Production and Operations Management

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PRODUCTION AND OPERATIONS MANAGEMENT

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Preface

Production and Operation Management (POM) is about the transformation of production and operational inputs into outputs, that when distributed, meet the needs of customers. POM incorporates many interdependent tasks which can be grouped under five main headings viz., Product, Plant, Processes, Programmes and People. Production and Operations Managers ensure that quality products are produced and delivered as quickly and cost effectively as possible. Therefore, a basic knowledge of this subject is essential for students of MBA programmes.

This book comprises 11 chapters covering various important topics such as Operations Strategy, Production Planning and Control, Design of Production Systems, Design of Work Systems, Aggregate Production Planning, Project Management, Scheduling of Operations, Maintenance Management, Quality Management and Facility Location and Layout.

This book is specifically designed to cover the syllabus of MBA programme offered by Biju Patnaik University of Technology. However, it may be found useful to students of MBA programme of any other Indian university as well. The book has special features such as illustrations, solved problems, review questions, problems to be solved and case illustrations and case exercises.

I have great pleasure to express my sincere thanks to Sri Niraj Pandey and Sri Anuj Pandey of Himalaya Publishing House for their keen interest and effort to publish this book. I am also thankful to Sri Vijay Pandey for his effort in printing and promoting this book in a very short time.

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I also thank my family members, friends and well-wishers for their constant support and encouragement for this endeavour. I also thank one and all who have directly or indirectly helped or supported me in my work. I invite readers, both students and teachers to offer their valuable suggestions as a feedback to me so as to improve the book in its future editions.

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Contents

CHAPTER ONE

Overview of Production and Operations Management

The managing of any organisation that produces products demanded by customers presents a greater challenge today than ever before. While all other functional managers are involved in planning, organising and controlling in their own field of work, production/operations managers who are in charge of manufacturing the products have the direct responsibility of **getting the job done**. They must be the leaders in the task of producing products demanded by the customers most **efficiently** and **effectively**. The production/operations managers are involved in planning, organising, co-ordinating, executing and controlling of all activities that create goods and/or services to satisfy the needs of their customers. Of all the functional areas of management, **production management** (which is also referred to as **operations management**) is considered to be crucial in any manufacturing organisation because it is responsible for converting raw materials into finished goods ensuring that the objectives regarding volume of production (quantity), quality of outputs (*i.e.*, products), cost of production (*i.e.*, productivity), the timeliness of production (*i.e.*, delivery schedules to meet customer demand), customer service and ultimately maximum possible customer satisfaction are met.

Meaning of "Production"

Production implies the creation of goods and services to satisfy human needs. It involves conversion of inputs (resources) into outputs (products). It is a process by which, raw materials and other inputs are converted into finished products. Earlier the word *"***manufacturing***"* was used synonymously with the word *"***production***"*, but nowadays, we use the term "manufacturing" to refer to the process of producing only tangible goods whereas the word "production" (or operation) is used to refer to the process of creating both goods (which are tangibles) as well as services (which are intangibles).

Any process which involves the conversion of raw materials and bought-out components into finished products for sale is known as **production**. Such conversion of inputs adds to the **value** or **utility** of the products produced by the conversion or transformation process. The utility or added value is the difference between the value of outputs and the value of inputs. The value addition to inputs is brought about by **alteration, transportation, storage or preservation** and **quality assurance**.

Meaning of "Operations"

The term "operations" refers to a function or system that transforms inputs into outputs of greater value. **Operations** are often defined as a transformation or conversion process wherein inputs such as materials, machines, labour and capital are transformed into outputs (goods and services). In a productive system, if the outputs are strictly tangible goods, such a system is referred to as a **"production system"** and the transformation process is referred to as **"production"**. Nowadays, the **service system** in which the output is predominantly a service or even a pure service, is also treated as a productive system and often referred to as an **"operating system"** instead of a "production system"

Difference between Goods and Services

(i) Services are usually ***intangible*** whereas goods are ***tangible*** (*i.e.,* can be touched and seen)

(ii) Services are often ***produced and consumed simultaneously***, services cannot be stored whereas goods can be produced and inventoried before consumption or use.

(iii) Services are often ***unique***, for example insurance policies, medical treatment procedures, haircut styles, *etc*.

(iv) Services have ***high customer interaction***, services are often difficult to standardize and automate because customer interaction demands uniqueness. The service product may have to be customized in most of the service offerings.

(v) Services are often ***knowledge based***, for example educational, health-care, legal and consultancy services and, therefore, difficult to standardize and automate.

(vi) Services are frequently ***dispersed*** because services may have to delivered to the client/customer at his/her place or office, a retail outlet or even at the residence of the customer/client.

(vii) Goods can be inventoried and can be resold whereas reselling of services is unusual and services cannot be inventoried.

(viii) Some aspects of quality of goods are measurable whereas many aspects of quantity of services are difficult to measure.

(ix) Selling and production are distinct in case of goods whereas in case of services selling is often a part of the service.

(x) Goods can be transported whereas service cannot be transported but the service provider can be transported.

(xi) Location of facility to manufacture goods, affects costs whereas location of service facility affects customer contact.

(xii) Manufacturing of goods can be easily automated whereas service is often difficult to automate.

NATURE OF PRODUCTION/OPERATIONS

The nature of production or operations can be better understood by viewing the manufacturing function as :

(i) Production/operations as a system,

(ii) Production/operations as an organisational function,

(iii) Production/operations as a conversion or transformation process and

(iv) Production/operations as a means of creating utility.

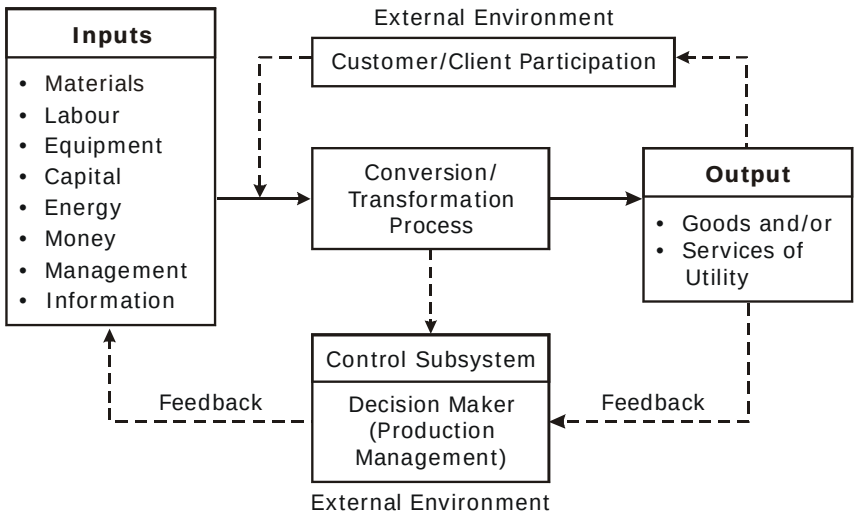
These four distinct views are discussed in the following section.

Production/Operations as a System

This view is also known as *"***systems concept of production***"*. A ***system*** is defined as the collection of interrelated entities. The systems approach views any organisation or entity as an arrangement of interrelated parts that interact in ways that can be specified and to some extent predicted. Production is viewed as a system which converts a set of inputs into a set of desired outputs. A production system has the following elements or parts : *(i)* Inputs, *(ii)* Conversion process or transformation process, *(iii)* Outputs *(iv)* Transportation subsystem, *(v)* Communication subsystem and *(vi)* Control or decision making subsystem.

Exhibit 1.1 illustrates the systems view of production/operations function.

Exhibit 1.1 : Systems View of Production/Operations Function

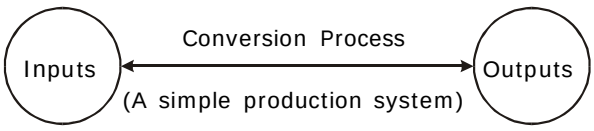


Production/Operations as an Organisational Function

To create goods and services, all organisations whether manufacturing goods or providing services perform four basic functions. They are *(i)* Marketing function *(ii)* Production or Operations function. *(iii)* Finance function and *(iv)* Human Resources function. Production is considered as a crucial function which creates goods and services whereas marketing function generates demand for products or obtains customers' orders, finance function keeps track of how well the organisation performs and takes care of all cash inflows and cash outflows, and human resources function looks into the people aspect of the organisation and the best utilisation of people in the organisation. Production function plays a central role in achieving the objectives of any business organisation.

Production/Operations as a Conversion/Transformation Process

The conversion or transformation sub-system is the core of a production system because it consists of processes or activities wherein workers, materials, machines and equipment are used to convert inputs into outputs, *i.e.*,



The conversion process may include manufacturing processes such as cutting, drilling, machining, welding, painting, *etc.*, and other processes such as packing, selling, *etc.*

Any conversion process consists of several small activities referred to as "**operations**" which are some steps in the overall process of producing a product or service that leads to the final output.

Table 1.1 illustrates some examples of conversion processes used in the production systems.

Table 1.1 : Examples of Conversion Processes used in Production Systems

Production System	*Inputs*	*Conversion Process*	*Outputs*
Steel Plant	Iron ore, coal/coke limestone, labour, machinery	Smelting, rolling	Steel sections, sheets
Restaurant	Hungry customers, chefs, services, equipment	Cooking and serving food	Satisfied customers
Automobile Plant	Raw materials and components, machinery, labour	Fabrication of parts and assembly of automobiles	Automobile
Oil Refinery	Crude oil, equipment, labour	Chemical processes (Fractional distillation)	Petroleum Products
Supermarket	Customers with needs, salespersons	Selling/retailing	Satisfied customers
College or University	High school students, teachers	Teaching (Imparting knowledge and skills)	Graduates (Educated persons)
Airline	Aeroplanes, pilots, engineers, flight attendants	Air transportation	Satisfied customers to their destinations

Production/Operations as a Means of Creating Utility

Production is defined as the process of adding to the value of outputs or the process of creating utility in outputs. "Utility" is the power of satisfying human needs. During the process of converting the raw materials into finished goods, various types of utilities are created while adding value to the outputs. These types of utilities are :

(i) **Form utility:** which is created by changing the size, shape, form, weight, colour, smell of inputs in order to make the outputs more useful to the customers. *For example,* iron ore is changed to steel, wood is changed to furniture, *etc.*

(ii) **Place utility:** which is created by changing the places of inputs or transporting the inputs from the source of their availability to the place of their use to be converted into outputs. *For example* the iron ore and coal are transported from the mines to the steel plant to be used in the conversion process.

