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Industrial Engineering and Management —An Introduction

1.1. HISTORICAL BACKGROUND OF MODERN INDUSTRY

The requirements of house which could not be fulfilled by one man alone, gave birth to a united work which in turn took the shape of a "factory". The growth of industry during the past 250 years was specially marked by technological development; the greater increase in inventions of products and processes, the wider use of steam engines as prime movers, the application of mechanical science to industrial processes, greater specialisation in tools, machines and the labour and the expansion of the principle of interchangeable parts. The modern industries brought several processes of manufacture under one roof, centralized and increased the use of power, introduced specialized tools and machines and hired workers for fixed wages.

World has moved from handicraft to mechanical to automatic mass production, from water power to steam to nuclear power, through mineral, chemical, metallurgical and electronic revolutions.

Modern Industry means "Factory System", and can be described as the system of production in which hand tools have been replaced by complicated and costly automatic machines. The works are carried out in large workshops by a large number of workers. The factory system may also be defined as "an attempt to organise the industries on modern and scientific lines". The factory system, also known as "modern system of manufacturing ", satisfies economic wants of individuals, communities and nations by manufacturing things in workshops, which utilize the men, materials machines, money and methods to meet the market needs.

The invention of one machine after another in the 18th and 19th centuries had a very great impact on the economic life of whole world. Actually, the process which first started in England later on spread over different parts of the world. The system of production which came into being as a result of this "Industrial Revolution" is now termed as "Factory system".

Technological development is bringing the change in the world very rapidly. Mechanisation has given birth to factory system, in which in place of individual production or job production

integrated plants are installed for mass production. Thousands of people are employed in big industries and high managerial techniques are required to control them.

With the growth in the size of industries, brought the beginning of management and management thinking.

Industrial management, manufacturing management, production management, and operations management — all of which describe the same general principle. The traditional view of *manufacturing management* began in eighteenth century with the concept of 'division of labour' advocated by Adam Smith. Charles Babbage, a mathematician extended Smith's work by recommending the use of scientific methods for analysing factory problems. Then F.W. Taylor who was recognised as the 'Father of Scientific Management' extended the scientific management theories to factory working. Taylor has also recognised the potential improvements gained from analysing the work content of a job and designing the job for maximum efficiency. Frank Gilbreth and his wife Lillion Gilbreth contributed to motion study in 1911. Lillion Gilbreth also wrote a book on her works concerning the human factors in organisation. In 1913, Henry Ford developed the concept of mass production, and work stations into an assembly line with moving belt. In 1913 also, Henry Gantt contributed in charting the production schedule. Harrington suggested the use of experts in organisation to improve efficiency. In 1928, Wilson developed the concept of Economic Ordering Quantity (EOQ). Elton Mayo contributed towards human relations. Till 1930, traditional view on manufacturing management prevailed.

Industrial or Production Management then became more widely accepted term from 1930s through the 1950s. During this period use of statistics was recognised in quality control, and operation research techniques were applied in production problems, techniques were developed on economic efficiency in manufacturing. Studies were also conducted to eliminate wasteful efforts of works and achieve greater efficiency. At this time other needs of workers were also realised, and social scientists started studying human behaviour in the work environment. Economists, mathematicians, and computer scientists also contributed newer, and more sophisticated analytical approaches. During this period value engineering technique, and concepts of CPM and PERT were also developed.

Now-a-days, organisational goals are better focussed to meet consumers' needs. Systems approach is taking an integrated look at the problems of operating systems. Computer applications to manufacturing, scheduling and control, materials requirement planning, applications of Japanese theories like 'Just in Time (JIT) system', Quality circles are being adopted. Other notable developments in recent past have been group technology (GT), computer-aided design/manufacturing (CAD/CAM) etc.

However, by generalizing the concept of productoin as the 'process through which goods and services are created' we can include both manufacturing and service organisations within the purview of production management.

1.2. SCIENTIFIC AND TECHNOLOGICAL REVOLUTION

Many factors contributed to the growth and development of modern industrial world. The tchnological revolution took place broadly in following stages:

1. Industrial Revolution

Industrial revolution took place in eighteenth century due to continuous application of skill and inventions for the increase in production. It took place in England in the period 1765-85. The textile industry underwent fundamental changes in the methods of production. Further improvements in textile industry were held thereafter. The inventions which took place during

this period and thereafter brought phenomenal changes in the quantity and quality of not only the textile industry but it practically spread over all other industrial activities. The notable inventions in late eighteenth and early ninteenth centuries were steam engine, drilling machine, planing machine, hydrulic press, blowers, steam hammer, heavy screw cutting lathes.

The first steam tramway was operated in 1804, steam boats began to ply in 1807, steam locomotives began to be manufactured and railway services started in 1829. With the use of iron for ship-building from 1818 and invention of screw propellor in 1836, transport by sea also developed rapidly.

Good effects of industrial revolution were:

(*i*) increase in volume of production, (*ii*) better quality of produuction,
(*iii*) lower unit cost of production,
(*iv*) specialization in manufacturing activities.

Bad effects of industrial revolution were:

(*i*) unemployment, (*ii*) degradation of labour skill,
(*iii*) requirement of huge financial investment,
(*iv*) shifting of population to urban areas,
(*v*) increse in pollution and bad living conditions,
(*vi*) energence of capitalism and division of society ie capitalists and workers.

2. Development of Corporate Form of Business Organisation

As mentioned above, industrial revolution created necessity of huge financial investments due to large scale production. To accept this challenge, the companies were formed with the principle of limited liability of the members to the extent of capital contributed by them in the company. This principle has helped to facilitate huge capital contribution with reasonable risk. Enormous growth of the modern business and the development of latest technology is the result of the success of this form of company.

3. Managerial Revolution

The large scale business organisations increase the complexities in the management of industrial units. This gives rise to the development of the science of management. The works of pioneers of management thoughts have been discussed in detail in the next chapter titled as "Development of Management Thoughts". The managerial revolution helped to cope up with increased complexities of industries and management of variety of functions and resources such as men, material, money and machines.

4. Technical Developments

Devlopment of technology is continuous on every front. The inventions are protected through the patents and copyright acts. The technologies or inventions are are hired through technological collaborations. The technological development has resulted introduction of industrialisation for achieving rapid economic development of country. The technological developments continuously strive to develop better and economic equipments, machines, plants, materials, methods etc. and by doing so, it improves the output-input ratio in the production processes and promotes the efficient utilisation of scarce resources. Thus technology helps to achieve more and qualitative production at a cheaper rate.

1.3. INDIAN INDUSTRY AND GLOBALISATION

Some of the basic major industries in India are:

(*i*) iron and steel industry
(*ii*) non ferrous metal and alloy industry
(*iii*) textile industry
(*iv*) jute industry
(*v*) machine tool industry
(*vi*) sugar industry
(*vii*) petrochemical industry
(*viii*) cement industry
(*ix*) paper industry
(*x*) automobile industry
(*xi*) electronic industry
(*xii*) IT industry

Since industrialisation is a backbone of the economic development for our country, therefore an industrial policy was prepared in 1948 by the Government of India for the development of industries. This policy was amended as and when required for industrial development. As per our industrial policy, public and private sectors both were started functioning together in a coordinated and planned way. Industrial policy resolution also stressed the need to develop the cottage and small scale industries, on scientific lines to enchance their competitive power.

Basically, globalization is a concept by which the globe becomes one unified entity cutting across the political, economic and regional barriers. A company can be said to be global in true sense, when:

(*a*) it provides a product or a service of a brand which is recognised and accepted by the world market and is export oriented.
(*b*) the entire quality system of the organisation is ISO:9000 certified.
(*c*) it has a overseas marketing and distribution system.

The organisation of the firm to become global should be flexible enough to meet the changes and satisfy the customer demands. Multi-product practices are always preferable.

The Industrial Policy Resolution 1990 and that of 1991 were the prime documents of economic liberalisation and bold steps taken for globalisation of Indian industry. Under this policy resolution, collaboration of foreign companies was promoted. Multinational companies are coming to India and Indian products are getting international market and exports are getting increased. The barriers of import and ecport have been removed. The Indian firms need the technological dymamism to become internationally competitive.

