

PERT helps determine project duration with probability.

3.10 Comparison of CPM and PERT

Feature	CPM	PERT
Time estimates	Deterministic	Probabilistic
Application	Construction, manufacturing	R&D, new projects

Feature	CPM	PERT
Focus	Time-cost tradeoff	Time control
Activity time	Single time estimate	Three time estimates
Use	Repetitive jobs	Non-repetitive jobs

Both techniques are widely used for planning and controlling projects.

3.11 Gantt or Time Chart

A Gantt chart is a bar chart that shows the schedule of activities over time.

Features:

- Horizontal bars indicate time duration
- Easy to understand
- Shows start and finish times
- Useful for monitoring progress
- Shows overlaps, delays, and resource allocation

Although simple, Gantt charts are widely used in project tracking and communication.

3.12 Work Study: Concept and Importance

Work study involves analyzing work systems to improve productivity. It has two main components:

1. **Method Study**
2. **Work Measurement (Time Study)**

Objectives of Work Study:

- Increase productivity
- Eliminate waste
- Improve working methods
- Reduce fatigue
- Reduce production cost
- Standardize operations

Work study forms the basis for continuous improvement.

3.13 Method Study: Procedure

Method study focuses on finding the best method of doing a job.

Steps:

1. Select the job to be studied
2. Record all facts (charts, diagrams)
3. Examine critically to eliminate unnecessary work
4. Develop a new method
5. Install the new method
6. Maintain and review

Tools used include:

- Flow process charts
- Operation charts
- Two-handed process charts
- String diagrams

Method study leads to systematic improvements.

3.14 Time Study: Procedure and Tools

Time study determines the time required to complete a job using a stopwatch or modern devices.

Steps:

1. Select the job
2. Record time using stopwatch
3. Determine normal time:
   Normal Time = Observed Time × Rating Factor
4. Determine allowance (fatigue, delay, personal)
5. Standard Time = Normal Time + Allowances

Time study is used for:

- Standardizing work

- Determining labour efficiency
- Setting wages and incentives
- Planning manpower

3.15 Motion Study: Concept and Objectives

Motion study focuses on eliminating unnecessary movements of workers. It was pioneered by Frank and Lillian Gilbreth.

Objectives:

- Reduce worker fatigue
- Improve workplace design
- Simplify work motions
- Increase efficiency

Motion study techniques include filming workers, studying their motions, analyzing wasteful movements, and redesigning workstations.

4. SUMMARY

This lesson explained the key concepts of project management and work study. CPM and PERT are powerful tools for planning and controlling projects. CPM uses deterministic times to identify the critical path, while PERT uses probabilistic estimates to handle uncertainty. Gantt charts help visualize project schedules. The lesson also described work study, method study, time study, and motion study as scientific management tools for improving productivity. Together, these techniques improve planning, execution, and efficiency in production and service operations.

5. KEY WORDS

Project Management
CPM
PERT
Critical Path
Gantt Chart
Work Study
Method Study
Time Study
Motion Study
Float

6. SELF-ASSESSMENT QUESTIONS

Short Answer Questions

1. What is project management?
2. Define critical path.
3. What is the expected time in PERT?
4. What is a Gantt chart?
5. What is method study?

Essay Questions

1. Explain CPM and its steps with an example.
2. Discuss PERT and compare it with CPM.
3. Describe different types of float and their significance.
4. Explain method study and time study with procedures.
5. Discuss the importance of project management in modern organizations.

7. REFERENCE BOOKS

1. Panneerselvam, R. *Production and Operations Management*, PHI.
2. Chase, Jacobs & Aquilano. *Operations Management for Competitive Advantage*.
3. Stevenson, W. J. *Operations Management*.
4. Buffa & Sarin. *Modern Production/Operations Management*.
5. Harold Kerzner. *Project Management*.

LESSON -11

QUALITY CONTROL – CONTROL CHARTS, ACCEPTANCE SAMPLING & QUALITY SYSTEMS

1. OBJECTIVES OF THE LESSON

- To explain the concept, need, and importance of quality control in production and service organizations.
- To describe the evolution of quality management and the meaning of a quality system.
- To explain different types of quality control techniques.
- To introduce control charts for variables and attributes and their applications.
- To discuss the concept and procedure of acceptance sampling.
- To explain the Operating Characteristic (OC) Curve and its role in sampling decisions.
- To provide understanding of single sampling plans and their relevance in quality control.

2. STRUCTURE OF THE LESSON

1. Introduction
2. Concept and Meaning of Quality
3. Evolution of Quality and Quality Management
4. Need for Quality Control
5. Definition and Components of a Quality System
6. Classification of Quality Control Techniques
7. Statistical Quality Control (SQC)
8. Control Charts – Concept and Purpose
9. Control Charts for Variables ($\bar{X}$ and R Charts)
10. Control Charts for Attributes (p, np, c, u Charts)
11. Acceptance Sampling: Concept and Importance
12. Types of Acceptance Sampling Plans
13. Operating Characteristic (OC) Curve

14. Single Sampling Plan

15. Advantages and Limitations of Acceptance Sampling

16. Summary

17. Key Words

18. Self-Assessment Questions

19. Reference Books

3.1 Introduction

Quality has become a critical competitive weapon in global business. Organizations that consistently deliver high-quality products and services earn customer trust, improve market share, and reduce costs associated with defects and rework. Quality control ensures that products meet predetermined standards of performance, reliability, and durability.

The growth of global competition, technological advancements, and increasing customer expectations have made quality an essential component of manufacturing and service systems. Statistical tools and quality systems help monitor, measure, and improve quality across all stages of production.

This lesson discusses essential concepts in quality control, including control charts, acceptance sampling, and quality systems.

3.2 Concept and Meaning of Quality

Quality refers to the degree to which a product or service satisfies customer requirements. It encompasses multiple dimensions such as:

- Performance
- Reliability
- Durability
- Conformance to standards
- Aesthetics
- Features
- Serviceability
- Perceived quality

A high-quality product consistently meets or exceeds customer expectations.

3.3 Evolution of Quality and Quality Management

First Era: Inspection

Early quality efforts focused only on final inspection to detect defective products.

Second Era: Quality Control

Statistical methods were introduced by Walter Shewhart in the 1920s.

Third Era: Quality Assurance

Quality became integrated with all functions—design, process control, supplier quality, and maintenance.