(iii) **Time utility:** which is created by storage or preservation of raw materials or finished goods which are in abundance sometime, so that the same can be used at a later time when they become scarce due to higher demand exceeding the quantity available.

(iv) **Possession utility:** which is created by transferring the possession or ownership of an item from one person to another person. *For example,* when a firm purchases materials from a supplier, the possession utility of the materials will increase when they are delivered to the buying firm.

(v) **Service utility:** which is the utility created by rendering some service to the customer. *For example,* a doctor or a lawyer or an engineer creates service utility to a client/customer by rendering service directly to the client/customer.

(vi) **Knowledge utility:** which is created by imparting knowledge to a person. *For example,* a sales presentation or an advertisement about some product communicates some information about the product to the customer, thereby imparting knowledge.

The activities carried out while creating the utilities discussed above are referred to as **production functions**.

Production Function

Production function may be defined as the creation of useful products for sale with the help of inputs such as materials, machines, labour, land, capital and management. The production function represents basically a physical relationship between inputs and outputs. It may be represented as

$$Q = f(a, b, c, d...)$$

where 'Q' is the quantity of output and a, b, c, d, *etc.*, represent the quantities of various inputs such as material, machine hours, labour hours, energy, *etc.*, The production function specifies the amount of outputs resulting from the amount of inputs used during a specified period of time. The productive use of the resources is described by the term **productivity**. Productivity is an index that measures outputs (goods and services) relative to the inputs (materials, energy and other resources).

It is usually expressed as, $\text{Productivity} = \frac{\text{Output}}{\text{Input}}$

Productivity is also known as **productive efficiency** or the **efficiency of the production process**. It indicates how well a productive process is carried out to convert a set of inputs into a set of outputs of value to the customer which also provides reasonable profits to the manufacturer or seller.

Importance of Production Function

The production is the core function of any business organisation. Production function creates goods and services and organisations exist primarily to create goods and/or to provide services. Without production function, there would be no need for any other function such as marketing, finance or human resource function. Also, more than 50 per cent of employees in a business organisation have jobs in the area of production. Moreover the production function is responsible for a major portion of assets in most organisations. Consumption of goods and services is an integral part of any society and production function facilitates creation of goods and services for the benefit of people in the society.

Box 1.1 lists some of the areas in which production/operations management can offer competitive advantage to a firm.

Box 1.1 : Areas in which Production/Operations Management can offer Competitive Advantage

(i) Shorter new product lead time (*i.e.*, speed to market)
(ii) Higher inventory turnover (*i.e.*, low inventory)
(iii) Shorter manufacturing cycle time
(iv) Higher product quality (*i.e.*, reduced defects)
(v) Greater flexibility
(vi) Better customer service
(vii) Reduced wastages
(viii) Higher productivity (*i.e.*, reduced costs)

Managing a Production/Operating System

Production management refers to the application of management principles to the production function in a production system. It consists of application of planning, organising, staffing, directing and controlling functions in the process of converting the inputs to the desired outputs, efficiently and effectively.

Production management is the process which combines and transforms various resources (inputs) used in a production system into value added outputs (products/services) in a controlled manner. The term production management is usually used for a production system which produces tangible goods whereas, the term operations management is more frequently used where the inputs are converted into intangible services. However, many authors use the common term "production and operations management" to represent either a manufacturing system or a service system.

Distinction between Production Management and Operations Management

Production Management refers to the application of management principles to the production function in a productive system such as a factory or a manufacturing plant. (*e.g.*, steel plant, cement plant, *etc.*). It involves application of planning, organising, directing and controlling the production processes employed for the conversion of inputs into outputs in a productive system.

Operations Management refers to a set of activities that creates value in the form of goods and/or services by transforming inputs into outputs. Operations management designs and operates productive systems or operating systems such as banks, hospitals, hotels, government agencies and manufacturing plants. Operations management includes activities such as organising work, selecting processes, arranging layouts, locating facilities, designing jobs, measuring performance, controlling quality, scheduling work, managing inventory and planning production.

From the above definition of production management and operations management, it becomes clear that there is hardly any difference between the two terms. But the two apparent differences between production management and operations management are:

(i) The term “production management” is mainly used for a productive system where tangible goods are produced; whereas the term “operations management” is more frequently used where various inputs are transformed into intangible services.

(ii) Operations management is the more recent term used to activities involved in the process of transforming inputs into outputs (goods and/or services) in a productive system, whereas the term “production management” (or manufacturing management) was used earlier to refer to activities related to the process of transforming inputs into outputs (mainly tangible goods).

Because of the narrow difference between the two terms, we use these two – Production Management and Operations Management terms interchangeably in this book.

Objectives of Production/Operations Management

Some of the important objectives of production/operations management are :

(i) Maximum customer satisfaction through quality, reliability, cost and delivery time.

(ii) Minimum scrap/rework resulting in better product quality.

(iii) Minimum possible inventory levels (*i.e.*,optimum inventory levels).

(iv) Maximum utilisation of all kinds of resources needed.

(v) Minimum cash outflow.

(vi) Maximum employee satisfaction.

(vii) Maximum possible production (*i.e.*, outputs).

(viii) Higher operating efficiency.

(ix) Minimum production cycle time.

(x) Maximum possible profit or return on investment.

(xi) Concern for protection of environment.

(xii) Maximum possible productivity.

Responsibilities of Production/Operations Managers

The following are the major responsibilities of production/operations managers :

(i) Meeting requirements of quality demanded by customers.

(ii) Establishing realistic delivery or completion dates.

(iii) Producing the required volume of products to meet the demand.

(iv) Selection and application of most economic methods or processes.

(v) Controlling the cost of inputs and conversion process and thereby keeping the cost of outputs within the desired limits.

Production managers are responsible for the amalgamation of five Ps namely **Product, Plant, Processes, Programs** and **People**. The **product** is the most obvious interface between production and marketing. It includes characteristics such as performance, aesthetics, quality, reliability, selling price, delivery dates and/or lead times. The **plant** includes buildings, equipment and machinery required to produce the product.

The plant should have the capacities to meet the present needs as well as that of the future. The considerations are : *(i)* design and layout of buildings, *(ii)* performance and reliability of machines and equipment, *(iii)* maintenance of machines and equipment, *(iv)* safety of installation and operation of machinery and equipment and *(v)* environment protection.

The **processes** include the transformation or conversion processes which convert the inputs into outputs. The factors to be examined in deciding upon a process are : *(i)* available capacity, *(ii)* available labour skills, *(iii)* type of production, *(iv)* layout of plant and equipment, *(v)* safety requirements in operations and *(vi)* costs to be achieved.

The **programs** consist of schedules or timetables which set times for delivery of products or services to customers. These delivery schedules in turn decide the time schedules for various activities such as design, purchase, manufacture, assembly, packing and despatch *etc*.

The **people** aspect of production management includes the skills, knowledge, intelligence, *etc*., of labour and managerial personnel which is crucial for the efficient and effective utilisation of resources for the production of outputs.

DECISION MAKING IN PRODUCTION/OPERATIONS MANAGEMENT

What Production/Operations Managers Do?

The production/operations managers manage all activities of the production/operations systems which convert inputs into the desired outputs (goods and services). The production/operations managers have the ultimate responsibility for the creation of goods or provision of services. Even though the kind of jobs that production/operations managers oversee vary from organisation to organisation, (because of the different products or services involved) their job is essentially managerial. They must co-ordinate the use of resources through the managerial process of planning, organising, staffing, directing (or influencing) and controlling. *Box 1.2* shows some of the responsibilities of productions/operations managers.

Box : 1.2 : Responsibilities of Production/Operations Managers

(i)	Planning	: Capacity, location, products and services, make or buy, layouts, projects and scheduling.
(ii)	Organising	: Degree of centralisation, subcontracting.
(iii)	Staffing	: Hiring/laying off of employees.
(iv)	Directing	: Incentive plans, issue of work orders, job assignments.
(v)	Controlling	: Inventory control, Quality control, Cost control.

A better insight to how production/operations managers manage can be had by examining the decisions in production and operations management, since all managerial functions such as planning, organising, staffing, directing and controlling involve decision making.

The decisions which production/operations managers make may be classified into three general categories:

(i) **Strategic Decisions:** Decisions about products, processes and facilities. These decisions are strategically important and have long-term significance for the organisation.

(ii) **Operating Decisions:** Decisions about planning production to meet demand.

(iii) **Control Decisions:** Decisions about controlling operations concerned with day-to-day activities of the workers, quality of products and services, production costs, overhead costs and maintenance of plant and equipment.

Some examples of strategic, operating and controlling decisions are discussed below :

Strategic Decisions: These are decisions concerning long range production/operations strategies. Some of the examples of strategic production/operations management (POM) decisions are :

(i) Deciding about launching of a new-product development project.

(ii) Deciding on the design for a production process for a new product.

(iii) Deciding on how to allocate scarce resources such as materials, machine and labour capacities and utilities.

(iv) Deciding about what new facilities are needed and where to locate them.

Operating Decisions: These decisions must help to resolve the issues concerned with planning production to meet customers' demands for products and services and to achieve customer satisfaction at reasonable costs. Examples of operating decisions are :

(i) Deciding how much finished goods inventory to be carried for each product.

(ii) Deciding the next month's production schedule for producing the products.

(iii) Deciding about hiring of casual (temporary) workers for the next month.

(iv) Deciding about the volume of purchase from each vendor for the next month.

