Unit – 5

Process Planning

When the design engineers have designed the product, the assembly drawings and working drawings of individual components are made. Now the process planners have to see how the product can best be made to meet the drawing specifications.

Process Planning:

Process planning can also be defined as the systematic determination of the methods by which a product is to be manufactured economically and competitively. It consists of devising, selecting and specifying processes, machine tools and other equipment to convert raw material into finished and assembled products.

Purpose of process planning:

The purpose of process planning is to determine and describe the best process for each job so that:

1. Specific requirements are established for which machines, tools, and other equipment can be designed or purchased.
2. The effort of all engaged in manufacturing are coordinated.
3. A guide is furnished to show the best way to use the existing or proposed facilities.

Process planning is intermediate stage between design and manufacturing as shown in fig.1.

Procedure of process planning:

To achieve the aim of economic manufacture of the product, process planning is done as follows:

1. The finished product is broken into sub-assemblies and individual components from manufacturing point of view.
2. Prepare a bill of materials for all components of the product which forms a basis for purchase of raw materials.
3. Decide which parts are to be manufactured in the plant and which parts are to be purchased from the market depending upon the facilities available in the plant.

4. Choose the appropriate blank size and select the most economical process to be followed to manufacture components of the product. This is done by comparing the various possible methods of obtaining the final product.

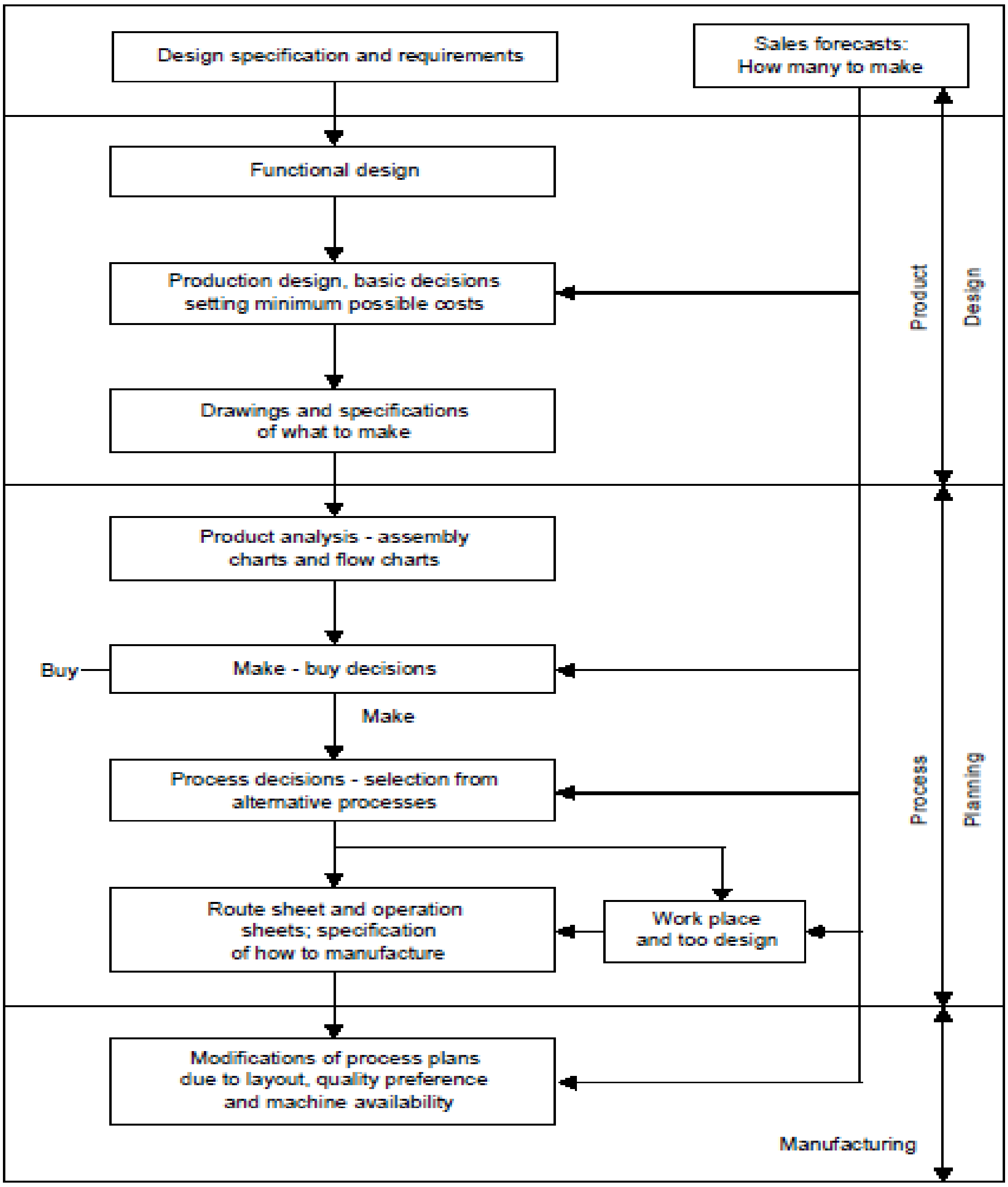


Fig 1: Concept of process planning

5. Decide the sequence of operations to be performed on each component in the process sheet.
6. Depending upon the accuracies called for by the drawings, determine the machine tools to do the operations.

7. Determine the need for any special equipment like jigs, fixtures, tools etc.
8. Determine the inspection stages and the instruments required and the need for designing any inspection devices.
9. Estimate the standard time for performing the job.
10. Determine the type of labour (skilled, semi-skilled or unskilled) required to do the job.

Process Sheet:

The whole information determined by the process planning is recorded in a tabular form in a sheet called process planning sheet. The character of this sheet will vary for different organization depending upon the production conditions and degree of details required. However, in general the following data is listed for each component the product:

1. Quantity of work to be done along with product specifications.
2. Quality of work to be completed.
3. Availability of equipment, tools and personnel.
4. Sequence in which operations will be performed on the raw material.
5. Names of equipments on which the operations will be performed.
6. Standard time for each operation.
7. When the operations will be performed?
8. Cutting speed
9. Feed
10. Material specification.
11. Job rating of labours.

Part description .... Part No. ....
Drawing number .... Assembly No. ....
Material specification .... Material size .... Lot size ....
Quantity required per unit .... Issued by ....
(Inclusive of scrap)

Operation No.	Description	Dept.	Machine	Tool std. or spl.	Jig / fixture gauges	Time analysis				Remarks
						Machining time	Handling time	Set-up time	Cycle time	

Computer Aided Process Planning

Computer Aided Process Planning (CAPP) has been investigated for more than 20 years; it can be categorized in two major areas; variant planning, where library retrieval procedures are applied to find standard plans for similar components, and generative process planning, where plans are generated automatically for new components without reference to existing plans. The latter system is most desirable but also the most difficult way of performing CAPP.