Fourth Era: Strategic Quality Management

Modern organizations adopt comprehensive frameworks like:

- Total Quality Management (TQM)
- Six Sigma
- ISO 9001 Certification
- Lean Quality

Quality is now a strategic tool for customer satisfaction and competitive advantage.

3.4 Need for Quality Control

Quality control is needed to:

- Reduce defect rates and rework
- Lower production cost
- Improve customer satisfaction
- Ensure product consistency
- Meet regulatory standards
- Enhance brand value
- Improve productivity and resource utilization

Effective quality control minimizes variation and ensures predictable output.

3.5 Definition and Components of a Quality System

A quality system is an organized structure of responsibilities, activities, procedures, and resources that ensures quality requirements are met.

Components:

1. Quality policy
2. Quality planning
3. Quality control
4. Quality assurance
5. Quality improvement

Examples of quality systems include ISO 9000 standards, Six Sigma systems, and TQM frameworks.

3.6 Classification of Quality Control Techniques

Quality control techniques fall into two major categories:

1. Statistical Techniques

- Control charts
- Acceptance sampling
- Process capability analysis
- Design of experiments

2. Non-Statistical Techniques

- Benchmarking
- Quality audits
- Checklists
- Flowcharts
- Cause-and-effect (Fishbone) diagrams

Statistical methods are quantitative, while non-statistical approaches are qualitative.

3.7 Statistical Quality Control (SQC)

SQC uses statistical methods to monitor, control, and improve the quality of processes and products. It helps identify abnormal variations caused by assignable causes.

Two major components:

1. Process Control

Ensures stability of the process during production using control charts.

2. Acceptance Sampling

Determines whether a batch should be accepted or rejected.

SQC is widely used in manufacturing and services.

3.8 Control Charts – Concept and Purpose

Control charts, developed by Shewhart, are graphical tools used to monitor the stability of processes over time.

Objectives:

- Distinguish between common and assignable causes of variation
- Identify process instability
- Maintain consistent quality
- Support continuous improvement

A control chart includes:

- Central Line (CL)
- Upper Control Limit (UCL)
- Lower Control Limit (LCL)

If all points fall within limits and show no pattern, the process is under control.

3.9 Control Charts for Variables ($\bar{X}$ and R Charts)

Variable control charts measure quality characteristics that can be expressed numerically, such as length, weight, or temperature.

1. $\bar{X}$ Chart (Mean Chart)

Monitors changes in the process average.

2. R Chart (Range Chart)

Monitors the spread or variability of the process.

Uses:

- Precision machining
- Chemical processing
- Metal forming
- Dimensional inspections

Interpretation:

- Points outside UCL or LCL indicate out-of-control process
- Patterns (trend, cycle) indicate assignable causes

$\bar{X}$ and R charts are widely used in process industries.

3.10 Control Charts for Attributes (p, np, c, u Charts)

Attribute charts measure quality based on countable characteristics such as defects or defective items.

1. p Chart

Tracks proportion of defective items in a sample.

2. np Chart

Tracks number of defectives (sample size constant).

3. c Chart

Tracks number of defects per unit when the opportunity for defects is constant.

4. u Chart

Tracks defects per unit when sample size varies.

Examples:

- Number of errors in bills
- Number of defects on a printed circuit board
- Proportion of faulty packages

These charts help monitor service-quality problems and manufacturing defects.

3.11 Acceptance Sampling: Concept and Importance

Acceptance sampling involves evaluating a sample of items from a lot to determine whether the entire lot should be accepted or rejected.

Purpose:

- Reduce inspection cost
- Speed up decision making
- Handle destructive testing situations
- Ensure supplier quality

Acceptance sampling is widely used in incoming and outgoing quality control.

3.12 Types of Acceptance Sampling Plans

1. Single Sampling Plan

Decision is based on one sample.

2. Double Sampling Plan

Two samples used if the first sample is inconclusive.

3. Multiple Sampling Plan

Several smaller samples are taken until a decision is made.

4. Sequential Sampling Plan

Each item is inspected sequentially until acceptance or rejection.

Single sampling plans are easy to use and most widely applied.

3.13 Operating Characteristic (OC) Curve

The OC curve describes the performance of a sampling plan. It shows the probability of accepting a lot at various levels of lot quality.

Interpretation:

- Steeper curves indicate better discrimination
- Poor-quality lots have lower acceptance probability
- Helps managers compare different sampling plans

OC curves are essential in designing sampling plans.

3.14 Single Sampling Plan

A single sampling plan involves:

1. Selecting sample size (n)
2. Determining acceptance number (c)

Decision Rules:

- If number of defectives $\leq c \rightarrow$ Accept the lot
- If defectives $> c \rightarrow$ Reject the lot

Example:

n = 50 items, c = 3 defects allowed
If inspection finds 2 defects → Accept
If 5 defects → Reject

Advantages:

- Simple and easy
- Low administrative effort
- Adequate for routine inspection

Limitations:

- May require large sample size
- Does not guarantee perfect quality

Single sampling plans balance cost and risk.

4. SUMMARY

This lesson explained the concepts and techniques of quality control. Quality is essential for customer satisfaction and competitiveness. Statistical quality control uses tools such as control charts and acceptance sampling to measure and control variation in processes. Control charts monitor process stability using variables ($\bar{X}$, R) and attributes (p, np, c, u). Acceptance sampling helps decide whether to accept or reject a lot using single, double, or sequential plans. OC curves describe the effectiveness of sampling plans. Together, these tools support organizations in achieving consistent quality and continuous improvement.

5. KEY WORDS

Quality		Control
Control		Charts
$\bar{X}$		Chart
R		Chart
p		Chart
Acceptance		Sampling
OC		Curve
Single	Sampling	Plan
Defects		
Quality System		

6. SELF-ASSESSMENT QUESTIONS

Short Answer Questions

1. Define quality control.
2. What is a control chart?
3. Differentiate between $\bar{X}$ chart and R chart.
4. What is acceptance sampling?
5. What is an OC curve?

Essay Questions

1. Explain the concept and need of quality control in manufacturing and services.
2. Discuss various types of control charts for variables and attributes.
3. Describe acceptance sampling and types of sampling plans.
4. Explain the significance of OC curve in acceptance sampling.
5. Describe the components of a quality system and its importance.

7. REFERENCE BOOKS

1. Panneerselvam, R. *Production and Operations Management*, PHI.
2. Montgomery, D. *Introduction to Statistical Quality Control*.
3. Stevenson, W. J. *Operations Management*.
4. Chase, Jacobs & Aquilano. *Operations Management for Competitive Advantage*.
5. Juran, J. M. *Juran's Quality Handbook*.