***Control Decisions*:** These decisions are concerned with problems in production such as variations in labour output (productivity), variations in product quality, breakdown of production equipment, *etc.* Production/ operations managers need to control poor worker performance, inferior product quality and excessive equipment breakdowns so that the profitable operation of the productive system is not affected. Examples of control decisions are :

(i) Deciding the course of action about a department's failure to meet the planned labour cost target.

(ii) Developing labour cost standards for a new or modified product design which is about to be taken up for production.

(iii) Deciding about the new quality control acceptance criteria for a product for which the design has been changed.

(iv) Deciding about the frequency of preventive maintenance for key machinery or equipment.

Table 1.2 lists the types of production management decisions and their applications.

Table 1.2 : Production management decisions and their applications

Type of Decisions	*Area of Involvement*	*Nature of Activities*
1. Strategic decisions (Planning products, processes and facilities)	*(i)* Manufacturing processes and technology design	*(i)* Product design, process design
	(ii) Plant location and plant layout	*(ii)* Choice of production technology
	(iii) Long range capacity planning (Equipment and labour capacity)	*(iii)* Choosing the best location
		(iv) Deciding about the type of plant layout and shop layout.
		(v) Deciding the installed capacity of the plant
2. Operating decisions (Matching production with demand)	*(i)* Production planning	*(i)* Preparing the master production schedule
	(ii) Inventory planning	*(ii)* Planning inventory levels for raw materials, work-in-process and finished goods
	(iii) Resource requirement planning	*(iii)* Planning for requirements of materials & capacities (Labour and equipment)
	(iv) Production scheduling	*(iv)* Detailed scheduling and machine loading charts
	(v) Procurement planning	*(v)* Vendor selection
3. Control decisions	*(i)* Labour productivity	*(i)* Controlling labour output through establishment of performance standards
	(ii) Quality	*(ii)* Controlling quality of incoming materials, semifinished goods and finished goods.
	(iii) Projects	*(iii)* Controlling projects (Costs and completion dates) using PERT/CPM techniques.
	(iv) Maintenance	*(iv)* Controlling machine down-time and repair time by good maintenance practices.

Box 1.3 shows ten important decision areas of production and operations management.

Box 1.3 : Ten decision areas of production/operations management

(i) Managing quality	*(ii)* Design of goods and services (product design)
(iii) Process strategy (process design)	*(iv)* Location strategies
(v) Layout strategies	*(vi)* Human resources strategies
(vii) Supply-chain management	*(viii)* Inventory management
(ix) Scheduling	*(x)* Maintenance

The ten decision areas in production/operations management shown in *Box 1.3* are illustrated in detail in *Table 1.3* below :

Table 1.3 : Ten critical decision areas of POM and their related issues

Decision Area	*Related Issues*
1. Quality management	*(a)* Who is responsible for quality?
	(b) How do we define the quality we want in our product or service?
2. Product and service design	*(a)* What product or service should we offer?
	(b) How should we design these products and services?
3. Process strategy (Process design)	*(a)* What process will these products or capacity design services require and in what sequence?
	(b) What technology and equipment is necessary for these processes?
4. Location selection	*(a)* Where should the facility be located?
	(b) On what criteria should we base the location selection decision?
5. Layout design	*(a)* How should we arrange the facility?
	(b) How large should the facility be to meet our production plan?
6. Human resources	*(a)* How do we provide a reasonable work and job design environment?
	(b) How much can we expect our employees to produce?
7. Supply-chain	*(a)* Should we make or buy a particular management component?
	(b) Who are our preferred suppliers and how many suppliers should we have?
8. Inventory	*(a)* How much inventory of each item should management hold?
	(b) When do we re-order?
9. Scheduling	*(a)* Should we subcontract production to outside sources?
	(b) Should we retain our employees on the pay roll during slowdowns.
10. Maintenance	*(a)* Who is responsible for maintenance?
	(b) What should be our maintenance policy?

ORGANISING TO PRODUCE GOODS AND SERVICES

To create goods and services, all organisations, whether manufacturing goods or providing services, perform three basic functions. They are :

(i) **Marketing:** which generates the demand or takes customers' orders for a product or service.

(ii) **Production/Operations:** which creates the product (goods or services).

(iii) **Finance/Accounting:** which keeps track of how well the organisation is performing, and takes care of cash inflow and cash outflow.

Production/operations managers need to build and maintain strong relationships both **intra-organisationally** and **inter-organisationally**. Inter-organisational relationship exists between production/ operations department and suppliers, whereas intra-organisational relationship calls for cross-functional coordination.

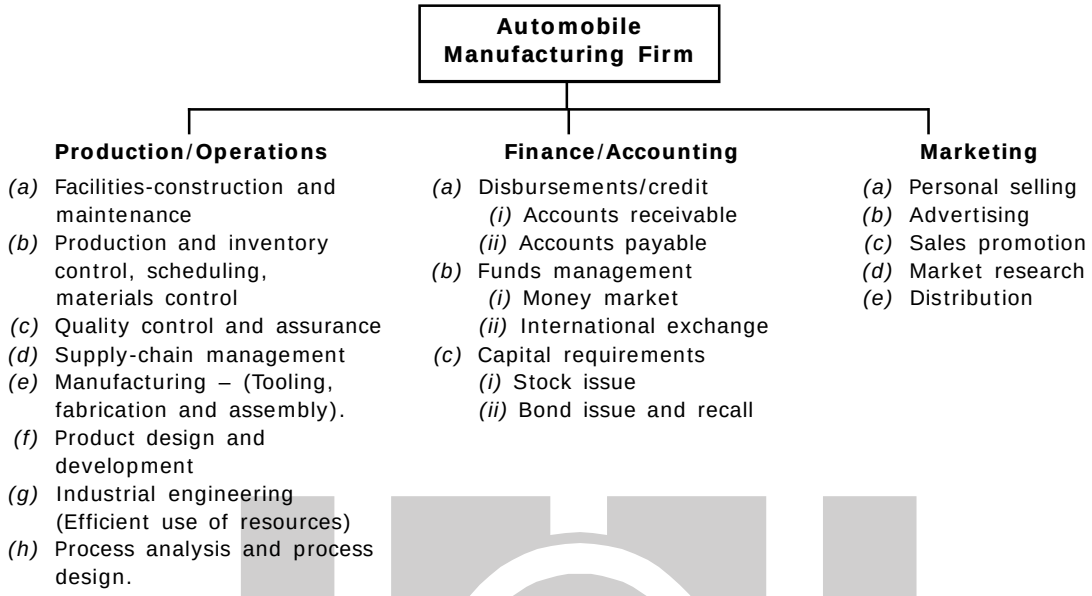
Cross functional coordination is essential for effective production/operations management. *For example,* marketing function determines the need for new products and services and the demand for existing ones and operations managers must bring together human and capital resources to meet these demands effectively.

Also, operations managers must consider facility location and relocations to serve new markets and the design of layouts for service organisations must match the image that marketing seeks to project to the customers. Operations managers must plan output rates and capacities to match the demand forecasts and delivery promises made to the customers.

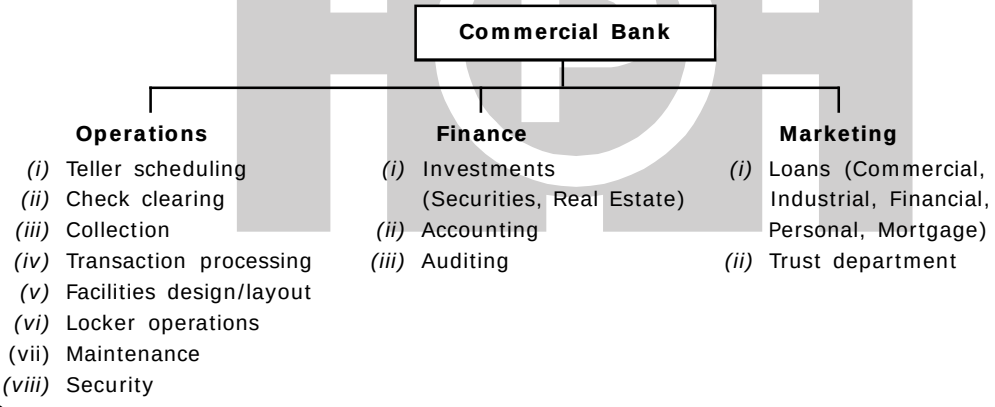
Exhibit 1.2 illustrates organisation charts for a manufacturing and a service organisation.

Exhibit 1.2 : Organisation charts for a manufacturing and a service organisation

***(a)* Organisation chart for a manufacturing organisation**



***(b)* Organisation chart for a service organisation.**



Operations managers need feedback from the accounting function to understand their current performance. Financial measures help the operations managers to assess labour costs, the long-term benefits of new technologies and quality improvement projects. Accounting helps in computing the production costs and in bills payment to suppliers.

FUNCTIONS OF PRODUCTION/OPERATIONS MANAGERS

The major functions of production managers may be categorised as shown below :

(i) **Production Techniques:** Equipment Design, Process Design, Plant Layout and Shop Layout, Design of Materials Handling System.

(ii) **Capacity Management:** Forecasting Demand, Delivery Commitment, Facility Location and Resource Allocation.

(iii) **Industrial Engineering** *(or* **Work Study***)***:** Method Study, Work Measurement.

(iv) **Production Planning and Control:** Estimating, Forecasting, Routing, Scheduling, Dispatching and Progressing.

(v) **Inventory Control:** Purchasing, Storing and Controlling Inventory Levels and Material Issues.

(vi) **Quality Control:** Inspection, Quality Control, Quality Assurance and Reliability, Statistical Quality Control and Total Quality Control.

(vii) **Maintenance:** Servicing, Repairing, Breakdown/Preventive Maintenance, Spare Parts Inventory Control and Equipment Replacement.

Skills Neded for Production/Operations Managers

The production managers need the following skills or competencies :

(i) **Technical Competence:** *(a)* Basic understanding of technology with which the production system works. *(b)* Adequate knowledge of the work they are to manage.

(ii) **Behavioural Competence:** Interpersonal relationships, the ability to work with other people.

PROBLEMS OF PRODUCTION/OPERATIONS MANAGEMENT

The problems involved in production management require two major types of decisions relating to :

(i) **Design of the production system** and

(ii) **Operation and control of the production system**.

