UNIT 10 PRODUCT DESIGN – INTRODUCTION

Structure

10.1 INTRODUCTION

In this unit, you will learn about product design, which is the process of deciding the unique characteristics and features of the company's product. The survival of any company in the global market lies in its ability to develop new and innovative products and services. You will also learn about process selection, which is the development of the process necessary to produce desired product or services. Product design and process selection affect product quality, product cost, and customer satisfaction. If the product is not well designed or if the manufacturing process is not true to the product design, the quality of the product may suffer. If a product is to achieve customer satisfaction, it must have the combined characteristics of good design, competitive pricing, and the ability to fill a market need.

This unit presents fundamentals underlying the design of profitable and marketable commodity. A design engineer may create on paper a device of excellent functional utility or sales appeal; but if that product is to become a reality, it must be produceable at a reasonable cost in just sufficient time to satisfy the customer. Thus it must be producable from available and advantageous materials, methods, processes, and equipment. At the same time, it must be competitive in quality, performance, appearance, and service life. Here the term product represents both product and services.

Objectives

After studying this unit, you should be able to

- explain product design and process selection
- identify factors affecting product design,
- describe qualification of a successful product design engineer, and
- explain steps in product design.

10.2 PRODUCT DESIGN AND PROCESS SELECTION

Product Design

The traditional staring point in the production process is designing the product or service. A product or service must be designed so that it must attract customers and it must be cost effective. Decisions related to design include the product features to include, the desired level of quality, the materials to use, and the resulting production costs. In order to accomplish the objectives related to product design, the successful product design engineer must be conversant with related terms.

Product

A product may be defined as an item created to satisfy the need of customers. In other words, a product is an article obtained by the transformation of raw material and is saleable.

Products in manufacturing and retail are tangible in nature while products for service industries are intangible in nature.

Product Classification

A general classification of products can be made on the basis of the pattern of needs of customers for the product, as shown in Figure 10.1.

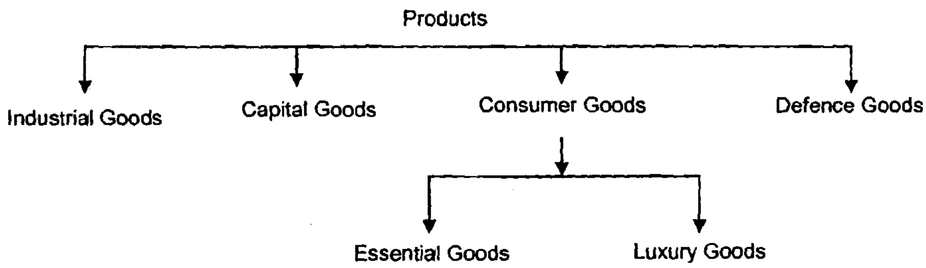

Figure 10.1

Industrial goods comprise of raw materials or semi-finished goods that are converted into more finished products, equipment, machinery, etc. The purchased industrial goods become part of the manufactured products that are later sold to consumers. An example of industrial goods is steel sheet. An automobile manufacturer buys steel sheets only because consumers will later buy the automobile, he will make from the steel sheets, otherwise he has no personal need for this item. Electric motors, temperature controllers, pressure gauges, solenoid valves, etc. are other examples of industrial goods. The design of industrial goods is influenced by the needs of the capital goods industry or many a times the purchaser gives his own specifications or requirements.

Capital goods are the goods, which when used will produce some kind of products; or generate some kind of power, viz. a prime mover, a machine tool, etc. The design of capital goods is often not changed as frequently as consumer goods. The specifications of capital goods concerning the functional or aesthetic quality are usually supplied by the customers.

Consumer goods are the goods that the customers buy for their own use or consumption. The design of a consumer goods is influenced mainly by customers' preferences. Competition amongst consumer goods' manufacturers is much too acute than that in the case of capital goods. Specifications regarding quality of consumer products are obtained through market research. Price of the consumer goods, because of competition, is generally kept as low as possible to gain monopoly in the competitive market. There is no hard and fast rule for drawing a distinction between essential and luxury goods. Some goods may be grouped under any one of the above two types depending upon the person who uses them. A cellular phone, for example, may be regarded as a luxury goods, when a college professor uses it. But to a professional doctor, it is an essential commodity, since with cell phone he can attend to patients who give him a call even when he is away from his clinic.

Defence goods on the other hand are meant for the country's security and therefore there is no open public market for the same. As a result there is little competition in this field. The design of defense goods is often a secret document. The manufacture of defense goods is mostly undertaken by the government in the state-owned factories, except under emergent circumstances when various private industries may also be ordered to undertake the manufacture of arms and equipment.

Product Design

The product-design function involves the development of specifications of a product that will be functionally sound, have eye appeal, and will give satisfactory performance for sufficiently long life.

Product design precedes product manufacture.

The idea (or need) for a new or improved product may originate from any one or more sources as shown in Figure 10.2.