LESSON -12

MAINTENANCE PLANNING AND CONTROL – RELIABILITY, JIT, SIX SIGMA, TQM, LEAN & KAIZEN

1. OBJECTIVES OF THE LESSON

- To explain the meaning and importance of maintenance management in production systems.
- To describe different types of maintenance and their role in preventing breakdowns.
- To understand the concepts of reliability and methods to improve system reliability.
- To explain modern production systems such as Just-in-Time (JIT), Six Sigma, Total Quality Management (TQM), Lean Production, and Kaizen.
- To highlight the strategic importance of maintenance in improving productivity and equipment life.
- To discuss how modern quality and productivity improvement techniques integrate with maintenance and operations.

2. STRUCTURE OF THE LESSON

1. Introduction
2. Meaning and Concept of Maintenance
3. Objectives and Importance of Maintenance
4. Types of Maintenance
5. Preventive Maintenance and Predictive Maintenance
6. Replacement Decisions
7. Concept of Reliability
8. Reliability Improvement
9. Just-in-Time (JIT): Concept and Principles
10. Six Sigma: Concept and Methodology
11. Total Quality Management (TQM)
12. Lean Manufacturing: Concepts and Tools
13. Kaizen and Continuous Improvement

14. Integration of Maintenance with Modern Production Systems
15. Summary
16. Key Words
17. Self-Assessment Questions
18. Reference Books

3.1 Introduction

Maintenance management plays a vital role in ensuring uninterrupted production, reducing downtime, and maintaining equipment efficiency. As machines and technologies become more sophisticated, the need for systematic maintenance increases. Modern production systems such as JIT, Lean, and TQM depend heavily on reliable equipment.

Effective maintenance planning ensures long equipment life, reduced cost of breakdowns, improved safety, and increased productivity. It also integrates with modern techniques such as Six Sigma and Kaizen to create a culture of continuous improvement.

This lesson discusses maintenance management, reliability concepts, and modern production systems in detail.

3.2 Meaning and Concept of Maintenance

Maintenance refers to all activities aimed at keeping equipment, machines, and facilities in good working condition. It includes inspection, lubrication, repairs, adjustments, and replacements.

Definition:

Maintenance is the process of preserving equipment by scheduling activities that reduce breakdowns and extend its useful life.

Maintenance is required for:

- Smooth production
- Safety of workers
- Product quality
- Long-term equipment reliability
- Cost reduction

3.3 Objectives and Importance of Maintenance

Objectives:

- Minimize equipment downtime
- Reduce repair and replacement costs
- Increase equipment life
- Improve system reliability
- Ensure safety
- Maintain product quality
- Optimize maintenance cost

Importance:

- Breakdowns disrupt production schedules
- Downtime increases operational cost
- Poor maintenance affects product quality
- Preventive maintenance reduces long-term costs
- Reliable systems enhance customer satisfaction

3.4 Types of Maintenance

Maintenance can be classified into:

1. Breakdown (Corrective) Maintenance

Performed after equipment fails.

Advantages:

- Simple to implement
- No planning required

Disadvantages:

- Unexpected downtime
- Higher repair costs
- Potential safety hazards
- Poor equipment life

2. Preventive Maintenance

Performed at regular intervals to prevent breakdowns.

Advantages:

- Reduces breakdown frequency
- Improves equipment life
- Supports planning and scheduling

3. Predictive Maintenance

Uses tools like vibration analysis, thermography, and sensors to predict failures before they happen.

4. Scheduled Maintenance

Performed as per a time-based plan (weekly, monthly, yearly).

5. Condition-Based Maintenance

Monitors real-time conditions (temperature, vibration) to determine maintenance needs.

3.5 Preventive Maintenance and Predictive Maintenance

Preventive Maintenance (PM):

Involves routine inspections, lubrication, cleaning, replacement, and adjustments.

Predictive Maintenance (PdM):

Uses advanced diagnostic tools to predict failures.

Examples:

- Vibration analysis for rotating machines
- Oil analysis for contamination
- Infrared thermography for overheating
- Ultrasonic testing for cracks

Predictive maintenance reduces unnecessary maintenance and improves reliability.

3.6 Replacement Decisions

Replacement decisions involve determining when to replace equipment instead of repairing it.

Factors considered:

- Age of equipment
- Maintenance cost
- Downtime impact

- Technological obsolescence
- Energy efficiency

Companies use economic life analysis and cost-benefit analysis for replacement decisions.

3.7 Concept of Reliability

Reliability refers to the probability that a system performs its intended function without failure for a specified period.

Definition:

Reliability is the likelihood that equipment will operate without failure under stated conditions for a specified time.

Importance of Reliability:

- Ensures consistent production
- Reduces downtime and cost
- Improves customer satisfaction
- Essential for safety-critical industries (aerospace, healthcare)

3.8 Reliability Improvement

Reliability can be improved through:

1. Better Design

Using high-quality materials and advanced engineering principles.

2. Redundancy

Adding backup components (e.g., two pumps instead of one).

3. Preventive and Predictive Maintenance

Regular inspections and diagnostics.

4. Operator Training

Skilled workers reduce misoperations.

5. Quality Control

Reducing variation and defects in production.

Improving reliability increases efficiency and reduces total cost of ownership.

3.9 Just-in-Time (JIT): Concept and Principles

JIT is a production philosophy that aims to eliminate waste and produce only what is needed, when it is needed, and in the required quantity.

Principles of JIT:

- Zero inventory
- Small batch sizes
- Continuous improvement
- Quick setup and changeover
- Close supplier relationships
- Quality at the source
- Smooth production flow

Benefits:

- Reduced inventory cost
- Improved quality
- Increased productivity
- Flexible production

JIT demands highly reliable equipment and effective maintenance.

3.10 Six Sigma: Concept and Methodology

Six Sigma is a data-driven methodology aimed at improving quality by reducing defects and variability.

Key Concepts:

- Defects per million opportunities (DPMO)
- Sigma level (6σ = 3.4 defects per million)

DMAIC Framework:

1. **Define** the problem
2. **Measure** current performance
3. **Analyze** root causes
4. **Improve** processes

5. **Control** improvements

Six Sigma integrates with maintenance to reduce variability and improve process capability.

3.11 Total Quality Management (TQM)

TQM is an organizational philosophy focused on continuous improvement and customer satisfaction.