1.4. INDUSTRIAL ENGINEERING

In the beginning, industrial enginnering was closely associated with the Time and Motion Study. This position continued from 1903, the years of main pioneer work of F.W. Taylor through his paper on 'Shop Management', till 1933 when the term 'Method Engineering' was developed by H.B. Maymard and his associates was added.

In the year 1943, the work standardization committee of the mangement division of the American Society of Mechanical Engineering (A.S.M.E.) attempted to define the limits of the field of industrial engineering. One appealing definition is given hereunder:

"Industrial engineering is concerned with the design, improvement and installation of integrated system of man, materials and equipments drawing upon specialized knowledge and skill in the mathematical, physical and social sciences either with the principles or methods of engineering analysis and design to specify, predict and evaluate the results to be obtained from such systems."

Some other definitions of industrial engineering are:

(1) Industrial engineering is the engineering approach to the detailed analysis of the use and cost of the resources of an organisation in order to achieve the objectives (to increase pro-

ductivity, profits etc.) and policies of the organisation.

If industrial engineer has to focus on only one objective, it would have to be *productivity improvement*. Productivity improvement implies (*i*) a more efficient use of resources, (*ii*) less waste per unit of input supplied, (*iii*) higher levels of output for fixed levels of inputs supplied and so on.

The inputs may be (*i*) human efforts, (*ii*) energy in any form, (*iii*) materials, (*iv*) invested capital etc.

(2) Industrial engineering is a branch of engineering that deals with the creation and management of systems that integrate people, materials and energy in productive ways.

(3) Industrial engineerig is the application of engineering principles and techniques of scientific management of the maintenance of high levels of productivity at optimum cost in industrial enterprises.

(4) Industrial engineering is a branch of engineering dealing with the optimisation of complex processes or systems and is concerned with the development, implementation and evaluation of integrated systems of people, money, knowledge, information, equipment, energy, material, analysis and synthesis as well as mathematical, physical and social science together with the principles and methods of engineering design to specify, predict and evaluate the result to be obtained from such systems or processes.

Depending on the sub-specialities involved, industrial engineering may also be known as, or overlap with Operation Management, Management Science, Operation Research, Work Study, Systems Engineering, Manufacturing Engineering, Ergonomics or Human Factors Engineering, Safety Engineering, Cost and Value Engineering, Quality Engineering, Facility Planning. And now indstrial engineers work to eliminate wastes of time, money, material, energy and other resources.

The above definitions show that the field of industrial engineering is quite broad and all the high productivity techniques are well within its purview.

Objectives

Industrial engineering has following basic objectives:

(*i*) improving efficiency, (*ii*) reducing wastage.

Efficiency is improved on resources employed *i.e.*, men, material, machine, management and money. Therefore, in industries efficiency is required to improve in the manufacturing process, methods, capital investment and efficiency of plant.

The second objective of industrial engineering is to reduce wastage at all levels.

Future Trends

We have observed that 'productivity' has become the concern of both industrial engineers as well as production managers. Their fuctions and responsibilities are also distinctly different. Therefore, in future two branches of these disciplines are likely to be separate. The modern industries have already started seprate branches such as 'productivity engineering' and 'productivity management'. These two are defined as under

Productivity Engineerng is concerned with the design, development, evaluation, planning and improving systems in manufacturing and service organisation.

Productivity Management is a formal management process involving all levels of management and employees with the ultimate objective of reducing the cost of manufacturing, distrib-

uting and selling of a product or service through an integration of the four phases of productivity cycle namely productivity measurement, evaluation, planning and improvement.

1.5. PLACE OF INDUSTRIAL ENGINEERING IN THE ORGANISATION

Industrial Engineering (I.E.) Department must be given a high position in the organization of a factory, so that the persons working in this department cannot be influenced by the officers working on the shop floor and their suggestions can be accepted with respect and acted upon. Since the Industrial Engineering Department is for the service of the management of an enterprise, therefore, it must be a staff and not a line activity.

The position of the head of the Industrial Engineering Department in relation to his fellow members of the staff depends upon following important factors.

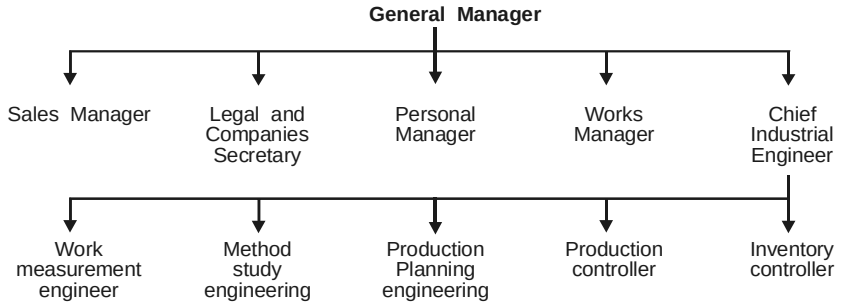
(*i*) Size of the organization

(*ii*) Type of organization and whether managed by owner himself or by professionals.

(*iii*) Nature of work carried out in the factory.

(*iv*) Qualifications, experience, personality etc. of the Chief of Industrial Engineering and those of other Departmental Heads.

Looking to the above factors, there cannot be any standard chart for organizational structure. A typical organization chart showing the position of Industrial Engineering Department is given hereunder :



Sometimes Chief Industrial Engineer is given a place under works Manager. It is due to the reason that Works Manager is responsible to increase the overall productivity and by putting the Industrial Engineering Department under him, he can give more importance to the suggestions or advices placed before him.

1.6. FUNCTIONS (ACTIVITIES) OF I.E. DEPARTMENT

The field of industrial engineering represents an area that is today undergoing rapid expansion and diversification. For example, among the many activities that an Industrial Engineering specialist might be called upon to engage in, we find the following :

1. Locate new plants and design their physical layout
2. Analyze and plan production schedules and inventories.
3. Devise ways to improve the productivity and moral of people at work.
4. Study equipment replacement feasibility.
5. Conduct the effective work measurement and set the time standards for effective wage payment.

6. Diagnose and correct causes of poor quality.
7. Conduct the study for methods improvement
8. Measure the effectiveness of marketing, advertising and other distribution policies.
9. Design, develop and evaluate complex man-machine systems.
10. Utilization of digital computers to receive tremendous quantities of information to digest, process and store information, and then to display this information for appropriate decision making.
11. Evolve better production methods by applying operation research techniques.
12. Analyze and schedule big projects by using of C.P.M. and P.E.R.T. network techniques.
13. Develop and maintain standards governing administrative and sales budget, including the summarizing of the sales forecasting function and the responsibility for the market analysis function.
14. Analyze, establish and control of all office routines and procedure from a functional stand point, including their simplification, development and control and the design of management information systems.
15. Aid in establishing cost controls, performance rating charts, budgetary controls and the like designed to fit his actual needs.
16. Assist in the development of training programmes and aid in training supervisors and workers in the proper performance of their duties.

1.7. MAIN BRANCHES OF INDUSTRIAL ENGINEERING

A wide area is covered under the Industrial Engineering. Following are the main branches of Industrial Engineering :

1. Work Study
   (*a*) Method study
   (*b*) Work measurement
2. Plant layout and Material handling
3. Inventory control
4. Operation research
5. Production Planning and Control.
6. Systems Engineering
7. C.P.M. and P.E.R.T. (Network Schedulting)
8. Value Engineering.
9. Cybernetics.

1. Work Study. It deals with the problems

(*a*) As to how should a job be done, and

(*b*)How much time a job should take for completion?

Answer for the first question is found by the Method Study, while for the second question by work measurement.

(*a*) Method Study. The aim of this study is to find a scheme of least wastage.

(*b*) Work Measurement. This technique is used to find the correct manufacturing time for a product. In this, the time required to do each detailed element of an industrial operation (including manual, mental and machining operations) is observed and recorded.

2. (*a*) **Plant Layout.** This is a technique of locating different machines and plant services within the factory, so that each operation is performed at the point of greatest convenience and greatest possible output of high quality at the lowest possible total cost can be achieved.

(*b*) **Material Handling.** As lot of production time is consumed in handling materials before, during and after the manufacture, therefore, by proper selection, operation and maintenance of material handling devices, we can increase the output, improve quality, speed up the deliveries and, therefore, reduce the cost of production.