The process planning function bridges the gap between engineering design and manufacturing and is thus a critical element in integrating activities within manufacturing organizations. Current CAPP systems range from simple editors for manual planning to fully-automated systems for planning a range of products. Some of the specific benefits of CAPP are:

1. Improved productivity

More efficient use of machines, tooling, material and labour. “Best practice” (in the form of optimized process plans) is documented for consistent application throughout the organization rather than captured mentally by the process planner.

2. Lower production cost

Cost reduction are realized through productive improvements. Also, the skill level required to produce process plans is less than that required for manual methods.

3. Consistency

Computerized methodologies assure consistent application of planning criteria. Also the number of errors generated during process planning is reduced.

4. Time savings

Time savings can range from days to minutes. Lead times are reduced and flexibility is increased due to the ability to react quickly to new or changing requirements. The amount of paper work and clerical effort involved with design changes is also reduced.

Selection of manufacturing process:

Manufacturing processes are the steps through which raw materials are transformed into a product. The manufacturing processes can be broadly classified into three categories viz. *shaping*, *joining* and *finishing processes* as shown schematically in *Fig.2*. The selection of a particular process from a wide range of choices for a given application requires a hierarchical classification of the processes. For example, *Fig.3* depicts how the shaping family can be expanded in different classes such as casting, deformation, moulding, composite and powder processing, and prototyping. Next, *moulding* as a class can be enlarged into a number of member processes such as *compression*, *rotational*, *transfer*, *injection moulding*, etc. Lastly, each *member process* can be identified with a number of *attributes*, which would facilitate the selection of a *member process* for a given material, dimension, level of requisite tolerances and so on. Similarly, *Fig.4* depicts how the joining and machining family can be expanded in different classes and actual processes.