Principles of TQM:

- Customer focus
- Employee involvement
- Continuous improvement
- Process-centered approach
- Integrated system
- Data-driven decision making

TQM strengthens the relationship between quality, maintenance, and productivity.

3.12 Lean Manufacturing: Concepts and Tools

Lean manufacturing focuses on eliminating waste and improving efficiency.

Types of Waste (Muda):

- Overproduction
- Waiting
- Transportation
- Over-processing
- Inventory
- Motion
- Defects

Lean Tools:

- 5S
- Value stream mapping
- Kanban

- Poka-yoke (error proofing)
- SMED (quick changeover)

Lean systems require high maintenance standards and equipment reliability.

3.13 Kaizen and Continuous Improvement

Kaizen is a Japanese philosophy meaning "continuous improvement."

Principles:

- Small, incremental changes
- Employee involvement
- Standardization
- Waste reduction
- Bottom-up improvement

Kaizen fosters a culture of continuous learning and innovation.

3.14 Integration of Maintenance with Modern Production Systems

Modern production systems depend heavily on efficient maintenance. For example:

- **JIT** requires zero breakdowns
- **Lean** needs reliable equipment to eliminate waste
- **Six Sigma** requires consistent processes
- **TQM** needs standardized work

Thus, maintenance is not merely a repair function but a strategic capability.

4. SUMMARY

This lesson covered the concepts and importance of maintenance management and modern production philosophies. It explained preventive, predictive, and breakdown maintenance, replacement decisions, and the concept of reliability. Modern systems such as JIT, Six Sigma, TQM, Lean manufacturing, and Kaizen were discussed as essential components of contemporary operations management. Maintenance integrates closely with these systems to ensure reliable equipment, reduced waste, improved quality, and higher productivity.

5. KEY WORDS

Maintenance
Preventive Maintenance
Predictive Maintenance
Reliability
JIT
Six Sigma
Lean Manufacturing
Kaizen
TQM
Condition Monitoring

6. SELF-ASSESSMENT QUESTIONS

Short Answer Questions

1. Define maintenance.
2. What is preventive maintenance?
3. What is reliability?
4. What is JIT in production?
5. What does Kaizen mean?

Essay Questions

1. Explain the types of maintenance and their applications.
2. Discuss the concept of reliability and methods of improving it.
3. Describe JIT and its principles with benefits.
4. Explain Six Sigma methodology and its relevance to operations.
5. Discuss Lean production, Kaizen, and their role in continuous improvement.

7. REFERENCE BOOKS

1. Panneerselvam, R. *Production and Operations Management*, PHI.
2. Stevenson, W. J. *Operations Management*.
3. Chase, Jacobs & Aquilano. *Operations Management for Competitive Advantage*.
4. Heizer & Render. *Operations Management*.
5. Imai, M. *Kaizen: The Key to Japan's Competitive Success*.

LESSON -13

GLOBAL PRODUCTION SYSTEMS & WORLD-CLASS MANUFACTURING

1. OBJECTIVES OF THE LESSON

- To explain the concept and evolution of global production systems.
- To understand the drivers of globalization in manufacturing and operations.
- To describe components and strategies of global production networks.
- To examine the characteristics and principles of world-class manufacturing (WCM).
- To discuss benchmarking, automation, and advanced manufacturing technologies in global production.
- To highlight the role of supply chain integration, flexibility, and continuous improvement in achieving world-class standards.
- To illustrate practices adopted by leading global manufacturing companies.

2. STRUCTURE OF THE LESSON

1. Introduction
2. Meaning and Concept of Global Production Systems
3. Evolution and Drivers of Global Manufacturing
4. Features of Global Production Systems
5. Components of Global Production Networks
6. Strategies for Global Manufacturing Competitiveness
7. Concept of World-Class Manufacturing (WCM)
8. Principles and Pillars of WCM
9. Characteristics of World-Class Manufacturing Organizations
10. Role of Automation and Advanced Manufacturing Technologies
11. Benchmarking and Global Best Practices
12. Role of Supply Chain Integration in Global Production
13. Flexibility, Agility, and Responsiveness

14. Continuous Improvement and Sustainable Manufacturing

15. Summary

16. Key Words

17. Self-Assessment Questions

18. Reference Books

3.1 Introduction

Globalization has transformed production and operations management. Companies are no longer confined to producing goods within national borders. Instead, they operate in global production systems involving multiple countries, suppliers, technologies, and markets. Multinational corporations (MNCs) distribute their operations across continents to optimize cost, quality, and productivity.

As competition intensifies, organizations aim to achieve world-class standards in manufacturing. World-Class Manufacturing (WCM) includes the adoption of advanced technologies, lean systems, continuous improvement, superior quality management, and agile supply chains. Leading companies such as Toyota, Honda, Samsung, Apple, Siemens, and General Electric have adopted WCM practices to dominate global markets.

This lesson explains global production systems, their components, and the principles of world-class manufacturing.

3.2 Meaning and Concept of Global Production Systems

A global production system refers to the geographically dispersed activities involved in producing goods and services across multiple countries. It involves coordination of:

- Production facilities
- Suppliers
- Logistics and transportation
- Design and engineering
- Technology and information systems
- Human resources

In a global production system, each part of the value chain is located in a region that offers competitive advantage such as low cost, skilled labour, proximity to markets, or advanced technology.

Examples:

- Apple designs products in the USA, sources components from Japan and Korea, and manufactures in China.

- Automobile companies have global manufacturing hubs in Mexico, India, Brazil, and Eastern Europe.
- Electronics companies rely on global supplier networks from Taiwan, Singapore, and South Korea.

3.3 Evolution and Drivers of Global Manufacturing

The growth of global production is influenced by several drivers:

1. Cost Advantages

Companies seek low-cost labour, raw materials, and production facilities.

2. Market Expansion

Companies want to reach consumers in multiple countries.

3. Technological Advancements

IT, automation, and digital platforms enable real-time coordination across borders.

4. Trade Liberalization

Reduction in tariffs and emergence of free trade zones encourage global production.

5. Transportation and Logistics Improvements

Containerization, air freight, and global shipping networks reduce delivery time and cost.

6. Access to Skilled Workforce

Countries like China, India, and Malaysia offer abundant technical talent.

7. Competition

Global competition pushes companies to improve efficiency and reduce cost.

These drivers push companies to develop global production networks.

3.4 Features of Global Production Systems

Global production systems have several defining characteristics:

1. Geographical Dispersion

Production activities are spread across countries.

2. Outsourcing and Offshoring

Companies outsource non-core activities to specialized vendors.