3. Inventory Control. It is the systematic location, storage and recording of goods in such a way that desired degree of service can be made to the operating shops at minimum ultimate cost.

4. Operation Research. This is a research technique, which offers alternative plans for a problem, to the management for making decisions. The scientific and quantitative analysis of the problem (done by the team of statisticians, psychologists, labour specialists, mathematicians, Industrial Engineers etc.) is presented before the management, to enable it to make sounder decisions. This deals with the complicated problems like, queuing, theory, linear programming, transportation problems, inventory control, sequential decisions, equipment replacement policy etc.

5. Production Planning and Control. It is the process of planning the production in advance, setting the exact route for each item to give production orders to shops and lastly to follow up the progress of products according to the production orders.

6. Systems Engineering. Systems engineering is the process of a successfully developing large scale complex man-machine systems, within cost, time and performance targets. Systems Engineer is a combination of Engineer, Scientist and Administrator. He must make use of new and unfamiliar disciplines also to achieve his objectives.

7. C.P.M. and P.E.R.T. These are the modern network techniques used by the management for programming.

8. Value Engineering. It is used for reducing the cost of a product by making changes in design, specifications of materials used, source of supply, tool design, machinability, tolerances, aesthetics etc.

9. Cybernatics. It has been observed that there is marked similarity between the structures of classical control system and various biological and other physical systems. Thus, cybernatics is a new engineering discipline in which biological and other physical systems are studied and then applied to engineering problems.

1.8. PRODUCTIVITY IMPROVEMENT THROUGH INDUSTRIAL ENGINEERING

All these activities of Industrial Engineering, if used properly, leads to increase in productivity. As every one knows, that productivity is of very much importance to a nation, as it creates the wealth of the nation. To improve the economic position in comparison to other countries, we must improve our productivity and performance. Productivity is the key to the important problem of inflation. In recent years, there had been regular pay increases, but we have forgotten that without improving the productivity, prices will be sky rocketing and we will lose competition in the world market. To compensate wage increase, we must increase the productivity.

To fight against inflation, we must increase the productivity. The battle fields of this fight are every place where resources (men, material, equipment, money , time, efforts etc.) are used. The factory and the agriculture are most important places where we must emphasise for productivity improvement. Other places like offices, hospitals, teaching institution etc., also need productivity improvement if the society and the country is to move forward.

Thus, our aim must be to make people more productivity conscious if we want to improve their standard of living. Productivity holds the key to the prosperity of the individual, a com-

pany and of a nation.

Increase in productivity results in :

1. Increase in production and hence higher profits.
2. Products produced will be cheaper.
3. Higher wages and bonus can be allowed to workers because of larger profits.
4. Improvement in living standards of workers.
5. Brings prosperity in the country.

Thus, we have seen that "Industrial Engineering is an organized continuous effort to improve productivity and quality and to reduce costs within an organization." For this purpose an industrial engineering must continue to lead the way in "Resource utilization" and it can play a vital role in increasing the productivity based on various factors stated earlier.

1.9. PRODUCTION

Production is an organised activity of converting raw materials into useful products, by organised utilisation of natural resources, men, money, materials and machines. Whereas in the input-conversion-output sequence, the smallest unit of productive activity, is termed as *operation*. Therefore, an operation is some step in the overall process of producing a product or service that leads to the final output.

Production can also be defined as follows :

(*i*) Production is a sequence of technical processes, requiring either directly or indirectly the mental and physical skill of craftsman and consists of changing the shape, size and properties of materials and ultimately converting them into more useful articles.

(*ii*) Production is a process developed to transform a set of inputs like men, materials, money, machinery, and energy into a specified set of outputs like finished products and services in desired quantity and quality in order to achieve the objectives of the enterprise.

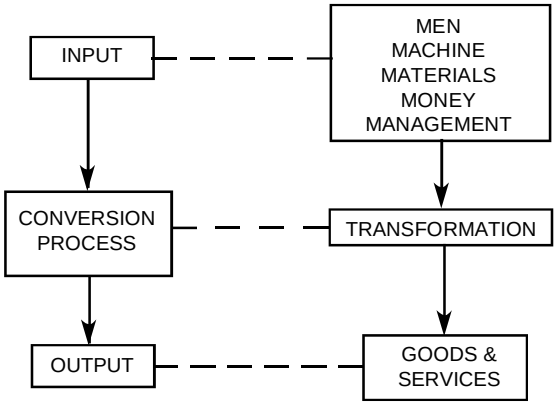


Fig. 1.1. Production System.

Production includes manufacture of goods and services, which has four recognised factors, namely (*i*) natural resources including land, (*ii*) labour, (*iii*) capital *i.e.* factory building, machinery, tools, raw materials etc., and (*iv*) Organisation. Production involves a wide range of activities starting from selection of site to the packing of products for distribution.

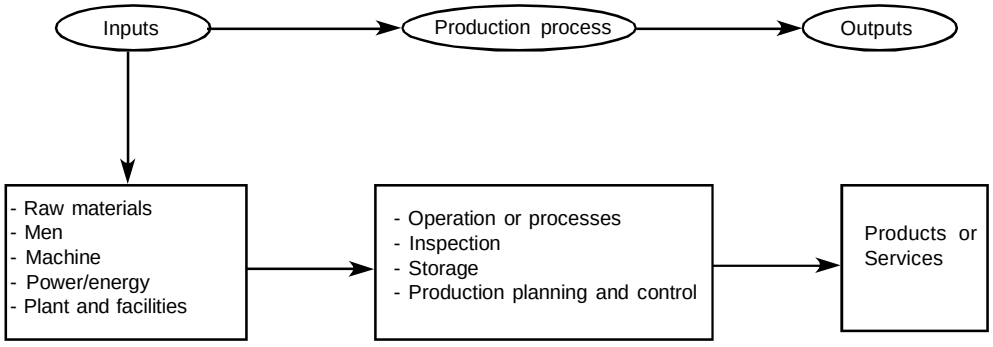


Fig. 1.2. Production System.

Production system consists of inputs at one end and the outputs at the other. The inputs and outputs are connected by a series of operations or processes, storages and inspections. A simple production system is shown in Fig. 1.2.

1.10. PRODUCTION FUNCTION

Most important task of the production management is to deal with decision making related to production processes so that the goods manufactured are according to the specifications, in the required quantity, at minimum cost and as per schedule.

In production system, we have materials, parts, ore etc. as inputs. The inputs are processed in a series of operations. The sequence number and type of operations (they may be mechanical, chemical, assembly, inspection, transportation etc.) are specified for each input. The output of the system will be complete parts, products, chemical etc. A mathematical model of the production system is constructed. This model also has an information system which provides a basis for management decision. These information systems of the model, known as '*Production Function*', provide an equivalent of a 'nervous system' for the model.

Production function shows the relationship between the input and output by a firm. By the study of production function, the maximum output which can be achieved with a given inputs (or resources) with a given state of technology is determined. The production function can be represented by a simple mathematical equation,

$$Y = f(X_1, X_2 \text{ etc.})$$

where Y = units of outputs, which is a function of the quantity of two or more inputs with X_1 indicating units of labour and X_2 units of machinery. Some quantities of production are assumed as fixed, *i.e.* not varying with change of output. Such quantities never enter in the equation.

A popular production function derived by Mr. Cobb and Mr. Douglas is as follows :

$$P = bL^a C^{1-a}$$

where P = Total output

L = Index of employment of labour in actual manufacturing.

C = Index of fixed capital in manufacturing.

a and $1 - a$ are known as elasticities of production and measured in a percentage. The Cobb-Douglas function in U.S.A. is represented by :

$$P = 1.01\, L^{0.75}\, C^{0.25}\, R_2{}^{0.9409}$$

The above function shows that 1% change in labour input (L) is associated by 0.75% change in output when capital (C) is fixed. Likewise, by 1% change in capital (C) when labour (L) is constant there is change of 0.25% in output. The coefficient of determination R_2 shows that 94% of the variations on the dependent variable (P) were accounted for by the variations in the independent variable (L and C).

The production function is helpful in making decisions because they can give guidance in two directions :

1. How to obtain maximum output from the given input ;
2. How to obtain a given output from the minimum input.

In complex problems, use of mathematics is quite complicated. But with the development of linear programming, it is possible to handle complicated problems.