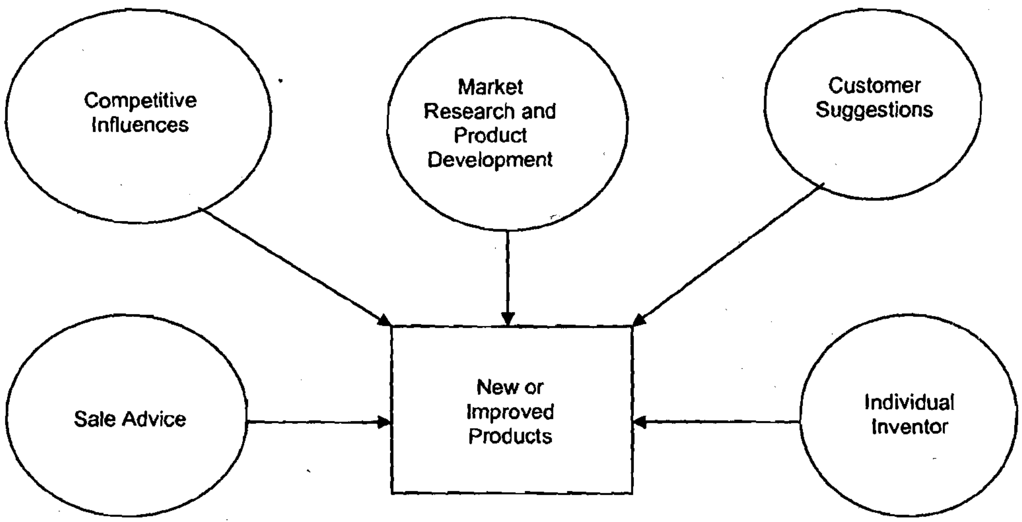

Figure 10.2 : Idea Generation Sources

Market research, product development project, customers' suggestions, sales advice and individual sources are some of the major sources from which the idea of a product may originate. By individual source, we mean an individual person hitting upon a plan for a new or improved product.

It should be apparent that not every idea necessarily leads to a new product that is placed on the market. However, every new product represents the crystallization of someone's idea. It has been estimated that on the average it takes nearly 500 possibilities at the idea stage for every single new product that is produced. The majority of ideas are thus eliminated at new-product conferences or after a preliminary laboratory investigation or an economy study.

After a firm has developed a list of ideas that appear to have product potential, it selects those ideas that will most likely lead to success. This selection procedure takes place at new-product conference which are attended by the representatives of sales, product engineering, manufacturing engineering, and marketing. Among the persons called upon to consider new ideas, some will be found to be always resistant to change. Their immediate reactions are negative. They should be persuaded for an adjustment to the new and different environment. Those participating in new product conferences should be practical men of vision who are up to date in their respective fields and who have the imagination and courage to work on an innovative idea that has promise.

At the new product conference, it is a good practice to record a profile of the various influencing factors for each new product being considered. Some of the influencing factors include :

(a) The utility value of the product

(b) The need for the product

(c) The product's sales appeal

(d) The advantages over similar products on the market

(e) The size of the potential market

(f) The patentability of the product

(g) The Research and Development costs

(h) The setup and tooling costs

(i) The profit potential

(j) The suitability of the company's engineering talent and production facilities

(k) The suitability of the company's sales force and means of distribution

(l) The strength of the company compared to the competitors

(m) The expected life of the product

(n) The compatibility of the product with other company products

The profile of a given idea may appear as shown in Table 10.1.

Table 10.1 : New Product Profile Record

Sl. No.	Factor	Very High	High	Medium	Low	Very Low
1.	Utility					
2.	Need					
3.	Sales appeal					
4.	Advantages and improvements					
5.	Size of market					
6.	Patentability					
7.	Research and development cost					
8.	Setup and tool cost advantage					
9.	Profit potential					
10.	Suitability of Engineering and Facilities					
11.	Suitability of sales and distribution					
12.	Strength of company compared					
13.	Expected product life					
14.	Product compatibility					

Process Selection

Process selection decisions determine the type of process used to make the product or service. For example, automobiles are made using an assembly-line type of process, while sailboats are made using a batch production method.

Process selection decisions are strategic in nature. They require a long term perspective and a great deal of cross-sectional coordination, since marketing, finance, human resources, and operations issues are all important. Process selection decisions tend to be capital intensive and cannot be easily changed. Therefore, the firm is committed to the process choice and bound by these decisions for years to come. There are three processes :

(a) Line process,

(b) Batch process, and

(c) Project process.

The characteristics of the three processes are summarised in Table 10.2.

Table 10.2

Characteristics	Process		
	Line	**Batch**	**Project**
Product			
Order type	Continuous or large batch	Batch	Single unit
Flow of product	Sequenced	Jumbled	Sequenced
Product variety	Low	High	Very high
Market type	Mass	Customised	Unique
Volume	High	Medium	Single unit
Labour			
Skills	Low	High	High
Task type	Repetitive	Non-routine	Non-routine
Pay	Low	High	High
Capital			
Investment	High	Medium	Low
Inventory	Low	High	As per requirement
Equipment	Special purpose	General purpose	General Purpose
Objectives			
Flexibility	Low	Medium	High
Cost	Low	Medium	High
Quality	Consistent	Consistent	Consistent
Delivery	On time	On time	On time
Control and Planning			
Production control	Easy	Difficult	Difficult
Inventory control	Easy	Difficult	Difficult

Service Process Design

Defining Service

Before designing the process, the service product must be defined. Most services come in bundled with facilitating goods in a service-goods package. For example, when customers go to a fast-food restaurant, they receive not only food but the service, which they hope is fast, courteous, and pleasant. In this case, the food is the facilitating good for service.