3. Standardized Processes

Uniform standards ensure consistency across global plants.

4. Use of ICT & Digital Integration

ERP, cloud systems, AI, and IoT enable integrated global planning.

5. Supply Chain Synchronization

Materials, information, and finances flow across borders in real time.

6. Focus on Core Competencies

Companies invest in design, innovation, and branding while outsourcing manufacturing.

7. Strategic Partnerships

Joint ventures and alliances enable access to technology and markets.

3.5 Components of Global Production Networks

1. Global Sourcing

Purchasing materials and components from international suppliers.

2. International Manufacturing Facilities

Owned or contracted factories located abroad.

3. Global Distribution Systems

Warehouses, logistics providers, and transportation networks.

4. Technology and Innovation Centers

R&D labs located in innovation hubs.

5. Global Workforce

Cross-cultural teams and international talent.

6. Information Systems Integration

ERP, SCM software, cloud computing.

Global networks create economies of scale and learning advantages.

3.6 Strategies for Global Manufacturing Competitiveness

1. Cost Leadership Strategy

Reducing production cost through scale, efficiency, and outsourcing.

2. Differentiation Strategy

Offering innovative and high-quality products.

3. Flexible Manufacturing

Adapting quickly to global market changes.

4. Localization Strategy

Customizing products for different markets.

5. Standardization Strategy

Using uniform processes across global facilities.

6. Technology Leadership

Investing in automation, robotics, and advanced manufacturing.

7. Lean Operations

Eliminating waste in global processes.

These strategies ensure competitiveness in global markets.

3.7 Concept of World-Class Manufacturing (WCM)

World-Class Manufacturing refers to a set of best practices that enable companies to achieve superior performance in quality, productivity, cost, and customer satisfaction.

WCM combines:

- Lean systems
- Just-in-Time
- Total Quality Management (TQM)
- Six Sigma
- Advanced manufacturing technology
- Continuous improvement
- Employee involvement

WCM is a holistic approach rather than a single technique.

3.8 Principles and Pillars of World-Class Manufacturing

WCM is built on several core principles:

1. Zero Defects

Producing defect-free products consistently.

2. Zero Waste

Eliminating all forms of waste.

3. Zero Accidents

Ensuring safety and ergonomic work environments.

4. Continuous Improvement (Kaizen)

Incremental and ongoing improvement.

5. Just-in-Time Production

Producing only what is required, when required.

6. Total Productive Maintenance (TPM)

Ensuring machines operate with maximum reliability.

7. Employee Empowerment

Encouraging participation and problem-solving.

8. Customer Focus

Meeting and exceeding customer expectations.

9. Standardized Work

Use of uniform procedures to reduce variation.

3.9 Characteristics of World-Class Manufacturing Organizations

World-class manufacturers exhibit several distinctive characteristics:

1. Strong Leadership and Vision

Commitment to excellence from top management.

2. Customer-Centric Approach

Customer needs drive all decisions.

3. Lean and Agile Operations

Elimination of waste and rapid response to change.

4. High Product Quality

Low defect rates and consistent performance.

5. Advanced Technology Adoption

Use of robotics, automation, and AI.

6. Skilled Workforce

Continuous training and involvement.

7. Global Benchmarking

Learning from the best practices worldwide.

8. Sustainable Manufacturing

Focus on environmental responsibility.

Companies like Toyota, Honda, and Samsung stand out as world-class manufacturers.

3.10 Role of Automation and Advanced Manufacturing Technologies

Modern technologies enhance global production efficiency:

1. Robotics and Automation

Increase precision and reduce labour cost.

2. Computer-Integrated Manufacturing (CIM)

Integrates design, production, and logistics.

3. Flexible Manufacturing Systems (FMS)

Handle variety with high flexibility.

4. Additive Manufacturing (3D Printing)

Enables rapid prototyping and customization.

5. Internet of Things (IoT)

Real-time machine monitoring and predictive maintenance.

6. Artificial Intelligence (AI)

Supports forecasting, scheduling, and quality control.

7. Big Data Analytics

Improves decision-making and efficiency.

Advanced technologies are foundational for world-class performance.

3.11 Benchmarking and Global Best Practices

Benchmarking compares a company’s performance with industry leaders.

Types of Benchmarking:

- **Internal Benchmarking**
- **Competitive Benchmarking**
- **Functional Benchmarking**
- **Strategic Benchmarking**

Global best practices include:

- Toyota Production System (TPS)
- Six Sigma of GE and Motorola
- Lean techniques of Honda
- Digital factories of Siemens

Benchmarking enables continuous improvement.

3.12 Role of Supply Chain Integration in Global Production

Supply chain integration ensures smooth flow of materials and information.

Components:

- Supplier collaboration
- Real-time data sharing
- Integrated planning
- Logistics optimization
- Global inventory visibility

Supply chain integration reduces lead time, cost, and risk.

3.13 Flexibility, Agility, and Responsiveness

Global markets demand:

1. Flexibility

Ability to produce different products quickly.

2. Agility

Rapid response to changes in market demand.

3. Responsiveness

Meeting customer expectations in real time.

Agile systems combine lean production, digital technology, and skilled workforce.

3.14 Continuous Improvement and Sustainable Manufacturing

World-class companies focus on continuous improvement through:

- Kaizen
- Lean Six Sigma
- Value stream mapping
- Problem-solving teams
- PDCA cycle

Sustainable manufacturing aims to reduce:

- Energy consumption
- Waste
- Pollution
- Carbon footprint

Sustainability enhances global reputation and long-term competitiveness.

4. SUMMARY

This lesson explored global production systems, their characteristics, and the drivers behind global manufacturing. It discussed components of global production networks and strategies used by companies to remain competitive. The lesson also explained the concept, principles, and characteristics of world-class manufacturing. Topics such as automation, benchmarking, supply chain integration, flexibility, agility, continuous improvement, and sustainability highlighted the capabilities required to compete globally.

5. KEY WORDS

Global Production
World-Class Manufacturing
Lean
Benchmarking
JIT
Automation
Agility

Global Supply Chain
Continuous Improvement
Kaizen

6. SELF-ASSESSMENT QUESTIONS

Short Answer Questions

1. What is a global production system?
2. Define world-class manufacturing.
3. What is benchmarking?
4. Mention two advanced manufacturing technologies.
5. What is agility in production?

Essay Questions

1. Explain the evolution and drivers of global production systems.
2. Discuss the features and components of global production networks.
3. Describe world-class manufacturing and its core principles.
4. Elaborate the role of automation and modern technologies in global production.
5. Explain benchmarking and its relevance to world-class manufacturing.