1.11. TYPES OF PRODUCTION

Different types of production can be placed under two categories, namely

1. Intermittent Production
2. Continuous Production

In intermittent production machinery is used for a short duration of time for producing an item, and then changed to produce another item. While in continuous production, set up of production is fixed and used to produce same item.

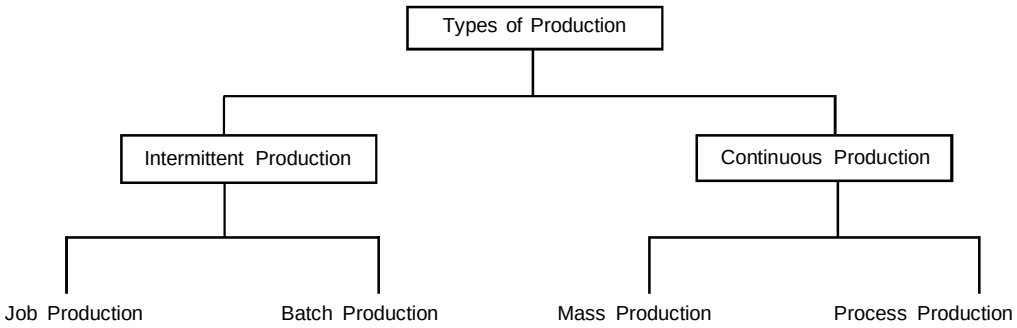


Fig. 1.3. Types of Production

1. Job Production

This is the oldest method of production on a very small scale. With this method individual requirements of the consumers can be met. Each job order stands alone and is not likely to be repeated. This type of production has a lot of flexibility of operation and hence general purpose machines are required.

Factories adopting this type of production, are generally small in size (ship building is an exception). The layout of such factories is made flexible so that different types of works can be easily and efficiently carried out with slight adjustments.

Even in this age of industrialisation, many things are produced on job production. This type of production is used for things which cannot be produced on a large scale, <MI>e.g.<D> things of high artistic nature requiring maximum attention, die work and foundry work etc. Man working in unit production gets an opportunity to produce large variety of products and he can become expert in very short time.

Advantages :

1. It is the only method which can meet the individual requirements
2. There is no managerial problem because of very less number of workers.
3. This type of production requires less money and is easy to start.
4. There is less risk of loss to the factory adopting this type of production.
5. Because of flexibility, there is no chance of failure of factory due to the reduction of demand.

Disadvantages :

1. There is no scope of commercial economy.
2. As the purchase of raw materials is in less quantity, hence cost of raw materials is slightly more.
3. For handling different types of jobs, only skilled and intelligent workers are needed, thus labour cost increases.

2. Batch Production

This type of production is generally adopted in medium size enterprises. Batch production is a stage in between Job production and Mass production.

Batch production is bigger in scale than the Job production while it is smaller than that of Mass production. Batch production requires more machines than that of Job production and less machines than that of Mass production. In Batch production, some of the machines are one purpose machines and remaining are general purpose machines.

As in this type of production, two or more types of products are manufactured in lots (*i.e.,* batches) at regular interval, therefore this is known as Batch production. Most of the engineering concerns are adopting Batch production. In this type of production, different products are manufactured and stocked and then sold on receipt of orders.

Advantages :

1. While comparing with mass production it requires less capital.
2. If demand for one product decreases then production for another product may be increased, thus the risk of loss is very less.
3. Comparing with job production, it is more advantageous commercially.

Disadvantages :

1. Comparing with mass production, cost of sales and advertisement per unit is more.
2. Raw materials to be purchased are in less quantity than that in mass production. Therefore, it is slightly costlier than that of mass production.

3. Mass Production

This type of production is a large scale production and is a continous production. In job production, factory works only when orders are received and when orders are not received for soemtime then for that period work may come to a standstill. But mass production is a continous production and it does not have any non-producing time.

This type of production requires specially planned layout, one purpose machinery and costly jigs and fixtures etc. In this method with the use of automatic machines, articles automatically move forward from one stage to the next stage of manufacturing operation.

In mass production, simplification and standardisation of products are made. With the help of specialised (one purpose) machines, articles of standardised nature can easily and economically be produced on a large scale.

Layout of the plant is such that it can be used for only one type of product. Sequence of flow of the product during manufacturing remains same. In this type of production, different machines are assigned a definite nature of work. Throughout the run of the plant, only one type of product can be manufactured.

To avoid the problem of material handling, use of mechanical means such as conveyors of different types, cranes etc. can be used.

Advantages :

1. Mass production gives better quality and increased production.
2. Wastage is minimum.
3. As raw materials are purchased on a large scale, higher margin of profits are available, while purchasing them.
4. Sales promotion and advertising do not prove to be costly as their expenses are spread over thousands of articles produced, hence cost per unit is low.
5. Only few skilled and rest semi-skilled workers are required hence labour cost is reduced.

Disadvantages :

1. During the period of less demand heavy losses on the invested capital may take place.
2. Because of all the machines used are one purpose machines therefore, this type of production is not changeable to other types of production.
3. Most of the workers handle only particular operation. They may get skill in their job but after sometime they feel bored with the repetition of same type of work.
4. As this type of production is on large scale, therefore it can not fulfil individual taste. It produces things of standardised form which are demanded on a large scale.

4. Process Production

In this type of production, the plant and its equipment and layout have been primarily designed to manufacture the desired product. Examples of such production are automobiles, chemical plants, fertiliser plants etc. Unlike other production systems, switch over to other product is very difficult and expensive and require change of layout. The change in product become extremely difficult and costly affair especially when special purpose machines and complex material handling systems are involved.

1.12. SERVICES AS PART OF PRODUCT

If we examine the nature of the delivery system for physical products, the clear line between products and services is much less apparent. Purchases of products involve services as well as the product itself. If we buy an automobile or an equipment, we buy not only the product but also the guarantee and some servicing.

Similarly when manufacturers buy products like raw materials and components from other producers, they are also buying services in the form of credit, supply according to schedule, technical advice and service.

Within the organisation itself services are essential to sustain production process, for example, machine maintenance, stores, material handling, tool cribs to supply required tools to mechanics and other services.

J.M. Juran in his book on 'Quality Planning and Analysis' has described the 'product means goods, software, or services'. In this book also for all practical purposes 'product' includes services.

1.13. INDUSTRIAL OR PRODUCTION MANAGEMENT

Definition.

Production Management is a branch of general management which is concerned with production activities. It can also be defined as 'Production management deals with decision-making related to production process so that the resulting goods or services are produced according to specifications in amounts and by the schedules demanded, and at a minimum cost'.

Operations Management can be defined as the management of the conversion process, which converts land, labour, capital, and management inputs into desired outputs of goods and services.

Scope of Production Management

1. Relating to designing of production system : These activities concern the production engineering, and include design of tools and jigs ; design, development and installation of equipment, and selection and optimisation of the size of the firm. Selection of plant location, plant layout, materials handling systems are functions of production engineering. The problems of human factor, and research and development are also considered.

2. Relating to analysis and control of production operations : These activities include production planning, production control. Production control activities are looked after at three levels : control of inventory, control of flow of materials, and control of work-in-progress. Other controls to be looked into are quality control, cost control and labour control.

Value Added Process

All operations add value to the object thereby enhancing its usefulness. In view of this, we can define an operation as 'the process of changing inputs into outputs and thereby adding value to some entity'.

The value can be added by performing an operation function in following ways :

(*a*) *By altering* the form or state of inputs.

(*b*) *By transporting* the entity, it may have more value if located somewhere else.

(*c*) *By storing* the entity in a protected environment for some period of time.

(*d*) *By inspecting* the entity, it can be better understood about its properties.

From the above we see that almost every organisation - manufacturing, transportation, warehousing, health-care, education etc. come within the purview of the operation management.

Conversion Process

All production or operation functions are essentially a part of the conversion process which transforms entities in size, shape, form, space, location, state and time. Therefore, every organisation can be considered as a conversion system which converts inputs into outputs through the operations.

1.14. SYSTEMS CONCEPT

System is a commonly used word with different meanings. Man is a system yet he has subsystems such as respiratory, digestive, and nervous system. But here we are interested in business or engineering systems, where each sub-system operates in a logical way both internally and as a part of the larger system. The system is the flow of information. The information flows into sub-system and causes certain actions. The sub-system operating within itself and it re-

ceives information from and sends to other sub-systems. The term system is also used as a methodical way of planning and coordinating the work to produce complex project.