The service-product bundle consists of three elements :

(a) The physical goods (facilitating goods)

(b) The sensual service provided (explicit service)

(c) The psychological service (implicit service)

Designing the product and processes together is very important for services. Delivery of services is a simultaneous marketing and operation act. Therefore, cross-functional cooperation is the essence of service design and delivery. Service cannot be provided without it.

Service recovery is an important part of the product design. When there is a service failure, service recovery is the ability to quickly compensate for the failure and restore, if possible, the service required by the customer.

Service design is different from product design. While designing tangible product, the service concept is based on meeting customer needs.

Service design is the activity of planning and organising people, infrastructure, communication and material components of a service, in order to improve its quality, the interaction between service provider and customers and the customer's experience. The increasing level of the service sector, both in terms of people employed and economic importance, requires services to be accurately designed. The design of the service may involve a re-organisation of the activities performed by the service provider (back office) and/or the redesign of time and place in which customers come in contact with service (front office).

SAQ 1

(a) List different types of product.

(b) What are the various sources of idea generation? Discuss.

(c) What are the factors which influence product design? Explain with the help of an example.

10.3 QUALIFICATIONS OF A SUCCESSFUL PRODUCT DESIGN ENGINEER

A successful product design engineer must be versatile, creative, and well-informed person. He not only must have an in-depth study of the essential physical sciences that underlie engineering, but he also must have a comprehensive knowledge of a considerable variety of materials and of production processes. He must be familiar with the organisation and the human factors. He must also be conscious that *appearance* is a highly significant factor in selling a product and he has to either design his product with that in mind or get help in the problem of achieving good appearance without sacrificing utility. Most important of all, he must be cost conscious, as almost all actions are based eventually on cost. Some basic traits of a successful product designer are:

Creative Thinking

Product designing is a creative occupation. Creative thinking is not, of course, confined to a particular field or to a few individuals, but is possessed in varying degrees by people in many occupations: the artist sketches, the news paper writer promotes an idea, the teacher encourages student development, the scientist develops a theory, he production engineer develops improved manufacturing processes or applies improved materials in creating a better product.

Creativeness implies newness, but it is as often concerned with the improvement of old products as it is with the creation of new ones. In engineering, the newly created thing must be useful; it should be of benefit to people, yet should not be so much of an innovation that others will not purchase it. A "how-to-make-some-thing-better" attitude, tempered with good judgment, is an essential characteristic of an effective, creative product design engineer.

Is creative ability born in an individual or is a person able to develop this ability? Answer to both parts of this question can be in the affirmative. Some people are born with more creativeness than others, just as certain people are born with a higher IQ than others. Also, it is possible to develop creative ability in the same way as it is possible to develop mental and physical skills.

To develop creative ability related to product design activities, it is essential to have an understanding of what creative engineering really involves. Creative engineering is, in part, a combination of the following :

(a) A curious and imaginative mind

(b) A broad background of fundamental knowledge

(c) A desire to do a complete job of solution, once a problem has been defined.

A thorough knowledge of fundamental principles of physics, chemistry, mathematics, and engineering subjects is a good foundation for creative thinking. Practical knowledge in the field of endeavor is equally essential. Young engineers cannot be expected to create designs of manufactured parts unless they have had contact with many kinds of parts and have studied their uses and methods of manufacture. However, knowledge is only a basis for creative thinking and does not necessarily stimulate it. The inherent personal characteristics of curiosity, intuitive perception, ingenuity, initiative, and persistence produce an effective creative thinker. Curiosity stimulates more ideas than probably any other personal characteristic.

Curiosity and Imagination

One aid to the development of curiosity is to train oneself to be observant. An engineer, especially, should be observant of objects about him that have been created by man. He must ask how the object is made, of what materials it is constructed, why it was designed of a particular size and shape, why and how it was finished as it was, and how much does it cost. These observations lead to creative thinker to see ways in which it can be improved, or to devise a better object to take its place. In the globally competitive industry, he may also be led to see a way to reducing its cost. Observation often leads to a revolutionary idea that may satisfy a public need. Here, one can cite the example to DeForrest, who was led to develop the thermionic electron tube by observing the effects of an electrical discharge on a nearby gas jet. This observation, seemingly irrelevant to what he was doing, caused him to wonder why the jet behaved in an unexplained manner. This was an incentive to develop the relationship of heat to electron flow and, having arrived at the explanation of that phenomenon, he progressed to the invention of the three-element electron tube, which is the core of radio broadcasting.

Closely associated with curiosity is inventive imagination. This trait, which is frequently indistinguishable from curiosity, can also be developed and strengthened through proper use and exercise. By taking ideas from our imagination and putting them together in new combinations we are developing our creative imagination. For example, try to visualise :

(a) A toothbrush with cleaning fluid contained in its handle

(b) A screwdriver with a flashlight tip

(c) An adjustable box wrench

(d) An edible soft-drink can

(e) A cigarette box that also serves as an ash tray

(f) An electric fan that is remotely controlled

(g) A simple and small automobile for a single person usable in standing posture

By putting together, in the mind, various combinations of known products we are using inventive imagination to develop new designs. It is not very easy to visualize absolutely new products to go beyond the bounds of one's own experience. Inventive imagination takes place only by putting together working concepts of known products in a new way. Thus, when a painter creates a new picture, or a sculptor develops a new figure, or an engineer conceives a new design, his inventive imagination is combining facts already in his mind.