7. REFERENCE BOOKS

1. Panneerselvam, R. *Production and Operations Management*, PHI.
2. Stevenson, W. J. *Operations Management*.
3. Chase, Jacobs & Aquilano. *Operations Management for Competitive Advantage*.
4. Heizer & Render. *Operations Management*.
5. Schonberger, R. J. *World Class Manufacturing*.

LESSON -14

PRODUCTIVITY – CONCEPTS, MEASUREMENT & DETERMINANTS

1. OBJECTIVES OF THE LESSON

- To explain the meaning and significance of productivity in production and service organizations.
- To distinguish between different types of productivity—partial, total, and multifactor productivity.
- To understand various methods of productivity measurement.
- To describe the determinants of productivity at individual, organizational, and national levels.
- To analyze the factors causing productivity improvement or decline.
- To understand the relationship between technology, quality, work culture, and productivity.
- To highlight managerial and policy initiatives for improving productivity.

2. STRUCTURE OF THE LESSON

1. Introduction
2. Concept and Meaning of Productivity
3. Types of Productivity
4. Productivity Measurement
5. Factors Influencing Productivity
6. Productivity at Industry and National Levels
7. Techniques for Productivity Improvement
8. Relationship between Productivity, Quality & Cost
9. Barriers to Productivity Improvement
10. Productivity in Service Industries
11. Role of Technology in Productivity Enhancement
12. Human Factors and Work Culture
13. Government Policies for Productivity Improvement

14. Summary
15. Key Words
16. Self-Assessment Questions
17. Reference Books

3.1 Introduction

Productivity is a key performance indicator in operations management. It reflects how efficiently an organization converts inputs (materials, labour, machines, and capital) into outputs (products or services). High productivity leads to lower costs, higher profits, better competitiveness, and improved standards of living. In today's competitive global environment, organizations must continuously evaluate and improve their productivity to survive and grow.

The increasing influence of technology, automation, digitalization, and global competition has made productivity improvement essential. This lesson provides an in-depth understanding of productivity concepts, measurement techniques, determinants, and methods of improvement.

3.2 Concept and Meaning of Productivity

Productivity refers to the ratio of output to input. It is a measure of how effectively an organization utilizes its resources.

Definition:

Productivity is the relationship between the quantity of output produced and the quantity of inputs used to produce that output.

Importance of Productivity:

- Reduces production cost
- Enhances competitiveness
- Improves profitability
- Promotes economic growth
- Increases wages and living standards
- Improves resource utilization

Productivity improvement is essential for organizational and national development.

3.3 Types of Productivity

1. Partial Productivity

Measures productivity with respect to a single input.

Examples:

- **Labour Productivity** = Output / Labour Hours
- **Machine Productivity** = Output / Machine Hours
- **Capital Productivity** = Output / Capital Invested
- **Material Productivity** = Output / Material Input

2. Multifactor Productivity (MFP)

Measures output against a combination of inputs such as labour and capital.

MFP = Output / (Labour + Capital + Materials)

3. Total Productivity

Measures overall efficiency of all inputs.

Total Productivity = Total Output / Total Inputs

Total productivity gives a comprehensive picture of efficiency.

3.4 Productivity Measurement

1. Output-Based Measures

Measures number of units produced or services delivered.

2. Revenue-Based Measures

Uses sales revenue as output.

3. Standard Hour Measures

Uses standard time required to complete tasks.

4. Value-Added Measures

Measures net output after deducting purchased inputs.

5. Physical Measures

Weight, volume, energy use, etc.

6. Service Sector Measures

Often difficult due to intangible outputs, variability, and customer involvement.

Factors required for accurate measurement:

- Standard definitions
- Consistent data

- Reliable measurement tools
- Appropriate input-output relationships

3.5 Factors Influencing Productivity

Productivity is influenced by factors at multiple levels:

A. Organizational Factors

1. Technology

Automation, robotics, and digital tools improve efficiency.

2. Work Methods

Efficient processes improve throughput.

3. Layout and Workflow

Good layout reduces movement and time wastage.

4. Quality of Inputs

High-quality materials reduce rework.

5. Maintenance

Reliable machines prevent breakdowns and delays.

6. Human Resources

Skilled and motivated workforce enhances productivity.

B. Individual Factors

- Attitude and motivation
- Health and safety
- Training and skills
- Work environment
- Job satisfaction

C. External Factors

- Government policies
- Economic conditions

- Infrastructure
- Availability of raw materials
- Competition

3.6 Productivity at Industry and National Levels

Industry Level Productivity

Industry-level productivity depends on:

- Technology level
- Scale of operations
- Industrial policies
- Labour skills
- Supply chain efficiency

Industries with high automation and specialization typically show higher productivity.

National Level Productivity

At the macro level, productivity contributes to:

- Economic growth
- International competitiveness
- Higher GDP
- Better employment
- Improved living standards

Countries like Japan, South Korea, and Germany are known for their high national productivity due to technology, education, and work culture.

3.7 Techniques for Productivity Improvement

Organizations use several techniques to improve productivity:

1. Work Study (Method Study & Time Study)

Improves work methods and standard times.

2. Lean Manufacturing

Reduces waste and increases efficiency.

3. Total Quality Management (TQM)

Improves quality and reduces defects.

4. Automation & Robotics

Enhances speed and accuracy.

5. Inventory Management Techniques

EOQ, JIT reduce carrying cost and waste.

6. Kaizen (Continuous Improvement)

Small improvements lead to big results over time.

7. Benchmarking

Learning from best performers.

8. Training and Development

Improves employee competency.

9. Ergonomics

Designing workplaces for comfort and efficiency.

10. IT and Digital Tools

ERP, IoT, AI, analytics support better decision-making.

3.8 Relationship Between Productivity, Quality & Cost

These three aspects are interconnected:

1. Productivity & Quality

High quality reduces rework, scrap, and delays, improving productivity.

2. Productivity & Cost

Improved productivity reduces cost per unit.

3. Quality & Cost

Better quality reduces warranty claims and customer complaints.

Organizations must balance all three for competitive advantage.

3.9 Barriers to Productivity Improvement

Organizations face several challenges:

1. Resistance to Change

Employees may resist new methods or technologies.

2. Lack of Training

Unskilled workforce reduces productivity.

3. Poor Work Culture

Lack of motivation and discipline affects efficiency.