Decisions related to the design of production system are **long-run** decisions whereas, decisions related to operations and control of the production system are **short-run** decisions.

The problems involve the relative balance of the emphasis on such factors as **cost, service** and **reliability** of both **functional** and **time** performance, which depends on the basic purposes of the total enterprise and on the general nature of goods and services produced. In general, manufacturing organisations emphasise more on cost, consistent with quality and delivery commitments whereas, service organisations may emphasise reliability and service, consistent with cost objectives (*for example,* hospitals).

Long-Run Decisions

Long-run decisions related to the design of the production system are:

(i) **Selection and Design of Products:** Product selections and designs with productive capability (*i.e.*, producibility of products) are interdependent.

(ii) **Selection of Equipment and Processes:** Selection of the most economic equipment and processes among the various alternatives considered, the firm's capability to invest in capital assets and its basic approach to production (*i.e.*, job, batch, mass or continuous production) must be considered.

(iii) **Production Design of Parts Processed:** Production design aims at selection of equipment, processes, and tools for economic production which set limits on the cost of outputs.

(iv) **Job Design:** It involves basic organisation of work as well as matching workers to their jobs in order to reduce fatigue and improve productivity.

(v) **Location of the System:** It is a trade-off decision since there is no one best location for a productive system to be located. The balance of cost factors determined by various considerations is critical.

(vi) **Facility Layout:** This involves decisions related to design capacity, basic modes of production, shifts of working, use of overtime and subcontracting. In addition, operations and equipment must be located in relation to each other such that the overall material handling cost is minimised. Other factors involved are heating, lighting and other utility requirements, the allocation of storage space, washing space and the design of the building to house the layout.

Short-Run Decisions

Short-run decisions related to the operations and control of the system are :

(i) **Inventory and Production Control:** Decisions made are concerned with allocation of productive capacity consistent with demand and inventory policy. Feasible schedules must be worked out and the load on machines and labour and the flow of production must be controlled.

(ii) **Maintenance and Reliability of the System:** Decisions must be made regarding the maintenance effort, maintenance policy and practice recognising the fact that machine down time may lead to idling of labour and production stoppage resulting in lost sales.

(iii) **Quality Control:** Decisions must be made to set permissible levels of risk that bad parts are produced and shipped or the risk that good parts are scrapped due to sampling inspection. Inspection costs must be balanced with the probable losses due to passing defective materials or products. Decisions regarding controlling the quality of on-going processes must be taken.

(iv) **Labour Control:** Labour is the major cost element in most products and services. Hence, work measurement and wage incentive systems must be developed to control labour costs and to increase labour productivity.

(v) **Cost Control and Improvement:** Day-to-day decisions which involve the balance of labour, material and overhead costs must be made by production supervisors.

The relative importance of these problems of production management varies considerably depending on the nature of the production system. The production manager must be able to sense the relative importance of these various problems in a given situation and take appropriate decisions to solve these problems.

THE HISTORICAL EVOLUTION OF PRODUCTION/OPERATIONS MANAGEMENT

Eventhough systems of production have existed since ancient times (*for example,* the great wall of China and Egyptian pyramids were built long time ago) the production of goods for sale and the modern factory system had their roots in the Industrial Revolution (which began in the 1770's in England and spread to other countries in Europe and later to the US in 19th century).

However, the substitution of machine power to human power started with the most significant invention of steam engine by James Watt in 1764. followed by invention of spinning jenny (1770) and powerloom (1785). Adam Smith advocated the concept of "division of labour" in his book "The Wealth of Nations" in 1776 and in 1832, Charles Babbage recommended the use of scientific methods for analysing production problems.

However, the era of scientific management started with the work of F.W. Taylor in 1878 who studied work methods in great detail to identify the best methods for doing each job. Taylor's book "The Principles of Scientific Management" published in 1911, laid the foundation for the field of production management.

A number of other pioneers also contributed to this movement including the following :

Frank Gilbreth and his wife Lillian Gilbreth were recognised for their contribution to the development of the "Principles of motion economy" and the concept of "Therbligs" in 1911.

Henry Gantt recognised the value of non-monetary rewards to motivate workers and developed widely used system of scheduling (machine loading) called "Gantt chart" in 1912, Harrington Emerson applied Taylor's ideas to develop organisational structure and encouraged the use of experts to improve organisational efficiency.

Henry Ford developed the concept of mass production and assembly lines with conveyors in 1913, in his automobile plant. Ford also used the concepts of "**interchangeable parts**" and **division of labour** (of Adam Smith) which enabled him to tremendously increase the production rate in his factories.

F.W. Harris developed the concept of "Economic Order Quantity" in 1915 which is still recognised as a classical work in inventory control systems. In 1931, Dodge and Romig and W. Shewhart developed the concept of sampling inspection and use of statistical tables for acceptance sampling plans. Earlier in 1924, Shewhart developed the concept of statistical quality control and use of control charts to control the quality of on-going processes.

The "human relations movement" was started by Elton Mayo in 1930's, through his famous experiments at Western Electric's Hawthorne plant and his findings came to be known as "Hawthorne effect". His studies revealed that in addition to physical and technical aspects of work, worker motivation is critical for improving productivity.

During the 1940's, Abraham Maslow developed motivational theory known as "Hierarchy of Needs Theory" which was later refined by Frederick Herzberg as "Motivation-Hygiene" theory in 1950s. Douglas McGregor added "Theory X" and "Theory Y" in 1960. In 1970, William Ouchi added "Theory Z" which combined the Japanese approach and the traditional Western approach to management.

After World War II, operations research and quantitative techniques were applied to production management resulting in decision models for forecasting, inventory management, project management and other areas of production management. Widespread use of personal computers and user-friendly softwares have popularised application of these quantitative techniques in production management since the 1980's. Development in Management Information Systems (MIS) and Decision Support Systems (DSS) provided a further boost to the developments in production management.

Advanced manufacturing technology enabled production managers to use Computer-Aided-Design (CAD), Computer-Aided-Manufacturing (CAM), Computer Numerically Controlled (CNC) machines, Robots, Computer Integrated Manufacturing (CIM), Flexible Manufacturing System (FMS), *etc.*, in the field of production management.

Moreover, a number of Japanese manufacturers have developed modern management practices that have increased the productivity of their operations and the quality of their products. The new approaches in production management emphasise quality (Total Quality Management) and continuous improvement (Kaizen), worker teams and empowerment to achieve customer satisfaction. The Japanese have spawned the "quality revolution" and adopted Just-In-Time (JIT) production system to put themselves in the forefront of time-based competition. [*Table 1.4* provides a chronological summary of some of the key developments in the evolution of production/operations management.]

THE SCOPE OF OPERATIONS MANAGEMENT

Operations management has been gaining increased recognition in recent years because of the following reasons:

(i) The application of operations management concepts in service operations.

(ii) The growing importance of quality.

(iii) The introduction of operation management concepts to other areas such as marketing and human resources and

(iv) The realization that the operations management function can add value to the end product.

The above reasons are briefly discussed in the following paragraphs:

(i) **Application of operations management concepts in service operations:** Initially, operations management concepts focused mostly on manufacturing. But as countries become more developed, services grow and represent a larger percentage of the economies of developed countries. This led to the expansion of application of operations management from manufacturing/production systems to service systems also in order to improve the productivity of service organisations. This is quite obvious because majority of the production systems have outputs consisting of both tangible goods and intangible services.

Table 1.4 : Historical Summary of Developments in Production / Operations Management

Approximate Year	*Contribution/Concept*	*Originator*
1776	Division of labour	Adam Smith
1790	Interchangeable parts	Eli Whitney
1911	Principles of management	F.W. Taylor
1911	Motion study and Industrial Psychology	Frank and Lillian Gilbreth
1912	Scheduling charts (Machine loading)	Henry Gantt
1913	Mass production and moving assembly lines	Henry Ford
1915	Mathematical model for Inventory management (EOQ model)	F.W. Harris
1930	Hawthorne studies on worker motivation	Elton Mayo
1935	Statistical techniques for quality control	F.W. Dodge, H.G. Romig, W. Shewhart
1940	Quantitative techniques approach	Operations Research Groups
1947	Linear programming	George Dantzig
1951	Commercial digital computers	Sperry Univac
1950s	Automation	Numerous
1960s	Extensive development of quantitative tools	Numerous
1975	Emphasis on manufacturing technology	W. Skinner
1980s	Emphasis on quality, flexibility, time-based competition	Japanese manufacturers
1990s	Internet	Numerous

(ii) **Growing importance of quality:** Quality is a key component of operations management. Quality is no longer limited to manufacturing function but important in all functional areas throughout the organisation. With the integration of manufacturing and services operations, quality is no longer limited to technical requirement of tangible goods but also equally important for service. Improvement in quality in all areas of the business improves customer satisfaction and increases customer loyalty.

(iii) **Expansion of operations management concepts to other functions:** In addition to quality, concepts of operations functions such as product design and process analysis are applied in other functional areas such as marketing, software development, finance and accounting, human resources, *etc*.

(iv) **A new paradigm for operations management:** In the post World Wide II period, upto 1970s, with demand significantly exceeding supply, operations managers emphasized on utilization of available production capacity — a reactive approach rather than planning pro-active for the future. In the early 1970s, competition world-wide became intensive and forced operations managers to assume a proactive role in developing the overall strategy for an organisation. They realized the role of operations function in adding value to the products manufactured (that is affecting how much a customer is willing to pay for the products). In this paradigm shift, operations strategies included other dimensions such as quality, speed of delivery and process flexibility for adding value to products, other than cost to increase profit margins. This approach to operations strategy resulted in a new paradigm for the operations functions.

Today, the scope of operations management ranges across the organisation. Operations management people are involved in product and service design, process selection, technology choice, design of work

systems, location planning, facilities planning and quality planning and control. The operations function includes many inter-related activities such as forecasting, capacity planning, scheduling, inventory management, quality assurance, employee motivation, facilities location and layout, *etc.* There are other areas which are interrelated with operations function, for example, purchasing, industrial engineering, maintenance and physical distribution operations managers apply ideas and knowledge to:

(i) Cut production time to improve speed of launching new products to market.