Time to Think

Most creative thinkers agree that it is necessary to take time out from routine activities to concentrate on problems of interest. They have found that in a state of mental relaxation ideas come to them more readily. We can take the example of David Ross, inventor of the Ross steering gear. Ross was inactivated by a critical illness shortly after his graduation in engineering. During this period he conceived the idea of the cam type of automobile steering gear, upon which was founded an important and profitable industry. He was very much interested in the development of student engineers, and one of his beliefs was that the young engineers should be given time to think. Thomas Edision is an another example, an accident early in life impaired his hearing out but he was not distracted by ordinary things about him and was able to think about his research problems.

Unless one takes time to think, one will not be able to focus his mind along a definite line. By taking time to think, one is able to concentrate upon a problem. Concentration necessitates keeping the mind logically thinking about one problem or idea for a period of time. Concentration can be developed through the Yoga and the mind can be trained to remain concentrated upon a subject for a definite length of time.

Energy and Persistence

Persons like Marcony and Edision were not dreamers, but men of energy and persistence who used ingenuity and initiative in developing their ideas. As soon as they had an idea, they put it down on paper, sketched it, and improved it while the idea was fresh in their minds. They worked for several hours at a stretch often until exhausted. This physical effort and recording of ideas clarified their thinking, stabilised their perspective, and eliminated impractical and undesirable ideas.

Systematic Procedure

The path followed by the creative thinker in developing a new product is long, and difficult, beset with many detours and byways. However, systematic procedure for the development of a product will reduce the time and effort of the engineer, who promotes the development from its early stages to completion. He sees it through design; selection of materials; setting up of operations and processes; selection of equipment; design of tools; formulation of specification, operation sheets, and sales data; use of standards; adoption of ideas; obtaining patents; and other related functions. Most of these are governed by economic considerations and are developed by a systematic procedure.

The systematic procedure that will give results through creative thinking begins with the establishment of the problem area. Being able to accurately and completely define the problem area is the first important step toward problem solution. No solution can begin until the problem is presented. In order to be able to state the problem the *pd* must have acute powers of observation and be able to associate ideas and facts in new relationships. He should utilize the questioning approach and have no misgivings as to change. He should not feel at all reluctant to "not conform" or be considered "illogical". He should have no fears of being ridiculed, but should have personal confidence and acceptance of his own inherent creative ability.

After the problem area has been established, the next important step is the collecting of pertinent facts and ideas. This usually starts with a survey of the trade literature of determine what already has been done. The library usually can provide much helpful information through the use of current periodicals and reference text materials. Issued patents may be procured in the general field of the established problem area. The issued patents will present the development that have taken place to date in the problem area.

After the pertinent facts are established, the ideas next step requires the ideas to be crystallised. Existing relationships in the problem area will need to be considered along with the development of new relationships. An idea is of value only when used and accepted by designer, management, and the public. The person whose idea is accepted – not necessarily the person who had the idea first – deserves the credit.

Although an incubation period is necessary, a creative idea should be crystallised as soon as possible by recording the idea in sketches, drawings, and written descriptions. Once the idea is crystallised, discussion with colleagues in order to obtain their reactions helps to assure that the idea is practical. Models and tests soon prove whether the idea is valuable.

The schedule of events that should take place between the development of ideas to the transformation of suitable resources into useful products is common to all projects. An understanding of this chain of activities will give you an appreciation of the many difficulties that must be overcome in new-product development. The flow chart given in Figure 10.3 will clarify the procedure that should be followed.

Even when the new product is developed and marketed, the development function does not end. Product development, in real practice, should be regarded as a continuous and dynamic activity. The progress of product development is usually slow at the initiation stage; the rate of development rises after the product development project is approved. Any product, of whichever type it may be, must have two broad objectives : immediate objectives and ultimate objectives. Immediate objectives of a product will be to stimulate the sales function, provide a new look and offer new advantages, utilise the existing equipment and skilled men, and satisfy the immediate needs of the customers. But the ultimate objectives of a product, which are more important and of permanent value, are to monopolise the market, tie the customer to only the branded product, to make possible its manufacture on quality basis and above all to reduce the cost of production and give its benefit to the customers.

A product design or redesign can be considered successful if it aims

(a) To satisfy customers' needs.

(b) To stimulate sales function.

(c) To have a radical change in form, shape and aesthetics.

(d) To utilise tangible resources, viz. men, machine, material and money.

(e) To have a monopoly in the market.

(f) To have convergent distribution.

(g) To attain low cost of production.

(h) To make production on quantity basis.

(i) To raise the national standard of living.

(j) To form a basis of future products.

(k) To simplify the product design.

(l) To standardise the product design.

By the convergent distribution, we mean the distribution of the product with the help of the existing distributing agencies. This lowers down the overhead cost.