4. Inadequate Technology

Outdated machines cause delays.

5. Poor Management Practices

Lack of planning and coordination.

6. Supply Chain Issues

Shortages, delays, and quality problems reduce productivity.

3.10 Productivity in Service Industries

Service productivity is challenging because:

- Output is intangible
- Customer involvement varies
- Quality is difficult to measure
- Services are heterogeneous
- Labour plays a dominant role

Improvement practices include:

- Standardization of processes
- Use of technology (ATMs, online banking)
- Queue management
- Staff training
- Automation (self-check-in kiosks, IVR systems)

Examples of high-productivity service sectors include IT services, airlines, and banking.

3.11 Role of Technology in Productivity Enhancement

Technology improves productivity by:

- Reducing manual effort
- Increasing accuracy
- Speeding up production
- Improving communication
- Enhancing planning and scheduling
- Facilitating innovations

Technologies such as ERP, IoT, robotics, AI, and automation have revolutionized productivity.

3.12 Human Factors and Work Culture

Human factors play a central role in productivity:

- Leadership
- Employee involvement
- Incentive systems
- Safety and ergonomics
- Communication
- Organizational culture

Countries like Japan emphasize discipline and continuous improvement, resulting in higher productivity.

3.13 Government Policies for Productivity Improvement

Governments support productivity through:

1. Industrial Policies

Encourage modernization and efficiency.

2. Infrastructure Development

Better transport and communication systems.

3. Labour Reforms

Promote flexibility and skills development.

4. Technological Support

Innovation funding, R&D support.

5. Education & Training

Skill development programs improve workforce competency.

6. Incentives for Modernization

Tax benefits for automation and modernization.

Government interventions create a conducive environment for productivity growth.

4. SUMMARY

This lesson explained the meaning, types, measurement, and determinants of productivity. Productivity is a critical indicator of efficiency in both manufacturing and services. Various factors influence productivity, including technology, work methods, labour efficiency, management practices, and external environment. The lesson also discussed barriers to productivity improvement and highlighted techniques for improving productivity at the organizational and national levels. The role of technology, human factors, and policy interventions were emphasized as key contributors to productivity enhancement.

5. KEY WORDS

Productivity
Partial Productivity
Total Productivity
Multifactor Productivity
Work Study
Lean
Kaizen
Automation
Efficiency
Competitiveness

6. SELF-ASSESSMENT QUESTIONS

Short Answer Questions

1. What is productivity?
2. Define partial productivity.
3. Mention any two factors influencing productivity.

4. What is lean manufacturing?
5. Name one barrier to productivity improvement.

Essay Questions

1. Explain different types of productivity with examples.
2. Describe techniques used for productivity improvement.
3. Discuss the relationship between productivity, quality, and cost.
4. Explain productivity measurement and its challenges in service industries.
5. Discuss the determinants of productivity at organizational and national levels.

7. REFERENCE BOOKS

1. Panneerselvam, R. *Production and Operations Management*, PHI.
2. Stevenson, W. J. *Operations Management*, McGraw-Hill.
3. Heizer & Render. *Operations Management*.
4. Chase, Jacobs & Aquilano. *Operations Management for Competitive Advantage*.
5. ILO Publications. *Introduction to Work Study*.

LESSON -15

SUPPLY CHAIN MANAGEMENT & LOGISTICS

1. OBJECTIVES OF THE LESSON

- To explain the concept, meaning, and importance of Supply Chain Management (SCM).
- To describe the components, structure, and functions of supply chains.
- To examine logistics management, its functions, and its relationship with SCM.
- To discuss transportation, warehousing, inventory management, and distribution as elements of logistics.
- To highlight supply chain integration, coordination, and collaborative planning.
- To explain modern supply chain technologies such as IoT, RFID, AI, blockchain, and digital platforms.
- To understand global supply chain challenges, risks, and strategies for resilience.
- To present best practices in modern, competitive supply chain management.

2. STRUCTURE OF THE LESSON

1. Introduction
2. Concept and Meaning of Supply Chain
3. Evolution and Scope of Supply Chain Management
4. Components of the Supply Chain
5. Functions of Supply Chain Management
6. Logistics Management – Meaning and Scope
7. Transportation in Logistics
8. Warehousing and Distribution
9. Inventory Management
10. Supply Chain Integration and Coordination
11. Bullwhip Effect and Its Control
12. Global Supply Chains
13. Digital Supply Chain Technologies

14. Supply Chain Risks and Resilience

15. Best Practices in Modern SCM

16. Summary

17. Key Words

18. Self-Assessment Questions

19. Reference Books

3.1 Introduction

Supply chain management has emerged as a powerful discipline in modern production and service systems. As organizations compete globally, the efficiency of their supply chains determines their competitiveness. The supply chain encompasses everything from procurement of raw materials to the delivery of finished products to customers.

Logistics, a major component of SCM, deals with transportation, warehousing, inventory control, and distribution. Effective logistics ensures products reach customers in the right quantity, at the right time, and at minimum cost.

Technological advancements such as blockchain, artificial intelligence, the Internet of Things (IoT), and cloud computing have revolutionized modern supply chains. This lesson explains the fundamental concepts, functions, technology, challenges, and best practices of SCM.

3.2 Concept and Meaning of Supply Chain

A supply chain is a network of organizations, people, resources, activities, and information involved in producing and delivering a product or service.

Components of a Supply Chain:

- Suppliers
- Manufacturers
- Distributors
- Wholesalers
- Retailers
- Customers
- Logistics providers

The supply chain involves the flow of:

- **Materials** (raw materials → finished goods)
- **Information** (orders, forecasts, data)

- **Finances** (payments, credit, terms)

3.3 Evolution and Scope of Supply Chain Management

SCM evolved from traditional purchasing and logistics, merging into an integrated discipline.

Evolution Stages:

1. **Traditional Materials Management**
2. **Physical Distribution Management**
3. **Integrated Logistics**
4. **Modern Supply Chain Management**
5. **Digital Supply Chains**

Scope of SCM:

- Forecasting
- Procurement
- Production planning
- Inventory control
- Transportation
- Warehousing
- Distribution
- Customer service

SCM extends across the entire product life cycle, including reverse logistics and sustainability.

3.4 Components of the Supply Chain

1. Procurement (Sourcing)

Process of selecting and managing suppliers.

2. Production

Conversion of raw materials into finished goods.

3. Distribution

Movement of goods through wholesalers and retailers.

4. Logistics

Transportation, warehousing, and inventory management.

