5. Setting the Final specification

As the team finalised the choice of a concept and prepares for subsequent design and development, the specifications are revisited. Specifications which originally were only targets expressed as broad range of values are now refined and made more precise.

Value Analysis

Value of a product is the performance and capability of that product relative to its cost.

$$\text{value} = \frac{\text{function}}{\text{cost}} = \frac{(\text{performance} + \text{capability})}{\text{cost}}$$

The concept of increasing value of a product is not only to minimise the cost but also to increase function and performance.

Role of Computer in Product Design

Product design is neither the pure imagination of the product by the designer nor the direct implementation of any idea or concept basing upon the customer's requirement. During product design several steps are associated to get a feasible design as output. Before implementation of computer in design process. The process was very critical and costly. At the same time design freedom, modification or changing was time taking and also a financial risk.

After getting the concept, the designer was preparing 3-dimensional view in a drawing sheet. Then detail drawings were prepared by Drafts man. During preparation of detail drawing drafts man was implementing his experience and thought process so that manufacturer will get a clear picture.

For some intricate profile designer had to prepare a real time model in wax or wood. After preparing a prototype model designer had to demonstrate the model. Sometime designer had to prepare 5 to 10 prototype model for different type destructive testing. Some time designer could not ensure the product quality due to limitation of real time analysis.

Before introduction of computer in design process designing was treated as ownership of skills. Design process was a lot of paper work job and designer has to be involved in testing process. If any small modification was needed due to reports of testing that modification was taking a lot of time.

Archive facilities of design and accessing old design from Archive was also a painful and time taking job.

Computer was introduced in design near about 1990 in India after introduction of free economy and globalization.

Designer is able to implement his on her imagination into design without help of anybody and with in very short span of time having the scope of modification due to introduction of CAD packages.

By the help of different analysis tool computer like Finite Element Analysis and other software packages like CATIA, PRO ENGINEERS etc. without developing any prototype model designer is able to know the limitations of his design from Engineering point of view.

Designer is not required to demonstrate the drawing as different options of computer aided design like rotation, zooming, solid model, wire frame model clarifies the objectives and dimensions of drawing to production people.

After all computer can save the design data and detail design, so concept of design Archive and accessing of design Archive has been eliminated. Same time thousands of design can be kept in a pen-drive or in a small memory electronics chips and also accessing of that is the matter of some minutes.

So it can be clarified that after introduction of computer in design both design cost, design development time and other related work has been drastically reduced but still conceptualisation of design is only practicable by designer's main storming not by clicking of mouse.

PROCESS PLANNING

7.1 INTRODUCTION

The planning is a function, that comprised of many activities to complete the manufacturing of a "product". The first and important function being "Administrative planning" which sets the manufacturing in motion. It co-ordinates and controll all the activities of a enterprise as a whole. The management creates an organisation consisting of different departments to carry out the policies or plans. The product planning is the first phase of a planning carried out after a lot of market survey and forecast. Product planning determines the final shape of the product after considering several design and manufacturing aspects. It prepares the assembly drawings and working drawings with complete specification of the components or product. Now here ofter "Process Planning' is done for the components/products to spell out the different operations to be carried out in "process sheets" before the actual manufacturing. So "*Process planning can be defined as a planning of the sequence of operations to be carried out at different stages with complete specifications as per the Drawing given for a given* product/components".

7.2 AIM OF PROCESS PLANNING

A process planning is a fundamental element of an industrial activity. An efficient and economical planning leads to success where as a faulty planning creats problems and bottleneckness at each stage of manufacturing activity. The *Process planning aims at deriving methods or series of methods for the manufacturing of a products with utmost quality as per specification in the drawing provided and in a very economical method.*

Process planning is a dynamic process with continueation, even after rolling out of the product. The effort remains to find out alternative production processes/technology and materials so as to reduce the cost of tooling labour and material.

The process planning, to achieve the aim proceeds as following

(1) It studies the total drawings of a product/Components thoroughly.

(2) It determines what parts to be manufactured and what parts to be purchased.

(3) It determines the sequence of operations to be followed for individual components in a particular process.

(4) It determines the blank size of the raw materials for the processes (i.e. forging, Milling, Turning etc)

(5) It prepares a material list of raw materials to be purchased for the components.

(6) It lays down specification of the machine tools which can perform the operation with required accuracy.

(7) It determines the need of any special toolings required for production of components.

(8) It determines the stages of inspection and design of inspection devices and gauges for various stages if required.

(9) It determines the time standards for performing of operations on the job and also fixes the rate of payments.

(10) It determines the kind of labour or skill required to do the job.

(11) It also estimates the approximate cost of the product even before the manufacturing of the product.

7.3 Functions of a Process Planning

Process planning provides vital information for the further actions. The process planning is used to further planning of following activities.

(1) **Estimation :**

To prepare cost estimation of a product for commercial purposes such as tenders quotations etc or even before production has started for a product to prepare project reports the information of process planning is used.

(2) **Layout Planning :**

To layout and design a complete manufacturing plan or change existing layout for a new product the information in process planing is used.