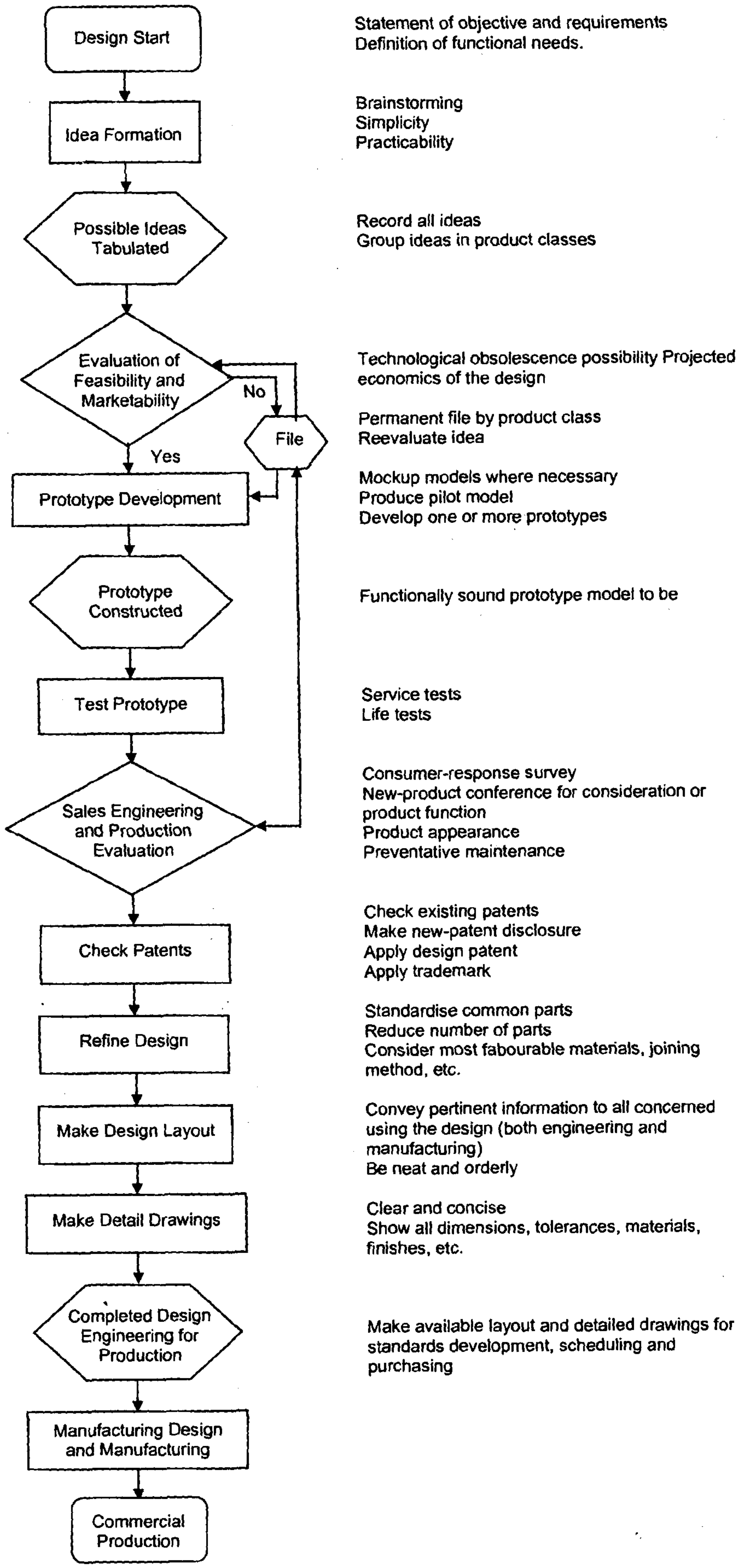

Figure 10.3 : New Product Development

A product can be designed with regards to the following three aspects.

Functional Design

This aspect of product design simply caters to the requirements of the product or the functions which the product is supposed to perform when in use. The use value of product, therefore is incorporated in the functional design.

There are three kinds of function which a product may be called upon to perform :

(a) *Basic function*, for which the product exists, e.g. 'to write' is the basic function of a pen.

(b) *Secondary function*, which supports the basic function and often brings about product differentiation e.g. if a pen has an ink eraser also attached to it. Then 'to erase writing' is secondary function of this pen.

Product differentiation refers to a variety of products for which there is market segmentation.

(c) *Esteem function*, which generates liking or increases the attraction to the user. It has no useful characteristics, and therefore may be eliminated for cost reduction and resource saving e.g. gold plating on the cap of a pen. People like to possess such a gold plated pen, but otherwise gold plating serves no useful purpose as far as 'writing' function of the pen is concerned.

Production Design (or Design for Manufacture)

This aspect of design is concerned with easy and economical production i.e. conversion of raw material into the finished product. Consider again the case of a pen. If its design is such that the clip is an integral part of the cap, it is far difficult to produce than when the design requires the clip and the cap to be produced separately and then assembled with say a nut and a screw. A design which is difficult (or impractical) to manufacture is just as unsatisfactory as a design which will function improperly.

Industrial Design (or Marketing Design)

This aspect of design is concerned with the colour, form, shape or styling which influence people to buy the product because of its eye-appeal. It also includes design for ease of use of product by the ultimate user, based on the ergonomic considerations. Consider again the case of a pen. Its round shape provides ease to hold in fingers. The diameter of the pen body should be such as to facilitate its grip with fingers and not unnecessarily increase the weight of the pen. Its colour should be appealing to the eye and preferably have some relation to the colour of ink in the pen.

Take another example of a chair. A good industrial design of an office chair will permit comfort to the user in that the user's legs will not hang but will rest on floor, give required support to user's back (by providing back rest) and hands (by providing hand rests), allow change of posture (by providing sufficient width of seat), etc.

In this design aspect, care should be taken to ensure that functional aspects and production aspects are not overlooked or unacceptably compromised.

SAQ 2

(a) Discuss the desirable qualities of a successful product designer?