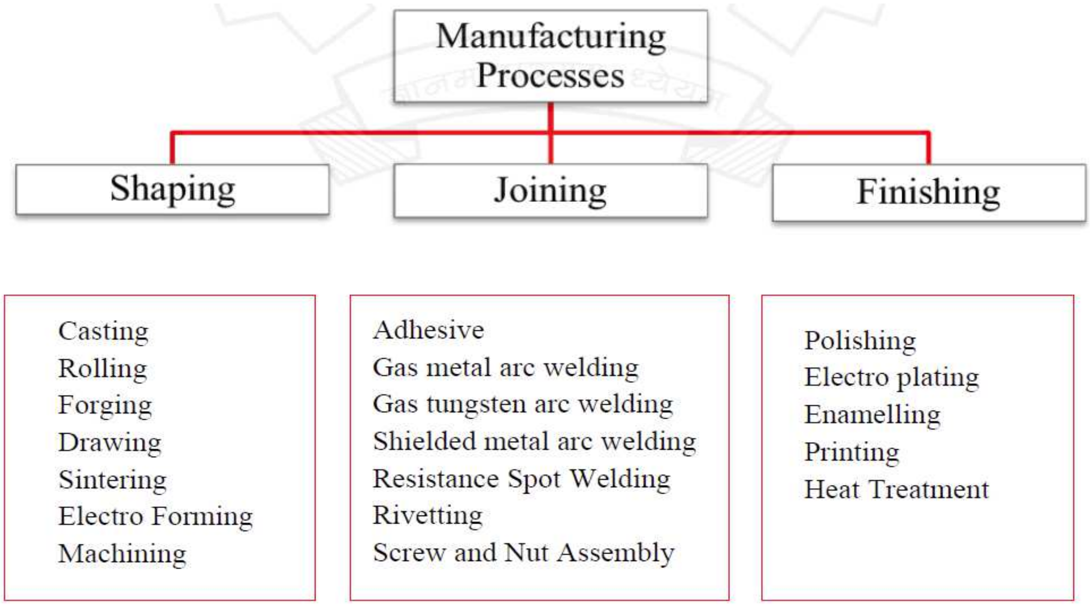


Fig.2: Different classes of manufacturing processes

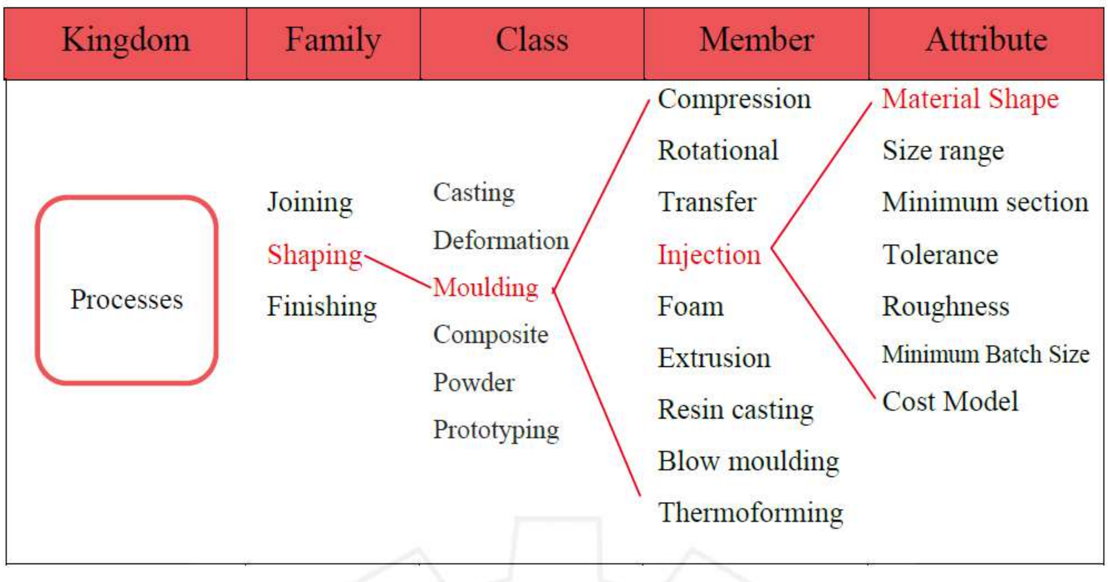


Fig.3: Taxonomy of process with part of the shaping family

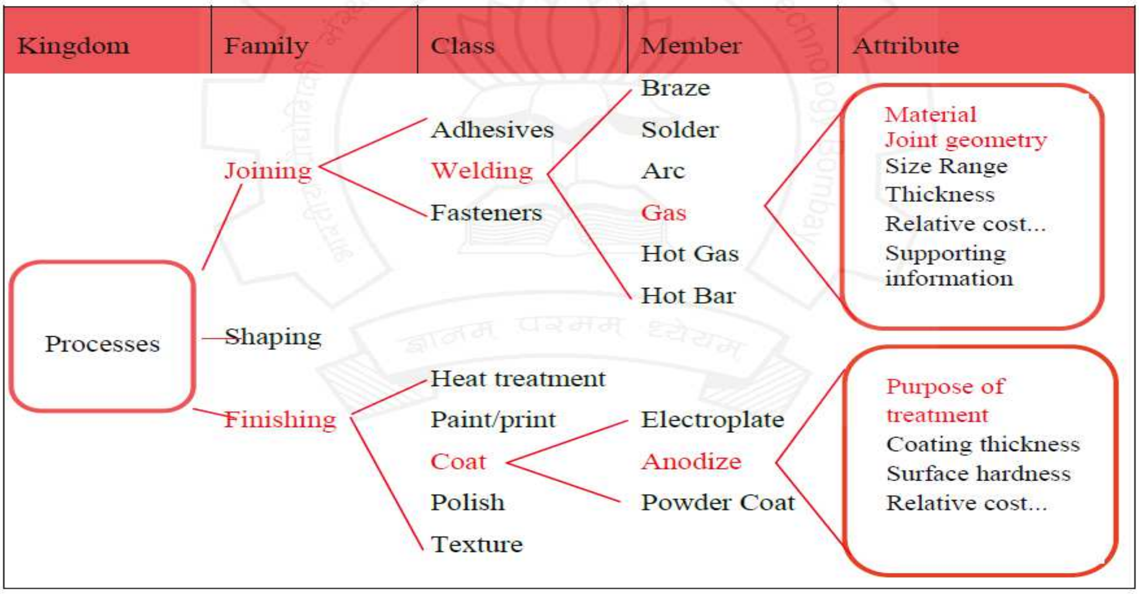


Fig.4: Taxonomy of processes with part of the joining and finishing family

Shaping Processes

The shaping processes are referred to those that use a certain raw material and shape it to a final part. Casting, moulding, powder material processing, primary and secondary material forming, machining are typical example of shaping processes.

Casting Processes

Most of the manufactured parts start its journey with casting process. In a typical casting process, metal is first heated in a furnace until it melts and then the molten metal is poured into a mold so that the liquid metal takes the shape of the mold cavity, which is the final shape of the part. Once the liquid metal in the mold cavity solidifies, the mold is broken or opened to take the final part out of the mold cavity.

Machining

Machining is a form of subtractive manufacturing in which a sharp cutting tool is used to physically remove material to achieve a desired geometry. Most of the engineering components such as gears, bolts, screws, nuts need dimensional and form accuracy for serving their purpose, which cannot be obtained through casting or deformation process like forging, rolling, etc. A wide variety of machining processes are available today that can broadly be classified in three main categories – conventional machining processes that are used for all kinds of bulk material removal operations, grinding processes that are primarily employed to obtain a desired surface finish, non-conventional or advanced machining processes that are used for special kind of material removal operations. As per the name suggests, non-conventional machining processes do not follow the principle of relative hardness as conventional machining, where the tool material must be harder than the work material for proper removal of material. The processes that remove material by melting, evaporation, chemical and / or electrochemical action etc. are generally referred to as non-conventional machining processes. Electrodischarge machining, electrochemical machining, laser and electron beam machining are some of the common examples of non-conventional machining processes.

Estimation of costs of manufacture:

All final decisions are usually based on cost. No matter how perfect the final design may be, no matter how much eye appeal it has, it will not sell unless the price is in line with competitive products. The relation between product design and price is obvious, yet this connection is too often overlooked by the functional designer. The better a product's features and design, the higher the price it will command. Conversely, a product that suffers in comparison with its competitors must be sold at a lower price, if at all.

Since cost influences many decisions of all those associated with designing for production, it is quite important that the engineer have not only an appreciation for, but an understanding of, cost. Two kinds of costs are of vital interest to the engineer: **development costs and the cost of the product**.

Development costs include cost of sales' analysis, research and engineering (such as engineering and draftsmen time), models, and tests. They include cost of tools, equipment, plant rearrangement, and obsolete stock; cost of training sales and service personnel; and promotional expenses such as advertising and instruction and service manuals.

The cost of the product is composed of the cost of each component of the product. Knowing these costs enables the engineer to choose between materials and processes so as to obtain the lowest product cost.

PRODUCT COST

"What does it cost?" is the eternal question asked the production design engineer by a supervisor or manager. There are many other important factors to be considered, such as capacity, appearance, and ease of repair, but cost enters the picture sooner or later in choosing materials, processes, and functions of design, and in negotiating sales contract with the customer. The structure of product cost is as shown below.

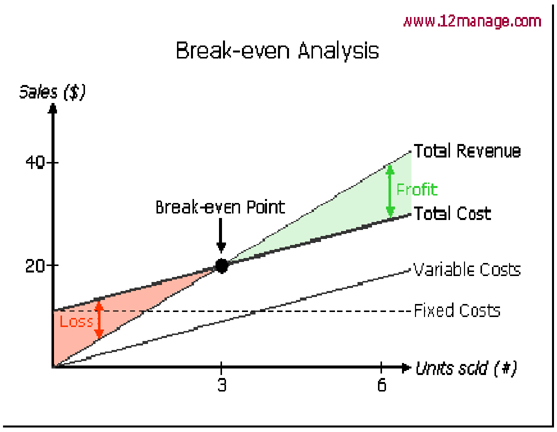
<table>
<tr><td></td><td></td><td></td><td></td><td>Profit</td><td rowspan="6">Selling Price</td></tr>
<tr><td></td><td></td><td></td><td>Sales Expenses</td><td rowspan="5">Total Cost</td></tr>
<tr><td></td><td></td><td>General Expenses</td><td rowspan="4">Manufacturing Cost</td></tr>
<tr><td></td><td>Factory Expenses</td><td rowspan="3">Factory Cost</td></tr>
<tr><td>Direct Material</td><td rowspan="2">Prime Cost</td></tr>
<tr><td>Direct Labour</td></tr>
</table>

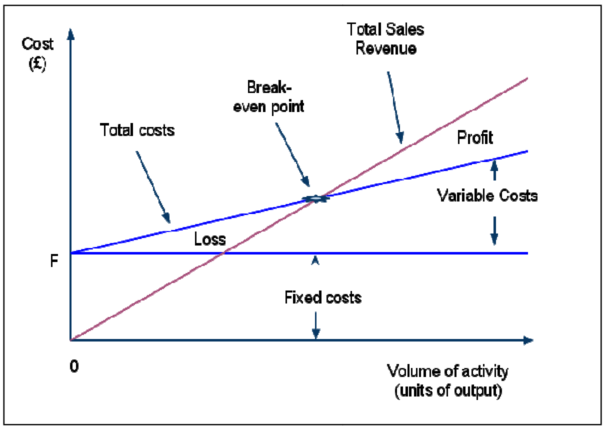
Item of cost entering into the development of selling price:

First cost or prime cost is usually thought of as including the cost of direct material and direct labor. When factory expense is added to prime cost, the factory cost is obtained. Manufacturing cost is made up of factory cost plus general expenses. Total cost of the product is then determined by adding selling expenses to manufacturing cost. After the total cost is determined, a reasonable profit is added in order to determine the selling price.