(3) **Production planning :**

To prepare a production plan with respect to existing facilities for a product, with existing product manufacturing in the line the process planning plays a very important role.

7.4 PRE REQUISITE FOR PROCESS PLANNING

To do a process planning of a specific product/components, it is highly important to have the complete datas regunding that product. The minimum informations that is needed to do a complete planning of process are as follows:

(1) Working drawing of non standard components with specification and manufacturing details of finished parts.

(2) Assembly drawing of product if any with position or assembly and subassembly drawing.

(3) Part list of a product/components, with standard and non standard specifications.

(4) Annual out put of product.

(5) Material of each component with requirement of treatments at various stages.

(6) Accuracy and surface finish of component as required.

(7) Specification and capacity data of machine tools available on production shop floor.

(8) Data on available machining, Measuring and auxiliary holding devices available.

(9) Standards sizes of blanks/stocks available in market.

(10) Cutting tools available.

(11) Information on standard items available in market.

7.5 SELECTION OF PROCESSES

As the process planning provides a economical manufacturing solution to a product manufacturing, it is vary important to select a proper process to achieve the above requirement while doing product design, the designer keeps three important aspect of a product in mind.

(a) Engineering requirement.

(b) Manufacturing requirement

(c) Economic requirement

Each of these requirement are vital for a success full product. Each of the product can be manufactured in more than processes.

The best process selection depends largely upon two important factors

(1) Quality of the product.

(2) Quantity of the product

(1) **Quality of Product :** At the required quality of the product goes higher very sophisticated machine tools and special tooling is required to produce the components with higher accuracy and dimensional tolerance. So selection of operation machine tools, cutting tools, holding device, measuring instruments etc get influenced by the job quality to be maintained.

(2) **Quantity of Jobs:** The number of jobs to be produced also has a significant influence in the selection of the processes. When a large number of jobs are to be produced then the special purpose. Machines (SPM), Jigs, Fixtures etc are used and there by reduce the holding and machining time. It effects the over all economy of the product. Where as when small quantity is required to be produced then different machine attachment are used increasing the cost of the product.

So to get a proper process planning the following factors should be taken into consideration.

(1) Quantity of components to be produced.

(2) Most economical operations that can give the shape and size within required tolerance.

(3) Differentiating the roughing and finishing operating

7.6 Selection of Machine Tools

The selection of correct machine tool is closely related to selected process of manufacturing. But there is a major difference of priorities while selecting both machine tool and the process. Machines tools generally represent long term capital commitment where as a process may be designed for a relatively short duration or of specific job work. So it is worth giving due importance to select a machine tool in a process planning.

Normally machine tools are selected by planners to perform the required operation from the catalogues provided by the machine tool manufacturers. But when a physical plant with machines is already available the both availability of the machine tool as well as the capacity of the machine tool influence the selection. A machine tool may not only be capable of performing all the machining operations but also posses wide range of speed and feeds to support machining. So the selection of machine tools requires a deep attention of the planner. The series of factors that must be considered for selecting a machine tool to perform definite operation required to produce a product as per specification or as follows

(a) The machine tool selected must be able to give required machining accuracy.

(b) The machine tool must be able to produce required no of parts in a specific time frame.

(c) Must be possessing sufficient power to perform the operations.

(d) The performance of machine tool must be economical.

(e) It should be convenient to operate.

The production capacity that ensures the required output for a plan is one of the decisive factors in the selection of machine tool for a specific plan to produce the product. However a general purpose machine tool although has a lower production capacity is more versatile than high production special purpose machine tools(SPM). They are also be equipped with accessories for a wide range of operations. So selection of machine tool is to strike a balance between two extremes. As the quantity to produce increases SPMs are prefered as they reduce the manufacturing cost sharply. For small quantity of production the general purpose machine tool is always economical. One other thing can be done to select the machine tool is to carry out a economic analysis of he the machine tools.

7.7 PROCESS OPERATIONS

During process planning it is important to understand different manufacturing operation before devising a sequence of operation. Certain operations in variably have more effect on manufacturing sequence than others. In addition to that some of the operations by their natures is required to be performed before some other operations i.e.. (casting before machining, machining before surface treatment, drilling before tapping and reaming etc)

Thus operations can be classified as follows:

(1) **Basic Process Operation :**

These are the operations which gives a initial shape and size to the component without dimensional accuracy. They require further operating to come to final shape and size. Ex- Casting, forging etc.

(2) **Principal process operations :**

These operations include all operatings which gives a accurate shape and size to the component with sufficient dimensional tolerance.

Example : machining, Hot working, cold working, moulding, welding, solderings, fastening etc.

(3) **Major Process Operaion :**

These are operations performed within the principal processes to give the final shape and size to the component as per the drawing specification example.

Machining- Turning, Milling, slotting, shaping etc.

Cold working : Sheet metal operation, like piercing, blanking, notching, drawing bending etc.

Hot working : Die casting, extruding, drawing, bending etc.

Assembly : Fitting, welding, soldering, fastening, brazing etc.