(b) When the product design can be said successful? Describe.

(c) Explain the aspects considered for product design?

10.4 EFFECT OF PRODUCT DESIGN ON COST

Product design for certain influences the product cost. It is seen that a complicated product design will associate high cost and vice versa. A product of simple design that uses standard materials and parts will cost less. Product cost is made up of

(a) Direct labour cost,

(b) Direct material cost,

(c) Direct expenses, and

(d) Indirect expenses.

Product cost can be reduced if better mutual understanding exists between the design department and the manufacturing staff. If they mutually decide to make use of the existing equipment with a little additional tooling, etc. it may be possible to reduce the cost of the product.

Sometimes product cost may be reduced more than necessary in order to compete in the market by either redesigning the product or by lowering the quality.

Product cost can be reduced by applying the concept of Value Analysis. It can also be reduced by considering the following aspects at the design stage.

(a) **Materials**

 (i) A product should be designed of a material which is cheaper, correct, and easily workable and processable.

 (ii) A product should be designed with a minimum of material to reduce material cost, processing cost, and machining costs.

 (iii) Alternate cheap materials should be considered. For example, an aluminum alloy may be used for making a casting instead of costly magnesium alloy, if this can serve the purpose.

 (iv) Depending upon the functional requirement, a product may be made out of metal of non-metal (i.e. plastic, etc.)

(b) A product should be designed out of as many standard (and inter-changeable) parts as possible.

(c) A product should be designed with parts as fewer as possible. Lesser the number of component parts, lesser is the product cost.

(d) A product should not be given unnecessary tight tolerances; this will increase rejection and in turn will add to the cost of the product.

(e) Too high a surface finish, simply for adding sale appeal will entail high product cost.

(f) To reduce product cost, some component parts of the product which cannot be economically and easily manufactured in the concern itself should be got manufactured from other company or purchased from outside suppliers.

(g) If feasible, the product may be redesigned so that use can be made of the available equipment and machinery for manufacturing the component parts of the product. This will help reducing cost of the product.

(h) The product design should be such that a minimum number of operations (machining, etc.) are required to convert raw material into the finished product. This will decrease the handling cost and thereby the product cost.

(i) Design should be simple so that the product can be manufactured without much complications.

SAQ 3

What are the various components of product cost?

10.5 REQUIREMENTS OF A GOOD PRODUCT DESIGN

It is not possible to specify exactly what constitutes a good design, but the essential requirements are that it should give rise to :

(a) Customer satisfaction,

(b) An adequate profit.

In order to achieve customer satisfaction :

(a) The product should function correctly.

(b) It should possess desired degree of accuracy.

(c) It should have desired degree of reliability.

(d) It should be easy to operate e.g., a number of controls should be operatable from one position.

(e) It should be sufficiently rugged to withstand all but exceptionally rough handling.

(f) It should have pleasant appearance. Colour and the surface finish play an important role in product design.

(g) It should be of reasonable price to complete other products in market.

(h) Product design should be such that it is easy to achieve accessibility for servicing.

(i) Product design should result in good space utilisation.

Making adequate profit means that its cost of manufacture should be low. For this

(a) It should be easy to manufacture the product within the available resources.

(b) It should consist of minimum number of parts.

(c) It should require minimum number of operations for manufacturing.

(d) Manufacturing process should be decided on the basis of the product quantity to be manufactured. For example, small parts on mass scale may be produced by die casting rather than the sand casting.

(e) The use of standard component parts wherever possible must be used as this leads to great saving.

(f) Good product design should not extend the through-put time.

(g) A well designed product should be easy to pack and distribute.

SAQ 4

Explain the requirements of a good product design.

10.6 ERRORS IN PRODUCT DESIGNING

A product may not sell well in the market because of certain errors in its designing. Such errors could be many, out of which the important ones are enumerated below :

(a) Error in assessing the value of the product. A detailed value analysis will tend to reduce this error to a minimum. A product though not made of the best available material or not made of the highest quality, may still have a supreme command in the market – the reason being its supremacy in worth in relation to other existing products.

(b) Errors in consideration of ergonomics (human anatomical science) in designing the product.

(c) Errors in form of the product, which includes design of size, shape, and geometrical parameters as well as the get-up on the package.

(d) Errors in anticipating the future in-roads of competition in the potential market.

(e) Errors in fixing up the selling price. Whatever may be the quality of the product, the selling price is so fixed, that it will be well within the buying capacity of the customers in the market.

(f) Errors in not utilising the existing manufacturing resources. Such failures raise the cost of manufacturing and hence the selling price.

(g) Errors in visualising the difficulties of distributing the products over a wide area and this failure to reach all the potential customers.

Apart from these, a product may also fail because of ignorance of the designers with respect to the patent and legal matters. The product designer must wait for the right time regarding the introduction of new product. Technical excellence, functional superiority, mechanical nicety, style, cost, sales price, sales volume, and timely availability are some of the many essential characteristic needs of a product. A compromise be may necessary for the design of product. Error in such compromise may lead to the failure of the product or a loss of goodwill of the company in the market.

SAQ 5

(a) List the possible errors in product design.

(b) Discuss a situation where a product can fail because of ignorance of designers to patent law.

10.7 EVALUATION OF PRODUCT DESIGN

The process of product design evaluation is complex. However, an organisation may use the following set of questions for ascertaining as to how good a product design is :

(a) Is the product adequate to meet the functional needs economically for which it is designed?