However, price is not always determined by cost; it is frequently determined by what buyer is able and willing to pay. It is influenced considerably by the lowest competitive price, and is determined at the point of sale, not in the factory. If profit is les than cost, the company must take steps to reduce the cost or cease manufacturing. Often a company does not know its costs and is unknowingly losing money for itself and competitors. Recently trade associations have educated small companies in cost procedures and thus maintained the market price above actual costs.

An understanding of the basis of costs will enable the production – design engineer to use good judgment in the section of materials, processes, and functions to create the best product. An increase in perfection from 90 to 99 percent may result in a 50% increase in development and product cost and destroy the sales value of the product. Cost, quality, and degree of perfection should be carefully considered in order to obtain the greatest profit over a period of time. Cost is still the deciding factor. The relationship between cost, sales, profit or loss and volume is best revealed on what is known as break – even chart.





KINDS OF COST PROCEDURES

The two most common forms of cost procedures are actual or recorded costs and standard or predetermined costs. Neither actual nor standard costs are true costs, as both are based on assumptions as to yearly volume of business, taxes, heat, light, rent, and many other expenses that are prorated to each unit.

ACTUAL COST

Under the actual cost system, the actual costs of material and direct labor are charged directly to the order. The factory overhead may be prorated entirely on the basis of labor costs or may be applied on both material and labor. The common method is apply overhead only on labor costs. In some cases actual labor rate of the person working on the job charged directly to order; however, the average rate is usually used. The material cost plus the direct labor cost plus the factory overhead cost equals the factory cost. The factory cost plus administrative and sales expense equals the total cost. The difference between the price and total cost is the profit and loss.

Therefore, there is no such thing as an actual cost. It is true that the actual material and possibly the actual labor are charged to the job. It could be possible to have a manufacturing unit making one product for a period of one year. Thus, a true cost could be determined.

STANDARD COSTS

Standard costs are estimated using sound assumptions as to material, labor, and overhead expenses. Each one of these items is under budget control, and variances from the standards are reported to management periodically. Thus management knows the current status of costs and can take action before jobs are completed or before damage is done.

STANDARD MATERIAL COSTS

Standard material costs are based on actual costs, which include selling price plus cost of transportation. The cost analyst looks over the history of the part and, with the aid of production and purchasing departments, sets a standard price for the material.

STANDARD LABOR COSTS

Standard labor costs are based upon the average labor rate of the operators for a machine, work station, group, or department. By means of job descriptions and classifications the average rate for each operator in group or department can be determined. If the costing rates are based on a group including several grades of jobs ranging from an hour, the normal composition of the group is recorded and the average rate is calculated. The same procedure applies to a department.

JOB COST SYSTEM

It is important that the production – design engineer have an understanding of the flow of cost data in a typical job cost system. With this understanding he is in much better position to talk with the accountants in relation to cost analysis of a given product design. In any job cost system, debit and credit are names given to left side and right side entries in the general ledger. For every left side entry, there must be an equal and offsetting right side entry.

Assets reflect debit balances and include such items as cash, receivable, and inventories. Liabilities are shown by credit balances and include payables as well as accrued items. Net worth is shown as credit balance on common stock, preferred stock, and surplus. The relationship between assets, liabilities, and net worth is

Assets = liabilities + net worth

The principal accounts maintained in a job cost system include: raw material, direct labor, factory burden control, factory burden absorbed, work in process, finished goods inventory, cost of goods sold, cash, accounts receivable, sales, and profit and loss. The flow of entries in these accounts is illustrated in fig 3.4

COST REDUCTION ACTIVITIES

Since costs are so vital to decisions made in designing for production, the people in engineering and manufacturing should understand the accounting system. Moreover, a definite plan for recording any savings, both actual and estimated should be made to serve as an incentive to further efforts in designing for lower cost. A low costing rate may not indicate an efficient shop. When making cost reductions, the management should study the efficiency of the overhead departments and obtain overall reductions in cost. The engineer should be aware of these conditions and assist in obtaining a true picture of the product cost.

DISTINCTION BETWEEN COST REDUCTION & COST CONTROL

Cost reduction is accomplished by changes in tools, processes, and design that eliminate operations, reduce the cost of the material, and use less expensive machines and fewer skilled operators. The costs of changes are justified by the decrease or difference in cost per unit. The saving per unit must pay for the change in a reasonable time. A separate record of such savings and expenditures for making the improvements must be kept for management's information.

Cost control has no connection with cost reduction. Cost – control procedures inform management that expenses are or are not according to plan. Rising or lowering costs of labor and material are reflected in variance accounts. Although these factors are often out of control of management and supervisor, it is their obligation to combat rising costs by training more efficient operators and obtaining less expensive materials. Lower costs permit reduction of selling prices and eventual broadening of the market.

Many expenses under the control of supervision can be reduced. The engineer, through his knowledge of these expenses, can save indirect costs. For example, he may know that one part is used on several active assemblies and could be stocked. By suggesting that the part be stocked, he saves the cost of setup. If he understands the operations used to make the part, he can usually suggest to the methods engineering department a better process of manufacture which is more economical in view of the increased number of parts on the order.

ESTIMATION OF COST OF CASTINGS

The total cost of manufacturing a component consists of following elements :

1. Material cost.
2. Labour cost.
3. Direct other expenses.
4. Overhead expenses.

1. Material Cost

(*a*) Cost of material required for casting is calculated as follows :

(*i*) From the component drawing, calculate the volume of material required for casting. This volume multiplied by density of material gives the net weight of the casting.

(*ii*) Add the weight of process scrap *i.e.* weight of runners, gates and risers and other material consumed as a part of process in getting the casting.

(*iii*) Add the allowance for metal loss in oxidation in furnace, in cutting the gates and runners and over runs etc.

(*iv*) Multiply the total weight by cost per unit weight of the material used.

(*v*) Subtract the value of scarp return from the amount obtained in step (*iv*), to get the direct material cost.

Note : The casting drawing is made by adding various allowances like-shrinkage, draft and machining allowance, etc., to the dimensions of finished component.

(*b*) In addition to the direct material, various other materials are used in the process of manufacture of a casting. Some of the materials are :

(*i*) Materials required in melting the metal, *i.e.*, coal, limestone and other fluxes etc. The cost of these materials is calculated by tabulating the value of material used on per tonne basis and then apportioned on each item.