A system can be considered as a structure of sub-systems, each having the following characteristics :

- Inputs
- Output
- Transformation process
- Feed back.

A 'system' may be defined as a group of inter-related parts or elements designed to achieve a particular goal. A 'system' always exists within an environment which provides resources as inputs into the system, and that accepts outputs of the system. A 'system' is always doing something. For example, human body is a 'system' while a rock is not a system (because it does not do anything).

The business system receives inputs from the investment in the form of the resources : men, machines, materials and money. The system also receives information from the environment so that management may define goals, plans etc. needed by the system.

A **sub-system** is usually a complete system functioning within a large system.

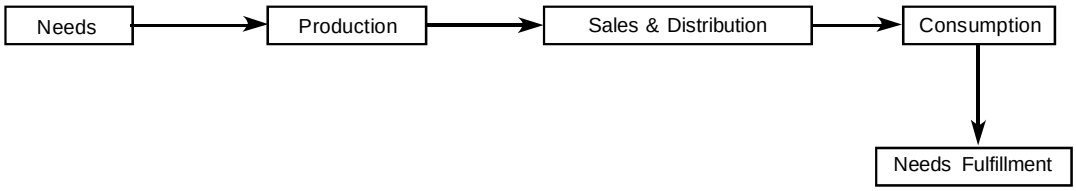


Fig. 1.4. An engineering system.

An engineering system usually utilises the human efforts, materials, machines and finance to achieve desired objectives. An engineering system comprises different stages of needs of production, sales and consumption as shown in Fig. 1.4.

A system can also be defined as an orderly arrangement of components (man, material, money, machine and environment) that are interrelated and act and interact with one another to perform task or function in a particular environment.

A system is composed of elements or subsystems that are related and dependent upon each other. A systems approach is a systematic and organised approach to get the task accomplished more efficiently, effectively and economically.

Subsystems. Subsystems are the parts that make up the whole system, and each system in turn is a subsystem of a still larger system.

Open and Closed Systems. A system is said to be an open system if it interacts with its environment. While it is said to be a closed system if it does not interact with its environment.

In order to control various functions, systems like inventory control, network scheduling, resource allocation, quality control and inspection systems etc. are adopted. For better interaction between various systems, Management Information System (M.I.S.) and communication systems are necessary.

Systems are required to be managed so that they can perform their functions effectively in a coordinated way. Different systems are designed and developed so as to fulfil the objectives of the company. In order to manage the systems effectively, proper organisation based on tradi-

tional methods of departmentation must be developed.

All systems related to personnel must be managed, keeping behavioural aspects in view. Motivational 'need model' and other models must aim for (*i*) identifying the personal goals of individual workers, (*ii*) develop a work situation which will fulfil the individual goals while accomplishing organisational objectives, and (*iii*) provide fair compensation related to the work.

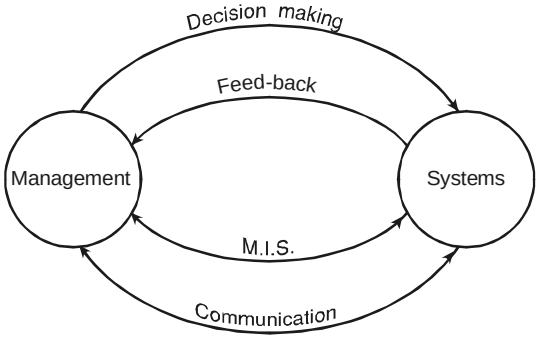


Fig. 1.5. Effective Management of System.

The system will work at optimum level when timely and relevant informations are received by the management, and timely decisions are taken and implemented. Feed back for further corrective action is necessary.

Following aspects should be integrated for improving the management process : (*i*) Information feed back system, (*ii*) Understanding of the decision making process, (*iii*) Management science techniques, like network, quantitative, and simulation approach, and (*iv*) M.I.S. and electronic computer.

Now-a-days basic consideration of management is under certainty and for programmed decisions. As decisions taken under certainty and on the basis of laid down policy, procedure or a rule, are likely to be better and more economical, therefore efforts are made to programme the decision rules through computer, to enable faster, accurate and economical decisions. Decision-making is treated as a central aspect of the managing. The concept of programmed decision is important because the ultimate goal is to provide purely programmed decisions. Efforts are made for more and programmed decisions through the use of management science techniques.

Therefore in order to achieve optimum results, management of systems through scientific, rational and logical approach is necessary.

1.15. DESIGNING A SYSTEM

As stated earlier when the needs arise, a system is required to be designed. Need gets the shape of system in the following stages :

1. Needs analysis, to explore potential needs.
2. Development of possible system.
3. Comparison of system needs and proposed system capabilities.
4. Review and modification of possible system.
5. Revaluation and decision to go ahead with the system.

1. Needs Analysis.

From the definition it is clear that the identification of actual needs is the first step in the design of any project. This need is observed on the socio-economic sense. This factor is very important as wrong judgment of need may cause the project to be failure because of no demand. Market research is conducted for making need analysis, for which habits and behaviour of the people in socio-economic system is kept in mind.

While conducting the market research, the needs of the people, when the product is likely to be ready for sale are considered. We shall have to be cautious against factors like :

(*a*) Changes in consumers taste.

(*b*) Ability of the competitors to offer better products.

(*c*) Developement of an entirely new technology making the product obsolete.

Actually it is very difficult to make reliable estimates of the future situations. But by way of systematic approach, experience and set of techniques, we can gather sufficient informations.

Basic Need Requirements of a Product. A product, therefore, must satisfy the following basic need requirements :

(*a*) *Consumers taste.* This must include the habit, social belief, social customs and environment in which consumers are living.

(*b*) *Prosperity of People.* Peoples' need changes with the change of their per capita income.

(*c*) *Adoptablity to Social Change.* Product must be evaluated with the property of the flexibility of accommodating and adopting the social change.

(*d*) *Conformity with the economic policy and law of the country.* It must be according to the economic policy and the law of the country.

2. Development of Possible System.

As stated above, after knowing the needs, next step is to develop a possible system. For this, serveral alternative systems are listed and considered, out of which best one is developed. The various alternatives may involve different costs and different probabilities of success. Out of these, best possible system is selected with the help of different objectives and then it is developed.

Objectives of Possible System for Selection Criteria. Following are some of the important objectives which must be considered while selecting a system for development :

1. Initial cost.
2. Production cost and maintenance cost over a specified period.
3. Reliability.
4. Performance.
5. Weightage.
6. Efficiency.
7. Safety.
8. Profit over a specified period.

Generation of Alternatives. As stated earlier, having known the needs or requirements, different alternatives are generated and best among them (selected by considering the factors mentioned above) is selected and developed further for execution. Thus selecting best method among available alternatives is a decision making process. Generation or listing of various available alternatives is an important task as one method out of these is to be selected for implementation. Hence care must be taken to list all the possible alternatives which may even seem to be unfeasible in the first stage. This also helps in getting new and good ideas.

3. Comparison of system needs and proposed system capabilities.

As explained above one best alternative system is selected and is then developed. When this system fully developed is compared with that of basic needs or requirements, if any thing is pointed out then it is noted for correction and further consideration.

4. Review and modification of possible system.

There is room for improvement, especially for any untested new system which represents a significant departure from the way the things have been done in past. If the system is at all complex there are bound to be some things neglected, some false assumptions and some errors

in reasoning. Also there are usually a number of ways to simplify and streamline the system which have been overlooked ordinarily. Many worth while changes can be made and occasionally an important improvement.

Therefore, the whole system is reviewed and tested with respect to principles of system and procedure design. At this stage it is important to correct deficiencies and incorporate as many improvements as possible before taking the decision to go ahead. Before final approval, it is also advisable to obtain suggestions from supervisors and other workers as they are in best position to detect flaws and deficiencies in the system.

5. Revaluation and decision to go ahead.

The modified system is once again revalued. It aims to find whether this will be a beneficial system, fulfills all needs and there are no technical, social, economical and legal problems.