(ii) Improve flexibility to meet rapidly changing customer needs.

(iii) Enhance product quality.

(iv) Improve customer service and

(v) Increase productivity and reduce costs and thereby improve profitability of the company.

Operations management is the management of productive resources that are used to create saleable products or services. It is that sale of products and services that provide an opportunity for profitability for an organisation. Profitability results from the creation of value and a strategy for maintaining a link to the customers who define value for the goods or services offered. The creation of value at a level that exceeds the cost of creating it provides the potential for profitability. Operations management has responded well to four dominant environmental forces affecting the business: *(i)* competition resulting from globalisation of business *(ii)* increasing levels of communication and competition brought about by the Internet and other disruptive technologies *(iii)* the impact of natural environment and *(iv)* regional pressures having impact on business decisions.

RECENT TRENDS IN PRODUCTION/OPERATIONS MANAGEMENT

Many recent trends in production/operations management relate to global competition and the impact it has on manufacturing firms. Some of the recent trends are :

1. **Global Market Place:** Globalisation of business has compelled many manufacturing firms to have operations in many countries where they have certain economic advantage. This has resulted in a steep increase in the level of competition among manufacturing firms throughout the world.
2. **Production/Operations Strategy:** More and more firms are recognising the importance of production/ operations strategy for the overall success of their business and the necessity for relating it to their overall business strategy.
3. **Total Quality Management (TQM):** TQM approach has been adopted by many firms to achieve customer satisfaction by a never-ending quest for improving the quality of goods and services.
4. **Flexibility:** The ability to adapt quickly to changes in volume of demand, in the product mix demanded, and in product design or in delivery schedules, has become a major competitive strategy and a competitive advantage to the firms. This is sometimes called as **agile manufacturing.**
5. **Time Reduction:** Reduction of manufacturing cycle time and speed to market for a new product provide competitive edge to a firm over other firms. When companies can provide products at the same price and quality, quicker delivery (short lead times) provides one firm with competitive edge over the other.
6. **Technology:** Advances in technology have led to a vast array of new products, new processes and new materials and components. Automation, computerisation, information and communication technologies have revolutionised the way companies operate. Technological changes in products and processes can have great impact on competitiveness and quality, if the advanced technology is carefully integrated into the existing system.
7. **Worker Involvement:** The recent trend is to assign responsibility for decision making and problem solving to the lower levels in the organisation. This is known as employee involvement and empowerment. Examples of worker involvement are quality circles and use of work teams or quality improvement teams.

8. **Re-engineering:** This involves drastic measures or break-through improvements to improve the performance of a firm. It involves the concept of clean-slate approach or starting from scratch in redesigning the business processes.
9. **Environmental Issues:** Today's production managers are concerned more and more with pollution control and waste disposal which are key issues in protection of environment and social responsibility. There is increasing emphasis on reducing waste, recycling waste, using less-toxic chemicals and using biodegradable materials for packaging.
10. **Corporate Downsizing (or Right Sizing):** Downsizing or right sizing has been forced on firms to shed their obesity. This has become necessary due to competition, lowering productivity, need for improved profit and for higher dividend payment to shareholders.
11. **Supply-Chain Management:** Management of supply-chain, from suppliers to final customers reduces the cost of transportation, warehousing and distribution throughout the supply chain.
12. **Lean Production:** Production systems have become lean production systems which use minimal amounts of resources to produce a high volume of high quality goods with some variety. These systems use flexible manufacturing systems and multi-skilled workforce to have advantages of both mass production and job production (or craft production).

In the previous section, we discussed production as a system which is also called as "systems concept of production". We also discussed simple production model having elements such as inputs, conversion process, outputs, transportation subsystem, communication subsystem and control subsystem.

In the following section, we will discuss production system in greater detail and also the various types of production, the types of production systems and the differentiating features of production systems.

DESIGNING AND OPERATING PRODUCTION SYSTEMS

As already mentioned earlier, the production manager is responsible for the creation of goods and services. This involves acquisition of resources and the conversion of these inputs into outputs using one or more suitable transformation processes. The transformation process involves managerial functions such as planning, coordinating and controlling the elements of the process including workers, equipment, facilities, allocation of resources and work methods. One of the major decisions that are made by production managers is the product design and/or service design which is taken in conjunction with marketing. Marketing people can be a source of ideas for new products and services and also for improvements to existing ones. Production people can also be a source of new ideas for improvements in the processes and product designs. Product and process designs are crucial for any organisation that wants to remain competitive in the market place. Production managers make decisions to guide the production system. Some decisions affect the ***design*** of the system and others affect the ***operation*** of the system.

SYSTEM DESIGN AND SYSTEMS OPERATION

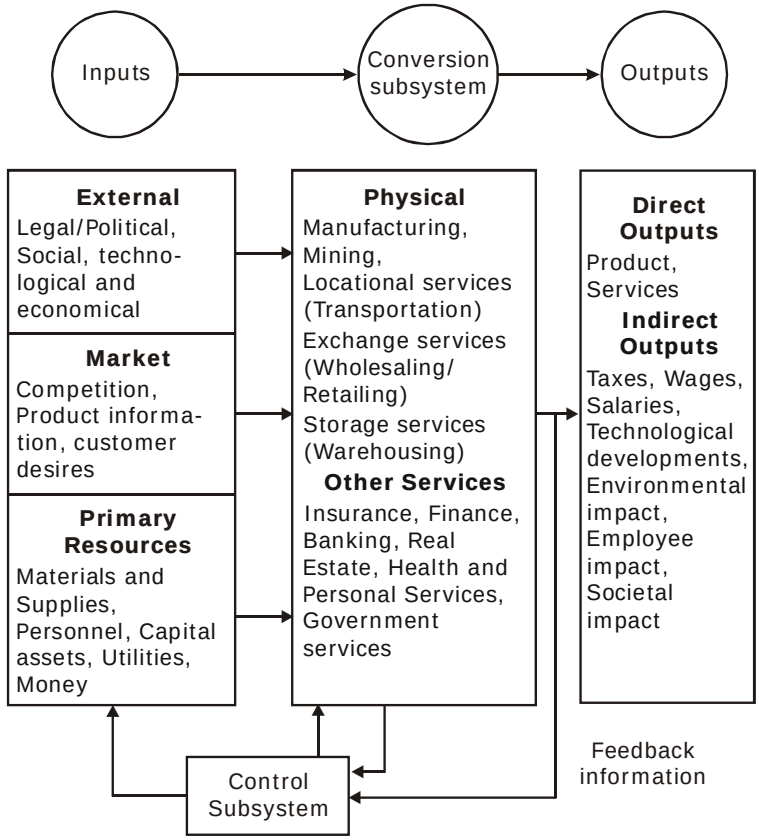
System design involves decisions relating to the capacity of the production system, the geographic location of facilities, arrangement of departments (plant layout) and placement of machines and equipment (shop layout) within the physical structures (buildings), product planning and acquisition of equipment and machinery.

Systems operation involves management of people, inventory planning and control, production scheduling, project planning and control and quality assurance. Production managers are also involved in day-to-day operating decisions. However, production managers have greater concern for *system design* because system design essentially determines many parameters of **systems operation** such as costs, space, capacities, and quality that are affected by design decisions.

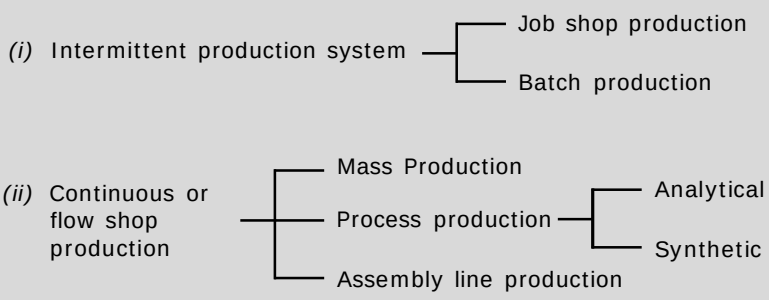
A Production System Model

A production system receives inputs in the form of materials, personnel, capital, utilities and information, which are then changed in a **conversion subsystem** into desired product/services, (called as outputs), A **control subsystem** monitors the quantity, cost and quality of outputs. The control subsystem ensures system performance by providing feedback to enable managers to take appropriate corrective action if and when necessary *Exhibit 1.3* illustrate a production system model and *Box 1.4* shows how production systems are classified.

Exhibit 1.3 : A Production System Model



Box 1.4 : Classification of Production Systems



***Inputs*:** Three general categories of inputs are :

(i) **External Inputs:** Usually informational in character and tend to provide production managers knowledge about conditions of the external environment of the system. Examples of external inputs are legal or political inputs, social, economic and technological inputs. The production managers must operate within the constraints imposed by the legal/political inputs (rules and regulations of government and business laws). Social and economic inputs indicate the trends (customers' likes and dislikes, changes in lifestyle and buying power) that may affect the system. Technological inputs enable production managers to improve the physical facilities, materials, methods, tools, processes *etc.*

(ii) **Market Inputs:** Market inputs also tend to be informational. It provides information about competition, product design, customer needs and desires, and other aspects of the market which are essential for the production managers to operate the system so as to respond to the market needs.

(iii) **Primary Resources:** These are inputs which directly support the production and delivery of outputs. *For example,* materials and supplies, personnel, capital and capital assets and utilities such as water, gas, coal, electricity, steam, compressed air, *etc.*

***Outputs*:** Outputs are categorised as : *(i)* direct outputs and *(ii)* indirect outputs.

The **direct outputs** are usually either tangible or intangible. The tangible goods are outputs of production systems whereas, the intangible services are outputs of service systems. However, there are some **indirect outputs** in both production and service systems. They are taxes, wages and salaries, technological advancements, waste, effluents, pollution, and impact on employees (health and safety) and on society/community.

***Conversion Subsystem*:** It is the core of the production system. It consists of workers, materials, and machines used to convert inputs into outputs. All organisations have the conversion or transformation in some form or the other and it varies greatly among organisations.