(*ii*) Material used in core shop for making the cores, *i.e.*, oils, binders and refractories etc. The cost of core materials is calculated depending upon the core size and method of making the core. Similarly the cost of moulding sand ingredients is also calculated.

The expenditure made on these materials is generally expressed as per kg of casting weight and is covered under overhead costs.

2. Labour Cost

Labour is involved at various stages in a foundry shop. Broadly it is divided into two categories:

(*i*) The cost of labour involved in making the cores, baking of cores and moulds is based on the time taken for making various moulds and cores.

(*ii*) The cost of labour involved in firing the furnace, melting and pouring of the metal. Cleaning of castings, fettling, painting of castings etc., is generally calculated on the basis of per kg of cast weight.

3. Direct Other Expenses

Direct expenses include the expenditure incurred on patterns, core boxes, cost of using machines and other items which can be directly identified with a particular product. The cost of patterns, core boxes etc., is distributed on per item basis.

4. Overhead Expenses

The overheads consist of the salary and wages of supervisory staff, pattern shop staff and inspection staff, administrative expenses, water and electricity charges etc. The overheads are generally expressed as percentage of labour charges. The cost of a cast component is calculated by adding the above constituents.

Calculation of Machining Times:

The basic relationship for determining the machining time for any machining operation is that the cutting time in minutes is equal to the distance the tool is fed, in mm, divided by the feed in mm per minute, i.e.,

$T_m = L / F$, per cut or per pass,

T_m = Cutting time in minutes, L = total travel in mm, F = feed of tool in mm per minute.

The distance a tool is fed to make a cut (L) is the sum of the distance the tool travels while cutting the material plus its approach distance plus its over travel.

The approach is the distance a tool is fed from the time it touches the workpiece until it is cutting to the full depth.

Approach distance for drill is the length of its point which is about one-forth the diameter of the standard drill.

The approach of most of the single point tool is negligible.

Overtravel is the distance the tool is fed while it is not cutting. It is the distance over which the tool idles before it enters and after it leaves the cut. This distance is calculated for face milling and slotting, but in other cases like drilling or turning it is taken as 0.8 to 0.6 mm.

Machining time for lathe:

Total tool travel = length of job + approach + two overtravels

$F = f * N$

N = r.p.m. of work or cutter

$N = 1000V / (\pi D)$, where V = cutting speed in meters per minute of the work or cutter, D = dia in mm of work or cutter. Therefore

$T_m = L / (fN)$

Machining time for facing:

$N = 1000V / (\pi D_{ave})$, where D_{ave} = average diameter

$T_m = L / (fN)$

Machining time for drilling:

$N = 1000V / (\pi D)$, where D = diameter of drill hole

$T_m = L / (fN)$,

($L = A + t + A = 2A + t$), where L = length of drill travel, t = depth of hole, A = 0.29D

Value engineering in product design:

Value engineering defined value analysis as: an organized creative approach, which has for its purpose the efficient identification of unnecessary cost, i.e. cost which provides neither quality nor use, life, appearance or customer features. (or) in other words

Value engineering (**VE**) is a systematic method to improve the "value" of goods or products and services by using an examination of function. Value, as defined, is the ratio of function to cost. Value can therefore be increased by either improving the function or reducing the cost. It is a primary tenet of value engineering that basic functions be preserved and not be reduced as a consequence of pursuing value improvements.

The philosophy of VE is implemented through a systematic rational process consisting of a series of techniques, including

(a) Function analysis, to define the reason for the existence of a product or its components,
(b) Creative and speculative techniques, for generating new alternatives, and
(c) Measurement techniques, for evaluating the value of present and future concepts.

Nature and measurement of value:

Value can be perceived as the ratio of sum of the positives and negative aspects of an object.

$\text{Value} = \sum(+) / \sum(-)$

Value engineering idea generation check-list:

Figure 5, shows a three dimensional matrix involves all possible combinations of five materials, seven designs and five manufacturing methods. The designer should select the best combination from 175 alternatives. Similar matrices can be constructed for various features of a product. Obviously, some combinations in the matrix are completely useless. We only need the best idea among the long list of alternatives.

The following list is representative of the questions the designer may have in mind while finalizing a design:

1. Can a material change improve the product performance?
2. Can lubricants and catalysts improve the performance of the product?
3. Should the appearance of the product be associated with major sports or cartoon figure?
4. Can a colour change make the product more attractive?
5. Shoud fragrant be added to the product?
6. Would a change in surface texture improve the appeal of the product?
7. Can the product be made with a special click sound to demonstrate positive engagement?
8. Where two components join or interact? Can the male and female components be interchanged?
9. Can the handles and buttons be repositioned to improve man-machine interaction?
10. Can the order of operation, direction of cut, or direction of movement be improved?
11. Should the product be made foldable?
12. Can miniaturization lead to low cost production?
13. Can the number of components be reduced to improve strength and decrease assembly?
14. Is the packing and labeling of the product appropriate in terms of cost and function?
15. Are all the components and manufacturing processes standard?

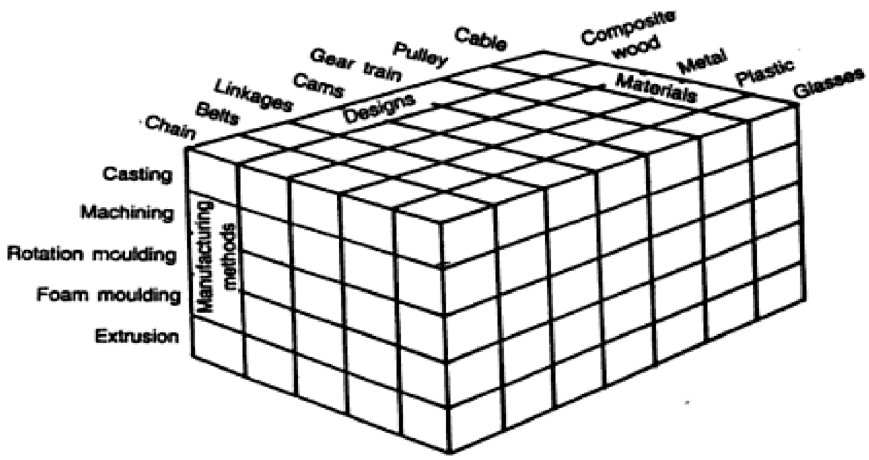


Fig.5: morphological approach for machine element, material and process.

12.14 MATERIAL AND PROCESS SELECTION IN VALUE ENGINEERING*

An engineer must not only understand the problems of engineering economy associated with production runs, but also how design and production interact. In the past, because of the limited number of materials and processes, a product engineer could prepare the majority of designs. Geometric designs were evaluated initially with the materials and processes which were available. This approach is no longer acceptable and the design methods of the past must necessarily be updated. Any product design today, particularly through value engineering, must undertake a rigorous study of the materials and process possibilities.