Apart from this a laboratory model of the product is to be made at this stage (generally after feasibility report) and tested for its performance characteristics to study the efficient achievement of the set goals. Then a citeria for performance is set in terms of materials, strength and durability. This test is also to be continued in terms of economic changes in the society at regular intervals in the light of advancement of science and technology.

Once the standards for evaluation have been set for the efficient performance of the subsystem of the main system. These sub-systems have to be synthesised in the form of prototypes which are to be used for further trial, progress and refinement work. They are to be made with correct physical appearance and layout but using non-production and hand building methods. Once the prototypes have been tested, a check has to be made for its profitable production at large scale.

System Design v/s Product Design

System design and product design are purely two different terms and to distinguish them clearly their comparison is given hereunder :

System design refers to the design of a collection of components through the conceptual modelling. Components of a system represent the system in hand e.g., an aeroplane is a physical system with component as fuselage, wings, engine and controls, whereas an engine may be treated as a system comprising inlet compressor, diffuse combustion chamber, turbine and nozzle. Each of the above listed items may referred to as products if considered individually. Thus, engine may be the product of a system consisting of moulding, machining, jig boring etc.

In principle, product design proceeds through the same steps as system design. This is obvious in view of the fact that both systems and products are based upon certain human needs and their development must be optimised in the same way. System design and product design, therefore, proceed through same ways and means and the study of one is complementary to that of the other.

System Requirement

In order to judge how satisfactorily an existing or proposed system is, several requirements are considered. Some of the important requirements to be considered are following, which help in judging the success of a system :

1. Fulfil its purpose effecively.
2. Require minimum time to process and implement.
3. Provide complete set of plans, so as to minimize confusion at a later stage.
4. It should cost less in the long run than any other system.

5. Be adoptable to changing conditions.
6. Must be acceptable to the management and the personnel engaged in its operation.
7. The plan of the system must be in accordance with the policies of the country and structure of the company, and the requirements of the law and government agencies.
8. It must give more benefits than available from other alternatives.

1.16. PROCEDURE FOR DESIGNING AN ENGINEERING SYSTEM

A system engineer must design a system in the following phases in sequence of order :

1. **Understanding the problem.** In first phase a system engineer must understand the problem and he is required to determine the overall system requirements and objectives. While determining the system requirements he must consider the different factors like performance, reliability schedule, cost, maintainability, power consumption, life expectancy and operating requirements and then give due weightage to each of these functions.

2. **Considering the alternative solution.** The next step is to consider alternative solutions. System engineer must be able to find out as many solutions as possible, as the more solutions are considered at initial level, greater will be the probability of getting a good system at final level. Then most promising and potentially useful solutions are given further consideration. Technical and financial feasibility study is conducted on these selected solutions. Generally the promising solutions are reduced to three for conducting the feasibility study.

3. **Choosing the most optimum system.** In the next step, one solution is finally selected which is best among all the solutions. This selection be made by using the correct and reliable data and informations so that correct decision be made. Accuracy in characteristics and data at this level is very important.

4. **Synthesis of the system.** This consists of the complete theoretical and physical design of the system. In this, effects of environment or internal forces on the stability of the system is determined. Socio-economic conditions at the time when the product is expected to be put are also considered.

5. **Updating equipment characteristics and data.** For further evolution of the overall system more emphasis is payed on the actual conditions and the system is further improved accordingly. For this purpose, feedback method is very useful. In feedback method, the information from each step is feedback to the previous steps for modification. This is repetitive in nature.

6. **Testing the system and refinement.** Experimental models are then tested to check the entire ideas. Component and proto-types are also tested as need arises. These tests data are the basis for redesign and refinement and the process is continued till a process-design is accomplished as per requirements.

7. **Application and operation.** In the end the system design is applied for planning the production, distribution of goods etc. After getting the green signal from all corners the operation from business point of view is started.

1.17. OVERALL OBJECTIVES OF A SYSTEM

As discussed earlier, a system have many objectives like performance, reliability, cost and schedule. All these factors are required to be considered in the design for any system. But depending upon the application and the customer requirements their weightage varies, some system may stress performance, other reliability, others cost and some other schedule. For

example, design of a radar would stress more for performance and reliability, while a mechanical screw jack for the use in cars would require more stress for cost and less for performance and reliability because of the difference in requirements. Therefore, it is necessary to consider each system separately and determine the relative importance of various objectives in the proper perspective.

A list of such objectives which would be used as guideline are :

1. Performance 2. Reliability 3. Cost
4. Schedule 5. Maintainability

A different individual may add a few more criteria. The importance of the criteria very much depends upon the requirements of the final objectives.

1. **Performance**. The most convenient way of describing the performance of a system is its efficiency. However the description of efficiency may vary from system to system as given in the following examples :

Performance of a thermal power plant may be measured in terms of ratio of energy output to thermal energy input, some persons may describe the performance in terms of Carnot efficiency.

Performance of an electrical machine may be described in terms of efficiency at a given load.

2. **Reliablity**. Reliability is a measure of successful performance of the system. Most accepted definition of the reliability is : "It is the probability of a device performing its purpose adequately for the period of time intended under-operating conditions encountered."

The reliability of a system is the function of reliability of each of its components. If the total reliability of system, as derived from the reliabilities of elements is less than that of the system desired in design, than for improving the reliability, quality of the components is required to be improved.

For improvement in the reliability of complex system, considerable efforts are made on the components. Use of transistors instead of vacuum tubes is the example for such improvement. A most useful method for this is the group redundancy. A group redundant system combines single elements into the logical functional groups which are operated in parallel. The redundancy technique utilise two parallel elements to reduce the probability of failure. While in group redundancy, we provide each channel of elements which perform a function with another duplicate channel. Thus we get a normal channel and a redundant (or standby) channel. When the normal channel fails, the standby channel is switched on.

3. **Cost**. It is a very important criteria for starting a project and therefore a detailed analysis of the cost is essential in the initial stage of the design. Costs are classified as (a) fixed charges, (b) Variable charges, (c) Past investments etc.

4. **Schedule**. Schedule is directly concerned with time as 'time is money'. Now-a-days very much stress is being given on schedule, and modern schedule control tools like C.P.M. and P.E.R.T. are used for the purpose. Delay means loss of man-months of efforts, production cost increase and bad image on the consumers.

5. **Maintainability**. Maintainability of a system may keep the reliability within prescribed limits. "Maintainability can be defined as the probability that a failed system will be restored to operatable condition within a specific time, when maintenance action is initiated under stated conditions." Thus it is a function of design and personnel concerned and, therefore, it can be improved by providing accessible test points, spare parts and necessary equipments for undertaking repairs, and by providing training to the operation staff for maintenance.

Advantages of Following Proper Systems

- Reduction in the operating time cycle.
- Lowering the inventories.
- Reduction of errors in estimating the costs and predicting the delivery dates.
- Elimination of avoidable operations and activities.
- Faster working capital turnover and reduction in working capital requirements.
- Faster implementation of decision-making and feed back thereof.
- Effective supervision.
- Strengthening of organisation structure.
- Better communication.

1.18. SYSTEMS APPROACH TO PRODUCTION MANAGEMENT

A system can be defined as an orderly arrangement of components like, men, materials, money, machine and environment that are inter-related and act and interact with one another to perform task or function in a particular environment. A system is composed of elements or sub-systems that are related and dependent upon each other. A systems approach is a systematic and organised approach to get the task accomplished more efficiently, effectively and economically. A system can be considered as a structure of sub-systems, each having the following characteristics :

(a) Inputs
(b) Transformation (conversion) process
(c) Output
(d) Feed back.

From the above, we see that every organisation can be represented as a system consisting of interacting sub-systems. The basic process of the system converts the resource input into some useful form of outputs. However, depending upon the efficiency of transformation (conversion) process, we may have undersirable outputs too, like pollution, scrap or wastage, rejection etc. A conceptual model of a production/operation system is shown in Fig. 1.6(a). In this model, output includes technical and economic efficiency, quality, delivery schedule and profitability; whereas control includes production planning and control, quality control, inventory control, cost control, maintenance control etc.