***Control Subsystem*:** This consists of the decision making group which is known as **Production Management.** The Production managers manage all activities of the production system. They obtain feedback information from the conversion subsystem and outputs to identify variations in performance if any and take decisions to carry out appropriate corrective actions as and when necessary.

PRODUCTION SYSTEM DIVERSITY

All organisations have at least one production system. A wide variety of these systems exist, several examples of which are given in *Table 1.5*.

Table 1.5 : Some Typical Production Systems

Production System	*Primary Inputs*	*Conversion Subsystem*	*Outputs*
Automobile factory	Purchased parts, raw materials, supplies, paints, tools, equipment, personnel, buildings and utilities	Transforms raw materials into automobiles through fabrication and assembly operations	Automobiles
Department store	Buildings, displays, shopping carts, machines, stock goods, personnel, supplies, utilities, and customers.	Attracts customers, stores goods, sells goods (exchange)	Marketed goods and satisfied customers
College or University	Students, books, supplies, personnel, buildings, utilities	Transmits information and develops skills and knowledge	Educated persons

Having discussed the concepts of the production system, it is necessary to know about the types of production systems and their features.

TYPES OF PRODUCTION SYSTEMS

Broadly production systems can be classified as :

(a) Manufacturing systems and service systems.

(b) Series and parallel production systems.

(c) Continuous flow and intermittent production systems.

These production systems are discussed in detail in the following paragraphs.

1. Manufacturing Systems and Service Systems

Production systems that produce goods are often referred to as **manufacturing systems** and the production of tangible goods is called **manufacturing.** Some common examples of manufactured goods are chemicals, steel, cement, automobiles, aeroplanes, beverages, packaged food and furniture.

Production systems that produce services are referred to as **service systems.** Services are intangible products that satisfy some need of a consumer including the enhancement of tangible goods. Examples of services systems are: healthcare services, legal assistance, financial services, accounting services, educational services, transportation services and warehousing services.

Products can also be combination of goods and services. Restaurants produce the tangible products along with the intangible services of delivery, cleaning of dishes and providing pleasant environment to the customers. (More about manufacturing systems and service systems will be discussed later in this chapter.)

2. Series and Parallel Production Systems

Production systems may exist in series; *for example,* when completed products are shipped from the factory to a warehouse, they are leaving the factory system only to arrive at a second production system, called a warehouse. The factory and the warehouse are two production systems which are in series.

Production system may also exist in parallel, such as when a number of factories produce similar products and supply several market areas. These factories may be considered as one large production system (*i.e.,* an industry). *For example,* several factories producing automobile spare parts are treated as part of larger system known as automobile spare parts industry.

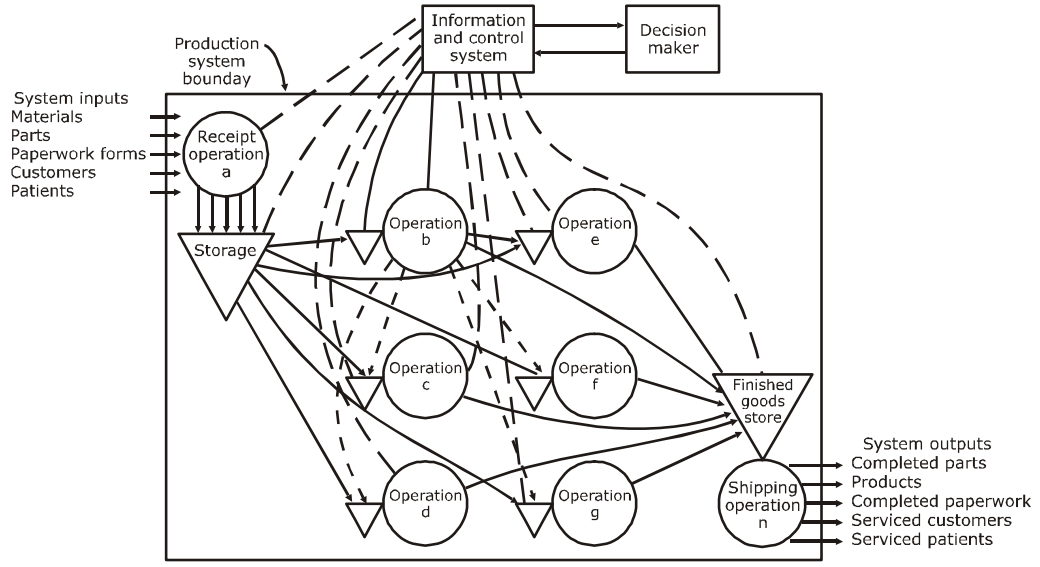
3. Continuous Flow and Intermittent Production Systems

Continuous Flow Production Systems are those where the facilities are standardised as to routings and flow. A standard set of processes and sequence of processes can be adopted. Continuous flow production systems are represented by production and assembly lines, large scale office operations and chemical processes.

Intermittent Production Systems are those where facilities must be flexible enough to handle a wide variety of products and sizes. In situations such as this no single sequence of operations is appropriate. Transportation facilities between operations must be flexible to accommodate a wide variety of routes that the inputs may require. Considerable storage between operations is required so that individual operations can be carried on some-what independently, resulting in ease of scheduling and better utilisation of men and machines. Intermittent production is represented by custom or job-order machine shops, hospitals and batch chemical processes.

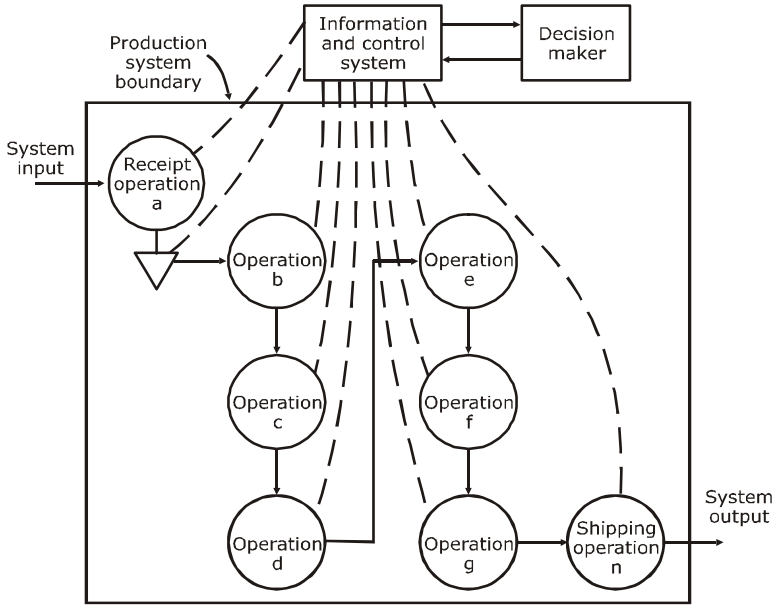
The production system model shown in *Exhibit 1.3* can be made to fit both the intermittent and continuous-flow situations by the specification of some of the detailed characteristics. *Exhibit 1.4* represents the intermittent production system.

Exhibit 1.4 : An Intermittent Production System



In the intermittent production system, inputs may be processed in any specified sequence of operations and are transported between operations. The number of operations may vary from one to any finite number. Storage occurs between all operations and the time in storage may vary from essentially negligible to any finite amount. It should be noted that in *Exhibit 1.4*, there are interconnections between all operations b through f, although only those originating at b are shown. The information and control system interconnects all activities and provides the basis for management decisions. *Exhibit 1.5* represents a continuous flow production system.

Exhibit 1.5 : A Continuous Production System



In the continuous flow production system the input-output characteristics are standardised, allowing standardisation of operations and their sequence. Minor storage of input occurs after receipt. Once on the transportation system, any storage between operations is combined with transportation (*for example,* conveyorised assembly line operations). In the ideal situation the operations are also combined with transportation so that inputs are processed while they are being moved (*for example,* painting of jobs which are being moved by means of a conveyor).

Having understood the meaning of production as a function of a production system it is necessary to understand the nature of various types of production.

The process by which goods and services are produced can be categorised on the basis of the following classifications.

(a) **Job Shop Production:** In this type of production a wide variety of customised products are made by a highly skilled workforce using general purpose equipment. It is also known as unit-production, one-off production, custom-built or taylor-made production. Ship building, furnace manufacture, tool making and printing orders are some of the examples of jobshop production.

(b) **Intermittent Flow or Batch Production:** In this type of production, a mixture of general purpose and special purpose equipment is used to produce small to large batch of products. Batch production is one form of intermittent flow production. It is used to produce moderate volumes of similar products. *For example,* ready-made garments and book manufacturers adopt batch production. Ice cream manufacturers produce a batch of ice creams of different flavour such as vanilla and strawberry.

(c) **Repetitive Flow or Mass Production:** In this type of production several standardised products follow a predetermined flow through sequentially dependent workcentres. Workers typically are assigned to a narrow range of tasks and work with highly specialised equipment. Examples are automobile and computer assembly lines.

(d) **Continuous Flow or Flow Shop Production:** Continuous processing or continuous production is employed when a highly standardised product or service is produced or rendered. Processing of chemicals, oil refineries, sugar and cement production are some of the examples of continuous flow production. Industries that use continuous processing involving chemical or metallurgical processes are sometimes referred to as **process industries** and the type of production adopted is known as **process production.** Production processes are usually performed **round the clock** in process industries to avoid costly shut-downs and start-ups.

Table 1.6 provides a summary of the characteristics of these four major types of production.

DIFFERENTIATING FEATURES OF PRODUCTION SYSTEMS

There are a number of features that differentiate production systems. The three important features are: *(i)* Degree of standardisation, *(ii)* Type of operation and *(iii)* Manufacturing operations versus service operations. These are discussed in detail in the following paragraphs.

(i) Degree of Standardisation

The output of production systems can range from highly **standardised** products to highly **customised** products. **Standardised output** means goods and services having high degree of uniformity. Standardised goods include radios, televisions, computers, newspapers, pens, pencils, canned foods, soft drinks, automobile tyres and the like.