12.14.1 The Problem

Many companies in India have been oriented to a particular manufacturing process, such as a foundry. With the greater emergency of product-oriented companies, they have the know-how to effectively utilize many different materials and processes to produce a particular product. This is one factor that has contributed to the need for a much more rigorous consideration of materials and processes. We are in the midst of a technological revolution. New processes and materials are being developed at an accelerating rate, and these have opened up whole new possibilities for product design and manufacturing.

Further, manufacturing companies are facing increased competition today, and the importance of materials and process considerations in terms of this competition are quite clear. A product may have excellent functional utility and sales appeal to the customer, but it is useless if it cannot be manufactured at a competitive cost. Since material and process are major contributors to the product cost, it is desirable that these are given considerable attentions before the product is put on the market. Once a product is released for production, there is a natural resistance to major changes in product design in the minds of persons who have been working with the existing design. It must be realized that "Process Selection saves rupees while Process Optimization saves paise". The potential effect of materials and processes on the competitive effect of a product is a very important factor contributing to the need for a rigorous consideration of materials and process in product design.

12.14.2 Design, Material, Process and Supplier Decisions

The manufacturing cost of a product is dependent on the decisions related to the following:

1. Design
2. Materials
3. Process
4. Supplier

There is a close connection between the selection of design, and materials and process (DMP). The major efforts in selecting materials and processes will have to be accomplished during "Concept Formulation". This is where a considerable amount of creativity is required with the main emphasis on generation of good ideas. The ultimate in good ideas is a solution to the design problem which will satisfy all the functional and aesthetic requirements, and costs almost nothing. This will, however, never be achieved, but it is surprising how much difference can be seen in the results of two designers working independently on the same problem.

In many cases, a geometric design will inherently dictate a particular material and process. However, DMP are important integrated aspects of the total product design. They are all mutually dependent. It is, therefore, important that the product alternatives considered be total in terms of their geometric design aspects, material aspects, and processing aspects. These product alternatives may be called DMP alternatives. This, however, does not mean that these three items cannot be considered independently in some phase of the design process. In fact, of 3 designs, 3 materials and 3 processes to be considered independently can lead to 27 possible combinations. If one more material were to be added, the number of alternatives could be increased by 9 rather than 1. Many of the combinations will not be feasible, such as steel combined with pressure die casting. But with the very large number of metals and alloys available, the number of alternatives will still be unmanageable.

12.14.3 Product Parameters

The consideration of materials and processes during product design requires setting up of product parameters in order to establish boundary conditions. This provides a basis for the evaluation of materials and processes. The product parameters spell out the design requirements in terms of those factors which affect the choice of materials and process. These factors generally can be classified as

1. Process Selection Factors:
   (a) Shape requirements
   (b) Size requirements
   (c) Tolerance requirements
   (d) Surface finish requirements
   (e) Annual volume requirements
   (f) Material characteristics (if material is determined)
2. Material Selection Factor
   (a) Material requirements
   (b) Process characteristics (if process is determined)

The product parameters, properly defined, will establish the problem definition at a given design level based on the above factors. No attempt is made to cover cost consideration in the definition of the product parameters as an awareness of potential costs will permeate the entire design effort. A detailed cost analysis will be accomplished only after the DMP alternatives have been generated.

12.14.4 Process Selection

Process selection requires a broad and extensive knowledge of various manufacturing processes. In many instances, value engineers well versed in a few processes have a tendency to use these more often to the exclusion of others.

The need for consideration of alternative processes can well be seen by the changes occurring in manufacturing, forgings are replaced by heavy stampings and castings. Stampings are being replaced by die-casting and plastic moulding. These changes are only representative of what is occurring continuously in today's manufacturing technology.

Process selection is the initial selection of a manufacturing process, which in combination with a geometric design and material, fulfils the design requirements. This, however, has various problems associated with it. A process may require various additional subprocesses to achieve the design requirements, which complicate the problem of process selection. Besides, there is a lack of adequate information on the capabilities and limitations of the various processes available with different Indian manufacturers and vendors, and the costs associated with them. This means that in many situations due to a lack of readily available information, adequate screening and evaluation of processes can be achieved. Since the capabilities of various manufacturing organizations vary according to their know-how and equipment, the evaluation of processes in terms of capabilities and limitation is normally done in relation to a specific manufacturing organization rather than using general information.

12.14.5 Process Selection Parameters

The following factors have a primary influence on the selection of a manufacturing process.

(I) Geometry. The consideration of processes is done in terms of a specific geometric design of a component or product in terms of its shape, size, general tolerance, surface finish, etc. The determination of geometric parameters must take into consideration any secondary processes that may be required.

The geometric shape has a significant effect on the selection of process. B.W. Niebel and Baldwin have suggested the following shape classifications:

(a) Solid concentric

(b) Hollow concentric

(c) Cup or cone concentric

(d) Solid or hollow nonconcentric

(e) Cup or cone nonconcentric

(f) Flat and flanged parts

(g) Spiral, repetitive, irregular concentric

(h) Miscellaneous complex.

Howard G. Lestle has classified various processes in the following four shape classifications:

(a) Solid concentric

(b) Hollow concentric

12.14.6 Material Selection

The selection of a sound, economic material for product design is in itself a difficult problem. The additional consideration of design material and process-material interactions complicates the problem further. In many situations, development work on the creation of new material leads to a solution of a design problem. Therefore, the continuous development of new and better materials must always be anticipated and exploited.

The general problem of material selection is choosing one material from the many available. In the design process, this proceeds from the initial consideration of broad classes of materials to the testing and evaluation of very specific materials. It is essential that the material requirements be specified in terms of product function and end use.

The generation of material alternatives is a major problem as there are thousands of metallic alloys. In addition to these are the large number of nonmetals, which further enlarge the scope of the problem. In the initial stages of design, the broad material groups can be considered, such as ferrous, nonferrous, plastics, and other nonmetals. Only in the later stages of design can the specific materials be considered. The determination of what alternatives are to be considered is done largely intuitively. With proper computer programs, the material selection process can be speeded up to a point where the consideration of large number of materials becomes practical.

In the initial evaluation of material alternatives, many can be rejected on the basis of absolute product parameters, such as strength, conductivity, magnetic permeability, etc. This is fairly straightforward in that either the alternative meets some absolute requirement or it does not. Once the materials which do not meet the requirements have been eliminated, the problem is far more difficult. Though all the remaining alternatives are acceptable, the question is how good they are compared to one another. The decision matrix is used in the final evaluation of specific alternatives. In addition, the materials finally selected is with respect to a particular geometric design and process, taking into account the DMP interactions.