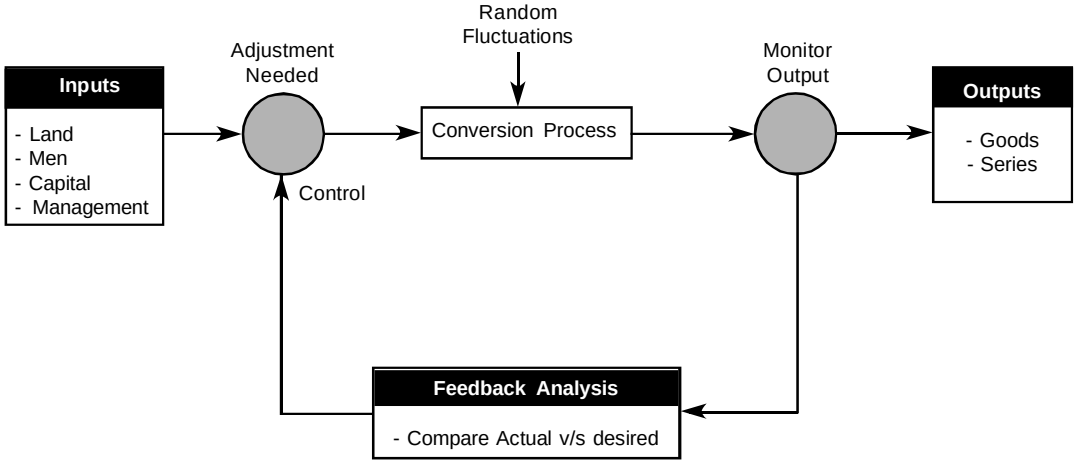


Fig. 1.6(a) Conceptual model of production management.

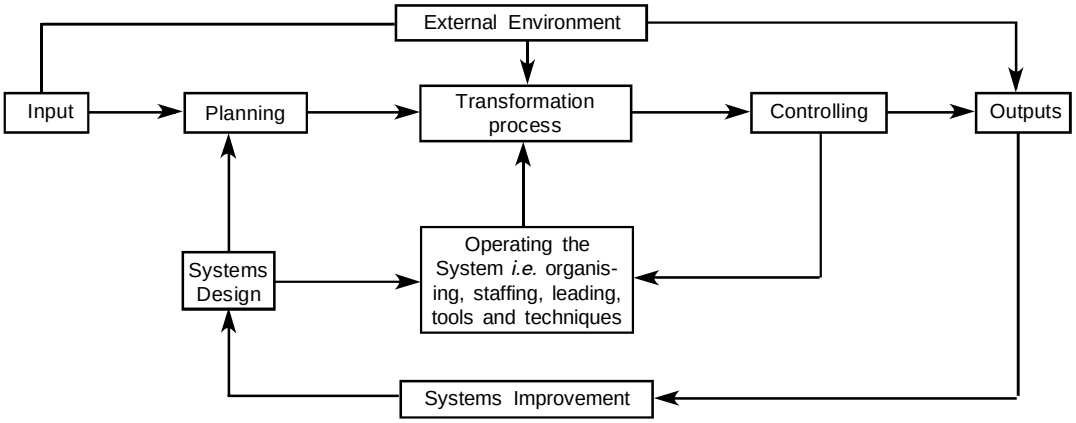


Fig. 1.6(b) Conceptual model of production management system.

Another model of production management system is shown in Fig. 1.6(*b*).

A systems model of the organisation has several sub-systems as shown in the Fig. 1.7. Any business organisation have finance, marketing, accounting, personnel, engineering, purchasing, and distribution systems besides operations system. All these systems are interrelated to one another in many ways.

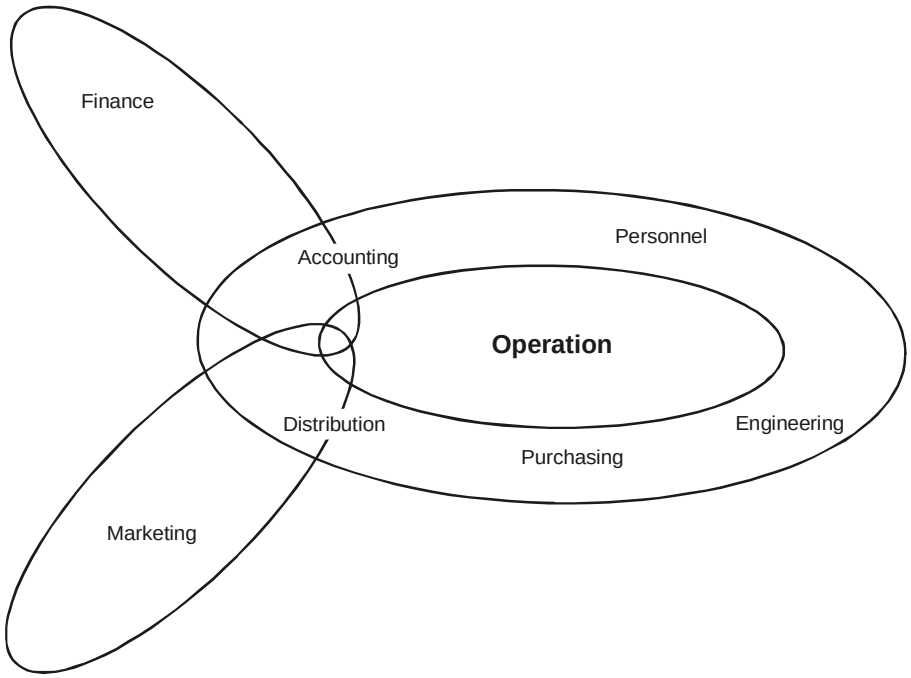


Fig. 1.7. A systems view of a business organisation indicating its sub-systems.

Production management has main subfunctions of planning, organising and controlling. This has been illustrated in the Fig. 1.8.

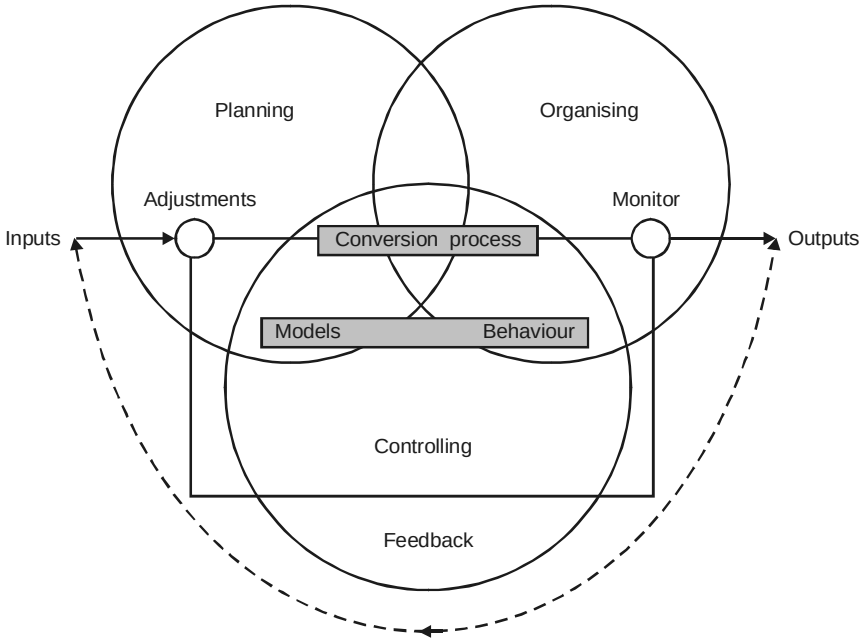


Fig. 1.8. A framework of production management systems.

Functions of Industrial/Production Management Systems

Major functions covered in the production management systems are as follows :

1. Planning Functions

(*a*) *Designing conversion systems.*

- — Operations strategy
- — Product and process selection
- — Facility location planning
- — Forecasting
- — Capacity planning
- — Layout planning

(*b*) *Scheduling Conversion Systems*

- — Scheduling systms
- — Operations scheduling
- — Aggregate planning

2. Organising Functions

- — Organising for conversion
- — Staffing
- — Production/operations standard
- — Structuring of operations
- — Job and work design
- — Payment systems etc.

3. Controlling Functions

Monitoring and control of conversion systems are on following aspects :

(*a*) Quantity
(*b*) Quality
(*c*) Time
(*d*) Inventory
(*e*) Cost
(*f*) Maintenance

Functions mentioned above have been discussed at relevant places in the book.