5. Customer Relationship Management

Understanding customer needs and building long-term relationships.

6. Reverse Logistics

Handling returns, recycling, and waste disposal.

3.5 Functions of Supply Chain Management

1. Planning

Demand forecasting, aggregate planning, and scheduling.

2. Purchasing

Supplier selection, negotiation, and contracting.

3. Production & Operations

Managing manufacturing processes.

4. Inventory Management

Balancing cost and service levels.

5. Transportation & Logistics

Optimizing movement of goods.

6. Warehousing

Storage and handling of materials.

7. Information Flow

Managing data across the supply chain.

8. Customer Service

Ensuring timely delivery and satisfaction.

3.6 Logistics Management – Meaning and Scope

Logistics management focuses on the efficient and effective movement of goods, services, and information.

Key Activities:

- Transportation

- Warehousing
- Material handling
- Order processing
- Packaging
- Demand forecasting
- Inventory control

Logistics ensures that the supply chain moves smoothly.

3.7 Transportation in Logistics

Transportation accounts for 40–60% of logistics costs, making it the most critical activity.

Modes of Transportation:

- Road
- Rail
- Air
- Water
- Pipeline
- Multimodal transport

Factors Influencing Mode Selection:

- Cost
- Speed
- Reliability
- Safety
- Accessibility

Transportation efficiency determines delivery performance.

3.8 Warehousing and Distribution

Warehousing supports storage and smooth flow of goods.

Functions of Warehouses:

- Storage

- Consolidation
- Break-bulk
- Cross-docking
- Sorting and value addition
- Risk bearing

Distribution involves network design, routing, dispatching, and last-mile delivery.

3.9 Inventory Management

Inventory accounts for a major investment in supply chains. Effective inventory control ensures customer satisfaction while minimizing cost.

Types of Inventory:

- Raw materials
- Work-in-progress
- Finished goods
- Spare parts

Inventory Control Techniques:

- EOQ (Economic Order Quantity)
- ABC Analysis
- JIT
- Safety stock
- Reorder point methods
- Vendor-managed inventory (VMI)

3.10 Supply Chain Integration and Coordination

Integration ensures all supply chain members act as a single system.

Types of Integration:

- **Internal Integration**: Coordination among departments.
- **External Integration**: Collaboration with suppliers and customers.

Benefits:

- Reduced bullwhip effect
- Improved forecast accuracy
- Lower cost and lead time
- Better customer satisfaction

Tools such as ERP, EDI, and cloud platforms enable integration.

3.11 Bullwhip Effect and Its Control

The bullwhip effect refers to the distorted flow of demand information upstream in the supply chain.

Causes:

- Demand forecast errors
- Batch ordering
- Price fluctuations
- Lack of transparency

Solutions:

- Sharing real-time data
- Reducing batch sizes
- Stabilizing prices
- Using collaborative planning, forecasting, and replenishment (CPFR)

3.12 Global Supply Chains

Global supply chains involve sourcing, producing, and distributing across multiple countries.

Challenges:

- Longer lead times
- Currency fluctuations
- Trade regulations
- Political risks
- Cultural differences

Advantages:

- Cost savings
- Access to global talent
- Economies of scale

Examples include Apple, Toyota, BMW, and Samsung.

3.13 Digital Supply Chain Technologies

Digital transformation has changed supply chain operations dramatically.

Key Technologies:

1. Internet of Things (IoT)

Real-time tracking of goods, machine monitoring.

2. RFID (Radio Frequency Identification)

Automated item identification and tracking.

3. Big Data Analytics

Forecasting, demand planning, route optimization.

4. Blockchain

Transparency, traceability, and fraud prevention.

5. Artificial Intelligence (AI) and Machine Learning

Predictive analytics, demand sensing, scheduling.

6. Cloud Computing

Integrates global supply chain data.

7. Autonomous Vehicles & Drones

Future of logistics and last-mile delivery.

Digital supply chains improve speed, visibility, and accuracy.

3.14 Supply Chain Risks and Resilience

Modern supply chains face various risks:

1. Supply Risks

Supplier failures, quality issues, shortages.

2. Operational Risks

Machine breakdowns, labour strikes, accidents.

3. Demand Risks

Sudden demand fluctuations.

4. Environmental Risks

Floods, earthquakes, climate change.

5. Geopolitical Risks

War, sanctions, trade disputes.

Strategies for Resilience:

- Dual sourcing
- Safety stocks
- Flexible manufacturing
- Nearshoring
- Business continuity planning
- Digital visibility tools

Resilient supply chains recover quickly from disruptions.

3.15 Best Practices in Modern SCM

- Lean supply chain principles
- Vendor development and long-term relationships
- Collaborative planning and forecasting
- Real-time information sharing
- Sustainable and green supply chains
- End-to-end visibility
- Logistics automation and robotics
- Demand-driven supply chain strategy

Leading companies implement these practices for competitive advantage.

4. SUMMARY

This lesson provided a comprehensive understanding of supply chain management and logistics. SCM integrates procurement, production, transportation, warehousing, and distribution to deliver goods efficiently. Logistics ensures the physical movement of goods, while supply chain integration reduces cost and improves service performance.

Digital technologies such as AI, IoT, blockchain, and cloud systems are transforming global supply chains. The lesson also discussed global supply chain challenges, the bullwhip effect, risk management, and best practices. Effective SCM is essential for customer satisfaction, operational efficiency, and long-term competitiveness.

5. KEY WORDS

Supply Chain
Logistics
Inventory
Transportation
Warehousing
RFID
Bullwhip Effect
Digital Supply Chain
Blockchain
Resilience

6. SELF-ASSESSMENT QUESTIONS

Short Answer Questions

1. What is a supply chain?
2. Define logistics management.
3. What is inventory control?
4. What is the bullwhip effect?
5. Mention two digital supply chain technologies.

Essay Questions

1. Explain the components and functions of supply chain management.
2. Describe logistics management and its major functions.
3. Discuss digital technologies and their impact on supply chain performance.
4. Explain supply chain risks and strategies for achieving resilience.

5. Describe transportation, warehousing, and inventory management in logistics.

7. REFERENCE BOOKS

1. Chopra, S. & Meindl, P. *Supply Chain Management: Strategy, Planning & Operations*.
2. Christopher, M. *Logistics and Supply Chain Management*.
3. Stevenson, W. J. *Operations Management*.
4. Heizer & Render. *Operations Management*.
5. Sunil Chopra. *Designing and Managing the Supply Chain*.