12.14.7 Material Selection Parameters

The primary conditions affecting the choice of a material in terms of various requirements are:

(i) Function. Many of the parameters developed for material selection are related to the functions the product must perform in terms of mechanical, physical, electrical, and thermal, properties of materials. This has to be based on a thorough understanding of the product application.

(ii) Appearance. The material makes a major contribution to the aesthetics of product. Though it is difficult to establish any quantitative parameters for this, this must necessarily be included for material selection.

(iii) Reliability. This is related to the probability that the material will meet all the requirements during the product life, and is closely tied to the other types of material. Reliability is gaining greater importance as a criterion for material selection due to increasing consumer demands for trouble-free products.

(iv) Service life. The length of service life over which the material maintains its desirable characteristics is a very important consideration in material selection.

(v) Environment. The environment to which the material is exposed during the product life is a very important consideration, depending on whether the environment is beneficial or harmful.

(vi) Compatibility. This is an important factor influencing material selection, whenever more than one type of material is used in a product or assembly, consideration of the possibility of galvanic action is essential.

(vii) Producibility. The selection of material in relation to the ease of producibility of an item is an important consideration, in the context of DMP interactions.

(viii) Cost. The material cost is a significant factor contributing to the overall cost. However, it must be remembered that the total product cost is of primary importance. It is conceivable that a DMP alternative having a high material cost could have a very low overall product cost.

12.14.8 Multivariable Chart

Computer programs can be developed for the evaluation of process alternatives in terms of various parameters related to the geometric design and materials. The major problem, however, would be the usefulness of the output data which is limited by the accuracy and applicability of the process capabilities data fed in. Programs could more easily be developed on the basis of published data. However, data developed and used in a manufacturing company would result in a more useful program.

A device often used by Industrial Engineers for combining two-dimensional matrices in one decision chart is known as a *multivariable chart,* first developed by Phill Carroll in his book, *How to Chart Data.*

A multivariable chart for process selection has been developed, for some ferrous materials based on published data in various reference books and surveys carried out in some manufacturing companies in Mumbai (Bombay).

The chart includes the following parameters for selection:

1. Geometric form
2. Surface finish
3. General tolerance
4. Production volume
5. Material

Use of multivariable chart grid. Starting from the column associated with the geometric shape classification based on the component shape, one goes vertically to reach the row associated with the required surface finish. One then goes along the row till the column associated with the required general tolerance is reached. Go down along this column until the row for the required production volume is reached. One then goes along this row until the column for the desired material is reached. The acceptable processes are listed in this column which meet the process selection parameters. From an initial consideration of the many processes, all but a few would have been eliminated because of

Group Technology

Group technology involves grouping components having similar attributes in order to take advantages of their similarities in the design or manufacturing phases of the production cycle. It is implemented through the application of well – structured classification and coding systems and supporting software to take advantage of the similarities of components, in terms of design attributes and processing sequence.

Reason for adopting GT:

Growing international competition and fast-changing market demands have put considerable amount of pressure on industries to streamline their production. Such marketing challenges, which are shown in the following list, can be successfully met by group technology:

1. Today, there is a trend in the industry towards low-volume production of a wider variety of products in order to meet the rising demand for specially ordered products for the affluent societies. The concept of mass markets of early 20th century has vanished. The share of the batch-type production in industry is growing each day, and it is expected that 75 per cent of all manufactured parts will be in small batch quantities.

2. As a result of the first factor, the conventional shop layout, i.e. process type or functional layout is becoming very inefficient and obsolete because of messy routing paths of the products between the various machine tool departments. Figure 13.16 explains this concept. Modern management concepts like business process and reengineering highlight the need for breaking of barriers between departments of an industry. Group technology and cellular manufacturing streamline material flow and reduce nonvalue adding activities.

3. There is a need to cut short the lead time, thus winning a competitive situation in the international market.

Benefits of GT

(i) Benefits in product design. As far as design of products is concerned, the principal benefit of group technology is that it enables product designers to design a product that was previously designed since a variety of engineering designs are already available for storing in the computer, and it facilitates easy retrieval of these designs. When an order of part is released, the part is first coded, and then the existing designs that match that code are retrieved from the company's library of designs software stored in the computer. This saves considerable amount of time in design work.

(ii) Standardization of tooling. Since parts are grouped into families, a flexible design for jigs or fixtures can be made for each family in such a manner that it can accommodate every member of that family, thus bringing down the cost of fixturing by reducing the number of that family. A machine set-up can be made once for the whole family instead of a machine set-up for each of the individual parts.

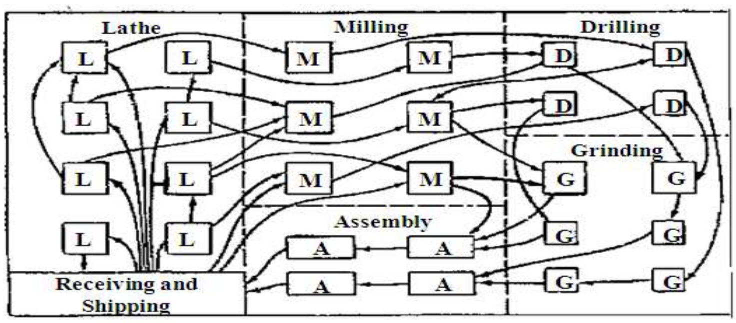
(iii) More efficient material handling. When the plant layout is based on the group technology principles, i.e. dividing the plant into cells, which is termed cellular manufacturing, results in easier material handling. This is in contrast with the "messy" flow lines in the case of the conventional layout. That comparison is clearly illustrated in Fig. 13.16.

(iv) Improving economies of batch type production: usually, batch type production involves a wide variety of nonstandard parts, seemingly with nothing in common. Therefore, grouping parts in families enables achieving of economies that are comparable to mass production.

(v) Easier planning and control: grouping the parts into families facilities the task of scheduling, since this work will be done for each family instead of for each part.

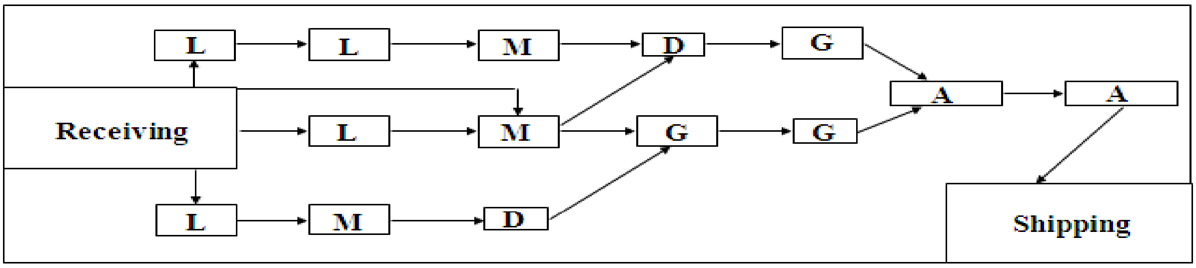
(vi) Reduced work in process and lead time: reduce work in process (WIP) and lead time result directly from reduced set-up and material handling time.