Standardised services include automatic car washes, televised newscasts, taped lectures and commercial airline services. Customised output means that the product or service is designed for a specific customer (either a business customer or an individual). Customised goods includes eyeglasses, custom-fitted clothing, window glasses (cut to order) and customised draperies. Customised services include tailoring, taxi rides and surgery.

Table 1.6 : Characteristics of Various Types of Production.

Data	Types of Production			
	Job Shop	*Batch*	*Repetitive or Assembly*	*Continuous*
Description of outputs	Customised goods or services	Semi standardised goods or services	Standardised goods or services	Highly standardised goods or services
Examples of goods	Speciality tools	Cookies	Automobiles	Steel, paper, flour, sugar
Examples of services	Hair Styling	Education	Car wash	Heating, air-conditioning
Examples of manufacturing facilities	Machine shop	Bakery	Assembly line	Steel mill, paper mill
Examples of service facilities	Beauty shop Barber shop	Classroom	Cafeteria lines	Central heating system
Volume	Low	Low to moderate	High	Vary high
Output variety	Very high	Moderate	Low	Very low
Equipment flexibility	Very high	Moderate	Low	Very low
Advantage	Able to handle a wide variety of work	Flexibility	Low unit cost, high volume, efficient	Very efficient very high volume
Disadvantages	Slow, high cost per unit, complex planning and scheduling	Moderate cost per unit, moderate scheduling complexity	Low flexibility, high cost of downtime	Very rigid, lack of variety, costly to change, very high cost of downtime

System with standardised output can generally use standardised methods, materials and mechanisations, all of which contribute to higher volumes and lower unit costs. In systems producing customised output, each job is sufficiently different so that workers must be more skilled, the work moves slower and the work is less susceptible to mechanisation.

(ii) Types of Operations

The degree of standardisation and the volume of output of a product influence the way a firm organises production. The type of operations vary widely dependent on the nature of the output of the system. *For example*, on one end of the scale, we have a single large scale service such as launching of a space shuttle or the construction of a product such as a sky scraper. On the other end of the scale, we have a continuous process such as oil refining. In between the extremes we have customised outputs such as custom-made furniture, special-purpose machines and customised auto-repair service. We also have batch production of paints and food products and mass production of goods such as television sets, soaps and detergents, personal computers, bicycles, two wheelers and automobiles.

Earlier we have discussed about continuous flow production system and intermittent (batch) production system. The continuous flow production system employs a type of operation known as **continuous processing.** Intermittent (batch) production system employs a type of operation known as **intermittent processing.**

Batch processing and job shop processing are two types of operations under intermittent processing.

Continuous processing includes operations or activities usually performed round the clock to avoid costly shut downs and start-ups. The systems using continuous processing produce highly standardised or

highly uniform products or services. Sometimes the system may use a semi-continuous processing known as **repetitive processing** to produce one or a few highly standardised products or services.

Processing of chemicals, photographic film, newsprint and oil products are examples of continuous processing whereas examples for semiprocessing includes automobiles, television, computers, cameras and video equipment.

Batch processing is used to produce moderate volumes of similar products. *For example,* food products, ice creams and pharmaceutical products produced in batches.

Job-shop processing is used to produce a single unit or a small lot of products or service with varying specifications according to customer needs.

(iii) Manufacturing Operations Versus Service Operations

Manufacturing and service are often similar in terms of **what** is done but different in terms of **how** it is done. *For example,* both involve design and operating decisions. Decisions on size of the building needed, location, schedule, control of operations and allocation of scarce resources are applicable to both manufacturing and service organisations. However, the major difference between manufacturing and service organisations is that the first is goods-oriented while the latter is act-oriented.

The differences involve the following :

1. Customer contact,
2. Uniformity of input,
3. Labour content of jobs,
4. Uniformity of output,
5. Measurement of productivity, and
6. Quality assurance.

These are explained in the following paragraphs :

***Customer Contact*:** Service involves a much higher degree of customer contact than manufacturing. The performance of service often occurs at the point of consumption whereas manufacturing allows a separation between production and consumption. This permits a fair degree of latitude in selecting work methods, assigning jobs, scheduling work and exercising control over operations. Service operations, because of their contact with customers, can be much more limited in their range of options.

Manufacturing operations can build up inventories of finished goods whereas service operations cannot build up inventories of time and are much more sensitive to demand variability.

***Uniformity of Input*:** Service operations are subject to greater variability of inputs than manufacturing operations. Manufacturing operations can control the amount of variability of inputs.

***Labour Content of Jobs*:** Because of the on-site consumption of services and the high degree of variation of inputs, services require a higher labour content than manufacturing which is more capital-intensive.

***Uniformity of Output*:** Manufacturing tends to produce products with low variability because of high mechanisation whereas service activities sometimes appear to be slow and awkward and output is more variable or non-uniform.

***Measurement of Productivity*:** Productivity can be measured more directly in manufacturing due to the high degree of uniformity of most manufactured items. In service operations, variations in demand intensity and in requirements from job to job make productivity measurement more difficult.

***Quality Assurance*:** Is more challenging in services when production and consumption occur at the same time. In manufacturing operations, errors can be corrected before the customer receives the output.

The differences between production of goods and service operations can be summarised as below: (Refer *Table 1.7*)

Table 1.7: Differences Between Goods and Service

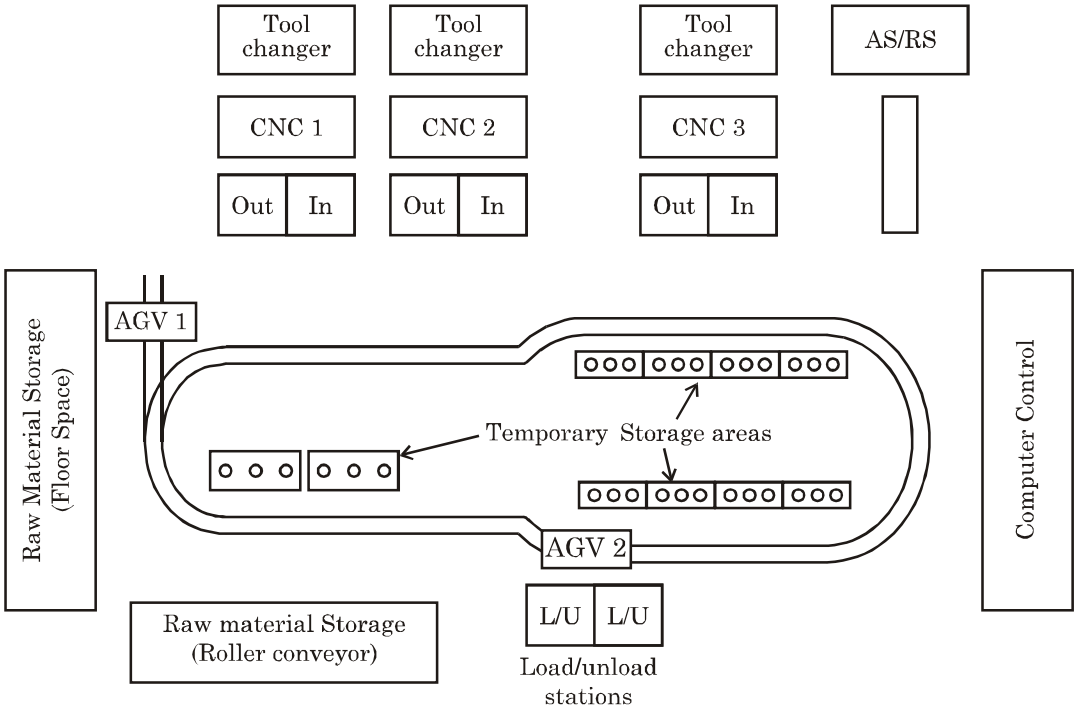
Characteristics	*Goods*	*Services*
Output	Tangible	Intangible
Customer contact	Low	High
Uniformity of input	High	Low
Labour content	Low	High
Uniformity of output	High	Low
Measurement of productivity	Easy	Difficult
Opportunity to correct quality problems before delivery to customer	High	Low

FLEXIBLE MANUFACTURING SYSTEM (FMS)

A flexible manufacturing system (FMS) is a configuration of a group of production machines (or work stations) connected by automated material handling and transferring machines and integrated by computer system which can give instructions to produce hundreds of different parts in whatever order specified.

***Exhibit 1.6* illustrates a flexible manufacturing system.**

Exhibit 1.6 : A Flexible Manufacturing System



An FMS is a type of **flexible automation system** which builds on the programmable automation of NC and CNC machines. Materials are automatically handled and loaded and unloaded for machining operations. Programs and tooling setups can be quickly changed and production can be quickly switched over from one job to another with no loss of change over time.

Key components of an FMS are:

(i) Several computer controlled machining centres or workstations having CNC machines and robots for loading and unloading.

(ii) Computer Controlled transport system (AGVs) for moving materials and parts from one machine to another and in and out of the system.

(iii) Computer controlled robots for loading and unloading stations.

(iv) An automated storing and retrieval system.

All the above subsystems of FMS are controlled by a control computer with the needed software. Raw materials are loaded on the AGVs which bring them to the work centres as per the sequence of operations unique to each part. The route is determined by the control computer. The robots lift the materials from the AGV and places on the work station where the required operations are carried out. After the completion of operations, the robots unload the job and place it on the AGV to move the job to the next workstation as per the sequence of operations.

The FMS is suitable for intermediate flow strategy with medium level of product varieties and volumes (40 to 2000 units per part). Also FMs can produce low variety high volume products in the same way as fixed automation systems.

Advantages

(i) Improved capital utilisation

(ii) Lower direct labour cost

(iii) Reduced inventory

(iv) Consistent quality

(v) Improved productivity

Disadvantages

(i) High initial capital investment

(ii) Limited ability to adopt to product changes

(iii) Substantial preplanning, tooling and fixture requirements

(iv) Standardisation of part designs needed to reduce numbers of tools required

(v) Requires long planning and development cycle to install the FMs.