(b) Is the product adequate to meet aesthetic requirements for use, satisfy customers' wants and harmonies with the image of the firm's other products?

(c) Have the basic materials and process alternatives been identified and their costs determined for the manufacturing volumes anticipated?

(d) To what extent have standard parts and fastners been employed?

(e) What steps have been made toward simplification of the original concept or model?

(f) What new technology, labour skills, and equipment are required? What additional provisions must be made to assure manufacturing and economic success?

(g) Does the design allow for ready inspection, adjustment, and repair, if desired?

(h) Have necessary safety provisions been built in the design?

(i) Does the design allow for economic assembly?

(j) Does the design permit the use of standard size shipping containers or materials?

(k) Does the design require special quality and production control techniques not currently in use?

(l) Does the design necessitate special handling and storage facilities?

(m) Does the design present any special hazards? Has the design taken care of these?

(n) Does the product design require assembly or partial assembly by the customer? If so, what instructions, drawings, and blue prints are required?

(o) What special jigs, fixtures, and machine modifications will be required? Can they be applied to future designs?

(p) What manufacturing bottle neck operations are foreseen? What control mechanism is required to balance the processes to achieve the forecast output level?

(q) Have the indirect and added supervisory costs been identified? Have these been eliminated or at least reduced?

(r) How much lead time is required for employee training and new process installation and run in? What measures can be taken to shorten it?

(s) Is the product compatible with the firm's other products and the public image of the firm's products for style, quality and similarity? Will extra marketing support be required?

(t) Do the tolerances reflect the customer's functional and aesthetic requirements? Are these tolerances attainable with the proposed processes, equipment, and labour skills?

SAQ 6

List down some major questions that need to be answered for evaluating a product.

10.8 LATEST DEVELOPMENTS IN PRODUCT DESIGN

Concurrent Engineering

Today, design engineers are expected to be expert in many disciplines that may range from manufacturing to human factors. As this is very difficult to realise, the team approach to designing is an alternative option. Concurrent Engineering or 'Simultaneous Engineering' as sometime it is called can be defined as "the simultaneous, interactive and interdisciplinary involvement of professionals belonging to areas such as design, manufacturing and field support to decrease product development cycle time while ensuring factors such as performance, reliability, quality, and support responsiveness.

The importance of the application of concurrent engineering is greater where the design has a significant impact on the production, testing, and servicing costs of the product, i.e. where the decisions made during the design phase of an item have the biggest impact on the overall cost of that item during its life span. Concurrent engineering recognises the fact that in order to compete effectively in today's global market, all costs associated with the product from design to shipment stage must be reduced. The centrestage of concurrent engineering is a team effort in which professionals belonging to different disciplines work hand-in-hand during the design and development of a new product.

This new concept of executing tasks in parallel is generally faster when compared to performing those tasks sequentially. However, for concurrent engineering to succeed in an organisation, a significant change in work culture is needed because it involves team work of professionals from several disciplines like manufacturing, maintenance, quality control, marketing, finance, accounting, and ergonomics. Some of these professionals may be external (from outside the company). The overall success of concurrent engineering approach depends on many things including :

(a) Training of team members (to able) to work as a group.

(b) Procedure followed by the team for weighing conflicting objectives.

(c) Way and mean followed to ensure team productivity.

(d) Organisational support.

Reverse Engineering

Reverse engineering may be described as the task (by person other than the original designer) of developing the functional specifications for an item (or equipment) based on an analysis of an already existing item (or equipment). Before undertaking an exercise in reverse engineering it is useful to understand the objective: to produce a clone or a surrogate item (or equipment). In terms of a clone, it means the exact reproduction of the original (at least as far as circumstances permit). More specifically, the clone must have the same function, form, operating mechanism, and fit as the original item (or equipment). In contrast, the surrogate item carries out the same function as the original, in addition to fitting in the same place as the original, but it does not necessarily appear to be the same as the original or use the same operating mechanism as the original.

In the case of a clone, the reverse engineering function is clearly far more extensive than in the case of the surrogate. Further, the high degree of complexity and sophistication of modern products has made the task of producing clones more difficult.

Reverse engineering activity requires consideration to the following :

Product Specifications

Most products require two types of specification – functional and dimensional. The functional specifications describe the working of the product (or system) as well as its associated sub-systems and their interactions. The dimensional specifications indicate the part dimensions, material used in the manufacture of the part, parameter values and their tolerances, and the description of the assembly of those parts during manufacturing. The reverse engineering activity is generally carried out in the following steps :

(a) Developing the functional specifications so as to fully understand the operating mechanisms, including an action requiring hardware decomposition into some sub-assemblies.

(b) Dis-assemble the sub-assemblies to isolate all the parts and then measure each part to establish the dimensions.

Design Factors

It is an accepted fact that the reverse engineering is more cumbersome than developing an original design. This is because of the inability, in general, to understand the mind of the designer when the design was developed; determining the crucial parameters affecting the product's performance; determining the treatments applied to the materials; and determining the elements critical to the item operation but are not necessary for the operation of the specific assembly.

Indirect Influences

The effectiveness of reverse engineering exercise can be greatly improved if a careful consideration is given to indirect influences prior to actually undertaking the exercise. These indirect influences include manufacturing philosophy, potential product users, maintenance requirement, logistic support philosophy, etc.