(vii) Faster process planning: group technology paves the way for automated process planning. This can be achieved through proper parts classification and coding system where a detailed process plan for each part is stored under its code and thus can be easily retrieved.



PROCESS-TYPE LAYOUT

GROUP TECHNOLOGY LAYOUT



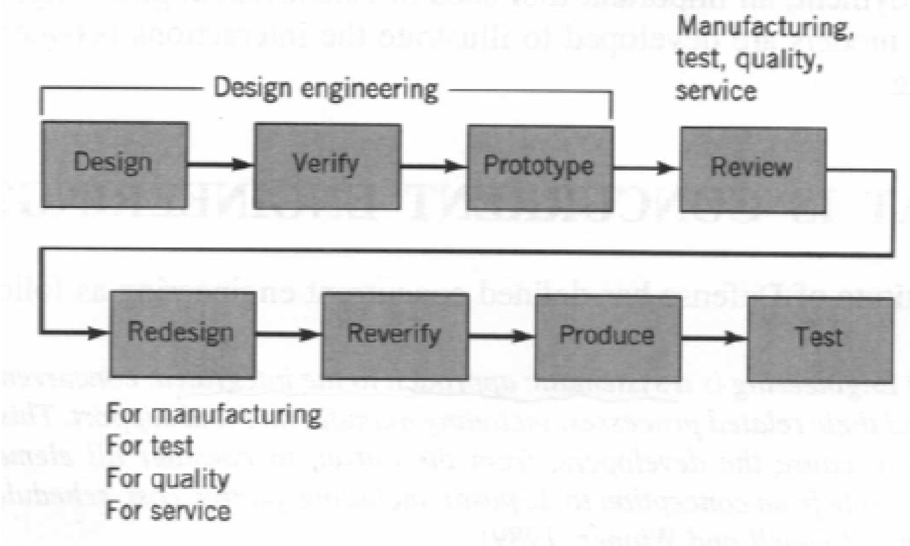
Concurrent Design:

- Market share and profitability are the major determinants of the success of any organization.
- The factors that influence and improve the competitive edge of a company are unit cost of products, quality, and lead time.
- Concurrent engineering (CE) has emerged as discipline to help achieve the objectives of reduced cost, better quality, and improved delivery performance. CE is perceived as a vehicle for change in the way the products and processes are designed, manufactured, and distributed.
- Concurrent engineering is a management and engineering philosophy for improving quality and reducing costs and lead time from product conception to product development for new products and product modifications.
- CE means that the design and development of the product, the associated manufacturing equipment and processes, and the repair tools and processes are handled concurrently.
- The concurrent engineering idea contrasts sharply with current industry sequential practices, where the product is first designed and developed, the manufacturing approach is then established.
- And finally the approach to repair is determined.

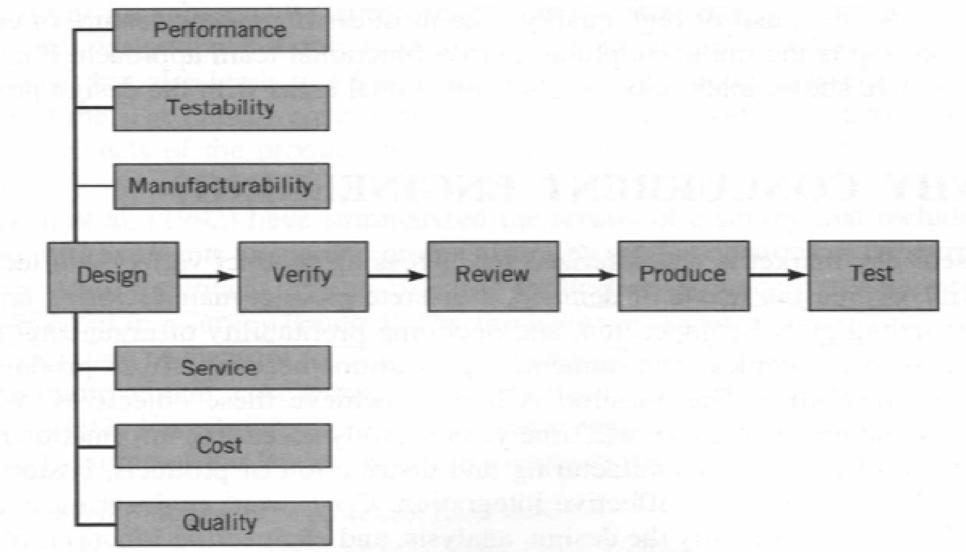
What is concurrent engineering?

Concurrent engineering is a systematic approach to the integrated, concurrent design of products and their related processes, including manufacture and support. This approach is intended to cause the developers from the outset, to consider all elements of the product life cycle from conception to disposal, including quality, cost, schedule, and user requirements.

Serial or Sequential Engineering



Concurrent Engineering



Why concurrent engineering?

- Increasing product variety and technical complexity that prolong the product development process and make it more difficult to predict the impact of design decisions on the functionality and performance of the final product.
- Increasing global competitive pressure that results from the emerging concept of reengineering.

- The need for rapid response to fast-changing consumer demand.
- The need for shorter product life cycle.
- Large organizations with several departments working on developing numerous products at the same time.
- New and innovative technologies emerging at a very high rate, thus causing the new product to be technological obsolete within a short period.

Schemes for CE

- CE is the application of a mixture of all following techniques to evaluate the total life-cycle cost and quality.
- Axiomatic design
- Design for manufacturing guidelines
- Design science
- Design for assembly
- The Taguchi method for robust design
- Manufacturing process design rules
- Computer-aided DFM
- Group technology
- Failure-mode and effects analysis
- Value engineering
- Quality function deployment

REFERENCES

1. Niebel BW & Draper AB: *Production Design & Process Engg,* McGraw Hill, Kogakusha, 1974.
2. Harry Nystrom, *Creativity and Innovation,* John Wiley & Sons,
3. Brain Twiss, *Managing Technological Innovation,* Pittrnan Publications, 1992.
4. Harry, B.Waton, *New Product Planning,* Prentice Hall Inc., 1992.
5. Chitale, A. K. & Gupta RC., *Product Design & Manufacturing,* PHI, 1997.
6. Product Design and Development, Karl Ulrich, Tata McGraw Hill
7. P. Narayana, Intellectual Property Law, Eastern Law Edn. 1997

8. G Dieter, Engineering Design - a materials and processing approach, McGraw Hill, NY, 2000.
9. And some internet websites related to the topics used in the subject / syllabus.