1.19. PRODUCTION MANAGEMENT V/S INDUSTRIAL ENGINEERING

Production management attempts to familiarize a person with concepts and techniques specific to the analysis and management of a production activity. Industrial engineering on the other hand, deals with the analysis, design, and control of productive systems. Here, productive system means any system that produces either a product or a service.

Productive management tells how to manage in a production environment, with lesser attention paid to the analysis and design of productive systems. The industrial engineers generally do not operate the systems they design.

1.20. MANAGEMENT SCIENCE

Management science is a problem solving process used by interdisciplinary team for decision-making and may use quantitative analysis and other scientific approaches.

The management science is the application of the scientific methods to the study of the operations of large and complex organisations or activities. Industrial engineering and operations research are the two disciplines which are associated with the management science.

Management science has following *characteristics :*

1. Uses inter-disciplinary approach.
2. Identifies all important functional interactions and determine their impact on the company as a hole.
3. Uncover new problems to highlight for study.
4. Uses systematic approach including mathematical modesl.
5. Primary focus is on managerial decision-making.

Management science uses following important *tools for solving managerial problems :*

1. Mathematical programming
2. Network techniques
3. Dynamic programming
4. Markov chain
5. Game theory
6. Inventory models
7. Waiting line models
8. Decision matrices
9. Decision trees
10. Simulation models. Models generally employed are :
    (*a*) Artificial intelligence, (*b*) Heuristic programming,
    (*c*) Management games, (*d*) Systems simulation, and
    (*e*) Monte Carlo simulation.

Above mentioned tools for solving managerial problems have been discussed in the book in detail at appropriate places.

1.21. DECISION-MAKING OF PRODUCTION MANAGEMENT SYSTEMS

Since Operations/Production Management is a function concerning decision-making with respect to a production/operation system so as to render the necessary customer satisfaction at lowest cost, we are discussing here different types of decisions, which are taken by a production/operation Manager. These decisions can be divided into following two groups :

1. Periodic Decisions. These are decisions related to selection, design and updating of resources, structures, systems and procedures.

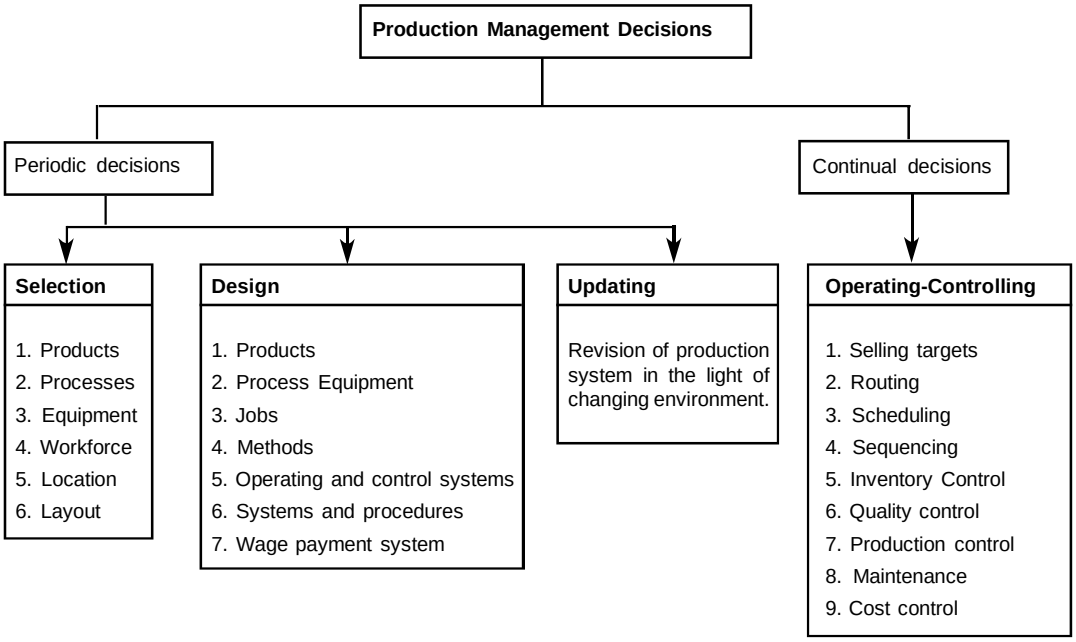


Fig. 1.9. Production Management Decisions.

2. Continual Decisions. These are the decisions which are required in day-to-day operation and control of production systems.

1.22. COMPETITIVENESS AND THE PRODUCTION FUNCTION

In order to compete in the global market, there are four dimensions of competitiveness that measure the effectiveness of the production function. These four dimensions are :

1. Cost
2. Quality
3. Dependability as a supplier
4. Flexibility.

1. Cost. Price is an important weapon used in the competitive market place. Profitability is also related to the difference between price and cost. Therefore, in order to compete on the basis of price, operation functions must be capable of producing at low cost. Hence it is necessary that by using the experience, scientific knowledge and management techniques organisation must use improved production methods and tools, improved product design, standardization, improved layout and flow so as to minimise material handling, economies of scale and improved management techniques.

2. Quality. Due to Japanese concept of quality and dominance of Japanese market in consumer electronics, automobiles, steel, machine tools etc., more attention is being paid now-a-days on quality. Customer needs are given maximum attention. Customers and clients are generally willing to pay more and can wait for delivery of superior quality.

3. Dependability as a supplier. Dependability of supply of off-the-shelf availability is considered as a strong favourable point in competitive market for an organisation. Customers, sometimes, may compromise on cost or quality in order to get on-time delivery when they need it.

4. Flexibility. A firm must be flexible enough to meet customers' needs. Customers' needs may be about service, change in specification, change in delivery schedule etc.

1.23. PRODUCTIVITY

"Productivity" is nothing but the reduction in wastage of resources. The resources may be men, machines, material, power, time and building space etc.

It may also be defined as human endeavour (Effort) to produce more and more with less and less inputs of resources as a result of which the benefits of production may be distributed more equally among maximum number of people.

According to V.K.R. Menon, productivity implies development of an attitude of mind and a constant urge to find better, cheaper, easier, quicker and safer means of doing a job, manufacturing a product and providing a service.

Output is obtained by the combined input of a number of factors such as men, material, money, land, management and production methods etc. The ratio between output and input of these factors is known as "Productivity" of the factor concerned. The most common unit of input of these factors is known as "Productivity" of the factor concerned. The most common unit of input is "Man-hour" of working time and productivity due to this factor is known as "Labour Productivity".

It can be represented by

$$P = \frac{O}{M}$$

where P = Labour productivity
O = Unit of output
M = Man-hour or efforts input.

For example, if a manufacturing concern is producting by using the same materials, machines, workers and number of hours, 150 items, now compared with 120 items previously. Then its productivity is said to have increased by 25%.

The productivity have been discussed as a separate chapter in details, in the book.

Difference between Production and Productivity

Sometimes, there arises confusion between Production and Prductivity. It is, therefore, necessary to differentiate them, so that there may not be any confusion.

"Production" of any commodity or service is the volume of output irrespective of the quantity or quality of resources employed to achieve that level of output. Once we put in it element of efficiency with which the resources are employed, we enter the area of productivity.

QUESTIONS

1. Write an essay on Industrial Management"
2. Define Production" Management. Discuss functions of production manager of a modern factory.
3. (*a*). Give brief history of the development of production systems. (*b*) Compare and contrast continuous and intermittent production systems.
4. Differentiate between job production, batch production and continuous production.

5. State the difference between production to stock and job order production. Give two examples of each.
6. Define Production. What are the types of Production ? Explain their advantages and disadvantages.
7. Explain the term 'production-function'. What is the utility of 'production function' for the managers.
8. Write short notes on :
   (*a*) 'Services' as a part of 'product'
   (*b*) Value added process
   (*c*) Scope of production management
   (*d*) Competitiveness and operations function.
9. Classify production management decisions, and discuss them in detail.
10. Explain the major functions of production management system.
11. Explain in detail about the 'systems approach to production management'.
12. List various activities of Industrial Engineering.
13. How productivity can be improved with the help of Industrial Engineering?
14. Discuss the place of Industrial Engineering Department in the manufacturing organisation.
15. What are the main branches of Industrial Engineering? Write a paragraph on each of them.
16. What is management science ? List the tools of management science for solving managerial problems.