Original Product Specimen

It is necessary to have least one sample of the original product to be cloned. This facilitates taking various decisions during the reverse engineering exercise.

Availability of Expertise

The reverse engineering often needs input from several technical experts. It is essential that their expertise is available when reverse engineering excise is undertaken. The core group of reverse engineering team has engineers, estimators, shop personnel and technicians as its members. Services of specialists in areas like vibration analysis, metallurgy, electronic circuit design may be called during the reverse engineering exercise.

For good return, reverse engineering should be applied to only those products which exhibit symptoms like excessive cost, high failure rate and high usage, and lack of supply. Additional factors that require considerations are patent right, and technical data adequacy and availability.

It is very important to understand the difference between traditional and reverse engineering design process. While traditional design process has stages like : need identification, design idea, prototype and test, and product, the reverse engineering design process has the following stages :

(e) Product

(f) Disassembly

(g) Measure and test

(h) Design recovery

(i) Prototype and test

(j) Reverse engineered product.

Reengineering

Reengineering is concerned with the examination and alteration of an item or a system under consideration to reconstitute it in a new form so that it is advantageous to use the item/system in that new form. The main objective of any reengineering project generally is to produce a better product (or a function) for the same cost, or a lower cost product (or a function) of a quality comparable to that of the existing product (or function). Another interpretation of reengineering is that it is some kind of reworking or retrofit of an existing product, which could simply be some sort of refurbishment. In that sense, reengineering can be viewed as improvement of an existing product with respect to reliability, safety or ergonomics. Thus, reengineering of a product involves the examination, study, and modification of its internal mechanism or functionality for the purpose of reconstituting it in a modern form with modern desirable features (say, to benefit from newly emerged technologies), but without making a major change to the product purpose or its inherent functionality.

Some synonyms for product reengineering are : modernisation, retrofit, renewal, redevelopment, and so on.

Value Analysis/Value Engineering

The purpose of value analysis/value engineering (VA/VE) is to simplify products and processes. Its objective is to achieve equivalent or better performance at a lower cost while maintaining all functional requirements defined by the customer. VA/VE does this by identifying and eliminating unnecessary cost. Technically, VA deals with products already in production documents and purchase requests. Performed before the production stage, value engineering is considered a cost avoidance method. The VA/VE analysis approach involves brain storming such questions as :

(a) Does the item have any design features that are not necessary?

(b) Can two or more parts be combined into one?

(c) How can we cut down weight?

(d) Are there non-standard parts that can be eliminated?

Business Process Redesign (BPR)

A systematic, disciplined improvement approach that critically examines, rethinks, redesigns and implements the redesigned processes of an organisation. BPR's goal is to achieve dramatic improvements in performance in areas important to customers and other stakeholders. BPR is also referred to by such terms as business process improvement (BPI) or business process development, and business process redesign. While the term can be applied to incremental process improvement efforts, it is more commonly and increasingly associated with dramatic or radical overhauls of existing business processes. BPR typically relies on information technology to achieve breakthrough results.

What is Business Process Redesign?

Business process redesign is the "the analysis and design of workflows and processes within and between organizations" (Davenport and Short, 1990). Teng, *et. al.* (1994) define BPR as *the critical analysis and radical redesign of existing business processes to achieve breakthrough improvements in performance measures.*

How Does BPR Differ from TQM?

Teng, *et. al.* (1994) note that in recent years, increased attention to business processes is largely due to the TQM (Total Quality Movement). They conclude that TQM and PBR share a cross-functional orientation. Davenport observed that quality specialists tend to focus in incremental change and gradual improvement of processes, while proponents of re-engineering often seek radical redesign and drastic improvement of processes.

SAQ 7

(a) What do you understand by concurrent engineering, how can it help in product design development?

(b) How can we use the conc ept of reverse engineering in product design and development?

(c) What is product re-engineering?

10.9 SUMMARY

In this unit you have studied fundamentals underlying the design of profitable and marketable commodity. The product-design function involves the development of specifications of a product that should be functionally sound, have eye appeal, and should give satisfactory performance for sufficiently long life. A successful product design engineer must be versatile, creative, and well informed person. Product design influences the product cost. Customer satisfaction, adequate profit, desired degree of reliability, accuracy, pleasant appearance, reasonable price, etc. are some of the requirements of a good product design. A product can fail in the market due to presence of errors in its designing, therefore a company must evaluate product design before launching the product in the market. Concurrent engineering is an approach that brings many people together in the early phase of product design in order to simultaneously design the product and the process. Reverse engineering is a way of using competitors' idea by disassembling and analyzing design features of competitors' product.

10.10 KEY WORDS

Concurrent Design : A new approach to design that involves the simultaneous design of product and processes by design teams.

Computer Aided Design (CAD) : A software system that uses computer graphics to assist in the creation, modification, and analysis of a design.

Computer Aided Engineering (CAE) : Engineering analysis performed at a computer terminal with information from a CAD database. It includes finite element analysis and kinematics.

Design for Assembly (DFA) : A set of procedures for reducing the number of parts in an assembly, evaluating methods of assembly, and determining an assembly sequence.

Maintainability : The ease with a product is maintained or repaired.

Modular Design : Combining standardised building blocks or modules in a variety of ways to create finished products.

Reliability : The probability that a given part or product will perform its intended function for a specified period of time under normal conditions of use.

10.11 ANSWERS TO SAQs

Please refer the preceding text for all the Answers to SAQs.