VERTICAL INTEGRATION

Vertical integration is the amount of the production and distribution chain, from suppliers of components to the delivery of products/services to customers, which is brought under the ownership of a firm. The management decides the level or degree of integration by considering all the activities performed from the acquisition of raw materials to the delivery of finished products to customers. The degree to which a firm decides to be vertically integrated determines how many production processes need to be planned and designed to be carried out in-house and how many by outsourcing. When managers decide to have more vertical integration, there is less outsourcing. The vertical integration is based on **"make-or-buy" decisions**, with **make** decisions meaning more integration and a **buy** decision meaning less integration

and more outsourcing. Two directions of vertical integration are *(a)* **Backward integration** which represents moving upstream toward the sources of raw materials and parts, for example a steel mill going for backward integration by owning iron ore and coal mines and a large fleet of transport vehicles to move these raw materials to the steel plant. *(b)* **Forward integration** in which the firm acquires the channel of distribution (such as having its own warehouses, and retail outlets).

The advantages of more vertical integration are disadvantages of more outsourcing and similarly, advantages of more outsourcing are disadvantages of more vertical integration.

Advantages of vertical integration are:

(i) Can sometimes increase market share and allow the firm enter foreign markets more easily.

(ii) Can achieve savings in production cost and produce higher quality goods.

(iii) Can achieve more timely delivery.

(iv) Better utilisation of all types of resources.

Disadvantages of vertical integration are:

(i) Not attractive for low volumes.

(ii) High capital investment and operating costs.

(iii) Less ability to react more quickly to changes in customer demands, competitive actions and new techniques.

FACTORS AFFECTING PRODUCTION AND OPERATIONS MANAGEMENT TODAY

Having understood the nature and types of production systems and also various kinds of decisions made by operations managers, it is necessary to know the factors affecting POM today. Of the many factors affecting POM today, six factors are significant. They are :

1. Reality of global competition,
2. Quality, customer service and cost challenges,
3. Rapid expansion of advanced production technology,
4. Continued growth of service sector,
5. Scarcity of production resources, and
6. Social responsibility issues.

The impact of these factors on production and operations management today is discussed in greater detail in the following paragraphs.

1. Reality of Global Competition

The world is rapidly transforming itself into a single **global economy** which is also referred to as a **global village** or **global landscape**. Markets once dominated by local or domestic firms are now vulnerable to competition from firms in all corners of the world. A country's borders no longer provides protection from intense competition from foreign firms. To succeed in global competition, companies must offer quality products at reasonable costs. Also, as companies expand their business to include foreign markets, so too must the operations management function take a broader, more global perspective in order for companies to remain competitive. The trend towards globalisation has placed increased emphasis on the logistics of where to locate facilities and the issues associated with moving materials over long distances.

2. Quality, Customer Service and Cost Challenges

Another key factor affecting POM today is **quality**. Successful firms now recognise that quality is no longer limited to the POM function, but is important in all functional areas throughout the entire

organisation, a new concept known as **total quality management** (or TQM in short). However, POM is primarily responsible to ensure that the firm is able to produce the products in the required quantities, in the required quality level, delivering the products to the customers at the desired time schedule and at the minimum possible cost.

Quality is no longer limited to the technical requirements of the goods being produced on the manufacturing shop floor. Service quality (*i.e.*, how we deal with our customers on a wide variety of issues affecting customer satisfaction) is equally important.

How companies integrate product quality and service quality, to properly meet the needs of the customers is a major challenge to today's managers. Improving quality in all respects of the business improves customer satisfaction and increases customer loyalty. Today's customers are demanding better quality, more variety and increased responsiveness to their needs — all at lower prices.

3. Rapid Expansion of Advanced Production Technology

Advances in technology in recent years have also had a significant impact on the POM function. Computer-numerical control (CNC) technology, increased automation and robotics have enabled the companies to improve the quality of products that are being manufactured. Information technology facilitates collection of data on individual customers so that the products can be mass customised to meet the needs of individual customers.

However, advances in technology place new requirements on the workforce and even on customers especially in service operations. *For example,* skilled workers are replacing unskilled workers in all types of operations. Employees must now have computer skills to use internet and carryout e-business. An organisation's workforce is nowadays becoming more and more educated and should be considered as its most valuable asset.

4. Continued Growth of Service Sector

The service sector is now growing far more rapidly than the manufacturing sector and more and more workforce is now employed in the service sector. *For example,* the motion picture industry employs more people in the United States than does the auto parts industry. Computer software service is the fastest growing service in the service sector.

Eventhough the majority of issues and concerns faced by managers in both the service sector and the manufacturing sector are the same, the special nature of services imposes additional constraints which vary with the kind of service provided.

5. Scarcity of Production Resources

Operations managers are faced with the problem of scarce production resources and matching the production resources with anticipated product demand. They are constrained to obtain the scarce resources such as materials and labour at the minimum possible cost and utilise the same with maximum efficiency. Operations managers nowadays devote much of their energy to inventory and materials management, scheduling operations and personnel, reduce wastage of materials and labour, cut costs and improve productivity in order to improve the competitive positions of their companies. They are responsible to prepare intermediate plans to consider **what to buy, from whom to buy, when to buy** and **how much to buy** to manage the scarce material resources and also to co-ordinate personnel decisions such as hiring, lay-offs overtime and subcontracting to make best use of the human and equipment resources.

6. Social Responsibility Issues

A new challenge facing operations managers is to make production systems environmentally compatible, yet efficient. This can be achieved by reducing production of harmful by-products, recycling

waste materials and energy, reducing packaging, using closed water systems for cooling and waste discharge and even scheduling employee work hours to reduce traffic and air pollution. Using environmentally sound production methods is not only the social responsibility but also a means of achieving economic benefits. The other ethical issues arising in many aspects of operations management are :

(a) **Worker Safety:** Providing adequate training, maintaining equipment in good working conditions and maintaining a safe working environment.

(b) **Product Safety:** Providing products that minimise risk of injury to user or damage to property or the environment

(c) **Quality:** Honouring warranties, avoiding hidden defects.

(d) **Obeying government regulations**, regarding regulation of environment.

(e) **The Community:** Being a good neighbour, providing employment opportunities to the local people and improving the standard of living of the community surrounding the company.

(f) **Closing Facilities:** Taking into account the impact on the community and honouring commitments that have been made.

To conclude, we can summarise the **current issues facing operations managers** are as below.

1. Speeding up the time it takes to get new products into production.
2. Developing flexible production systems to enable mass customisation of products and services.
3. Managing global production networks and managing the supply chain (*i.e.*, managing the flow of information, materials and services from material suppliers through factories and warehouses to the end customer).
4. Developing and integrating new process technologies into existing production systems.
5. Achieving high quality quickly and keeping it up in the face of restructuring (*i.e.*, achieving quality parity with the competition through total quality management).
6. Managing a diverse workforce.
7. Conforming to environmental constraints, ethical standards and government regulations.

REVIEW QUESTIONS

1. Define the terms "Production", "Production system" and "Production Management".
2. Discuss the following views of the nature of production :
   (i) Production as a system.
   (ii) Production/operations as an organisational function.
   (iii) Production/operations as a conversion process.
   (iv) Production/operations as a means of creating utility.
3. What is a "Production function"? State its importance.
4. Discuss the statement "Production is a means of creating utility."
5. State the objectives of production/operations management.
6. Mention the areas in which production management can offer competitive advantage to a firm.
7. Mention the responsibilities of a production manager. Explain how a production manager amalgamates the five ‘Ps’ namely product, plant, processes, programs and people.

8. Describe the various decisions made by production managers under three categories, *viz.*, strategic, operational and control decision areas of production management.
10. Explain what is meant by "organising to produce goods and services". Draw a typical organisational chart for a manufacturing and a service organisation.
11. Explain the major functions of a production manager.
12. Discuss the problems that may arise in production management and the decisions production managers have to take to solve these problems.
13. Give a brief account of the historical evolution of production management.
14. Discuss the recent trends in production/operations management and explain how these trends have helped to improve the efficiency of production management.
15. Distinguish between “system design” and “system operation”.
16. Mention various types of production.
17. Discuss a “production system model” with a diagram. Describe its elements such as inputs, conversion and control subsystems and outputs.
18. What do you understand by “production system diversity”?
19. Distinguish between
    (a) Manufacturing system and service systems.
    (b) Series and parallel systems.
    (c) Continuous and Intermittent production systems.
20. Discuss the characteristics of job shop production, batch production, mass production, continuous or flow production.
21. Explain the differentiating features of production systems.
22. Describe the factors affecting production and operations management today.
23. Discuss the scope of operations management.
24. Distinguish between production management and operations management.
25. Discuss the differences between goods and services.
26. Write short notes on: *(a)* Flexible manufacturing system, *(b)* Vertical integration.

Production management and operations management are management jargon that needs to be simplified for those who are sitting on the fence or those inside an organization unable to comprehend them clearly. Sometimes it becomes confusing to be talking about production management inside operations management but they are separate and distinct entities in the study of management as ultimately, production is a part of the whole cycle of operations. Read on to clarify the doubts. Operations Management. The study of set of activities comprising supervision, planning and designing of business operation... Production and Operations Management (â€œPOMâ€) is about the transformation of production and operational inputs into â€œoutputsâ€ that, when distributed, meet the needs of customers. The process in the above diagram is often referred to as the â€œConversion Processâ€. There are several different methods of handling the conversion or production process â€“ Job, Batch, Flow and Group. POM incorporates many tasks that are interdependent, but which can be grouped under five main headings: PRODUCT. Marketers in a business must ensure that a business sells products that meet customer needs and wants. The role Â„ Operations managers manage the production system; their primary concern is with the activities of the conversion process or production. Marketing mangers Â„ Managers in the marketing function are responsible for creating a demand for an organizationâ€™s products and services.Â 3. Scientific Management - contributions: time study, methods analysis, motion study, human factor in work, Gantt charts - getting the desired result with the least waste of time, effort, or materials. 4. Human Relations and Behaviorism - The human relations movement studies were initially begun by industrial engineers and were aimed at determining the optimal level of lighting to get the most production from work.