(4) **Auxiliary Process Operation :**

These are operations to ensure continuity and completion of principal process operations. These operations generally change the physical characteristics or appearance of he work piece.

Example - Heat treatment, welding, polishing honning etc.

(5) **Supporting Operations.**

These are operations necessary to successfully complete the production process. These operations normally are the next step of the principal process operations.

Example : Inspection and quality control handling and packaging shipping.

7.8 Design of Sequence of Operation

As the selection of best processes in a planning scenarios is of much importance, no operation sequence should be accepted without review. The review should be done to see if newer or better methods of planning can be developed for increased productivity and reduction of cost. It must be remembered that there is always a room for further improvement.

To establish a sequence or operation for a new product, or component in a new plant optimization of process should be done with new equipments as required.

However to plan a process sequence in an existing plant is difficult, as the operation sequence must suit the equipment available in the plant and also the loading condition of the plant. The equipment most suited may be over loaded or unavailable.

How ever there is certain fundamental principles which are to be kept in mind for determining most efficient sequence of operations weather planning for a new layout plant or for a existing plant.

(1) The first operation in the sequence should be the one which provides the outline for the desired product which is obtained by removal of maximum stock of material from the blank size raw material.

In case of a cast or a forged blank defects are revealed while removing a thick layer of material which enables to reject the piece and no more operation should be performed on it. Removal of thick layers also relieve the internal stresses of the work piece.

(2) Finishing operation is the last operation in the sequence.

(3) Roughing and finishing operations must be performed in different set ups with separate toolings. (Machines of different grade of accuracy and tools of different geometry are required for the above two operations).

(4) The datum surface must be selected with great care.

[This selection of a datum surface is of prime importance because the first setting of the work piece is made with this datum surface as reference. If any errors comes in on account of this step all the subsequent operations will be of sheer wastage of time and labour of the production of the defective workpiece. In the first stage any of the un-machined surface is taken as daturm and the machining is done on the opposite surface. But subsequently the machined surfaces are taken as the datum surfaces. These surfaces must be large enough to withstand the forces of clamping and shear force of machining.]

(5) The inspection stages should be

(i) After roughing operation.

(ii) Before operations which one to be done in other departments and after the completion of the above operations.

(iii) Critical and complex operations.

(iv) After the last machining operations.

(6) Surfaces whose machining will not greatly effect the rigidity of the workpiece should be machined earlier in the sequence.

(7) The operation of sequence has to carried out taking into account the primary operations like drilling etc to be performed earlier to secondary operation like tapping, reaming etc and auxiliary operations like heat treatment.

7.9 COST ESTIMATION

Cost estimation is the next exercise after the process planning. Experienced and qualified personnel are required who had particularly, worked in an organisation as an estimator. The exercise of cost estimation has to be carried out very carefully so that data are accurately determined as many decisions are based on the cost estimates only.

Purpose of Cost Estimates:

1. To predict the cost to manufacture a product, component or any tool viz. jig, fixture, cutting tool and dies.
2. To compare the cost estimates of different methods and the select the economical method for production.
3. To compare the cost of manufacturing costs over two machines or tool set-ups and then decide to purchase the most economical machine or tool set-ups.
4. To control the cost of a product or component by analysing the constituents of the cost.

The estimation is thus, a technique of predicting the essential manufacturing cost of a product or a single component of it or tooling set-up with a reasonable degree of accuracy and with in a limited period of time by detailed analysis of the product or its component. Estimation is different from costing or cost accounting .Costing concerns itself with the accumulation of data pertaining to expenses on material, labour and overheads which belong to a particular period of operation in a department in reference to a product. The work of cost accounting progresses as the progress in the manufacturing reaches its end product inside the plant. This is therefore, a long procedure and sometimes takes a complex nature. Cost accounting can tell the management about the cost when all activities are completing and the product is ready for shipment. Therefore the estimation technique is resorted to estimate of cost for referring to sales office enquiries or for even deciding whether to accept the customer demand or not. Estimation can compare the cost the product to be produced with one already being marketed. This helps in deciding whether to put the product on the production line. All commitments of todays competitive business as regards securing of a contract of profit are based on accurate cost estimation.

Pre-requisites for Estimation

Estimation proceeds with the study of details of the drawing of the products. Besides the geometrical details of the product the set of drawing sheets contain many other information such as number-off , assembly components, their materials, surface treatment and surface finish. The estimator derives following information's from the drawing sheets:

1. Data on cost of materials and rates of labour.
2. On the specifications of machine tools and tooling which enables to determine the cost of the plant and equipment.
3. Depreciation costs of machinery and plant.
4. Indirect cost of factory, administrative and sales.
5. Pertcentage indirect cost, percentage of direct labour, and the prime cost to be charged as constituents of cost.

Estimation for a Product:

A product like an automobile consists of hundreds of components which are to be process planned first, then each operation on the component may require the designing of the pattern, tool gauge, die for mass production of the components. Therefore ,apart from the material and labour costs of manufacturing , the cost of making the tooling and gauges have to be determined in advance separately, as an independent estimate and shown as an item of direct expense for each component of the product. Similarly, the cost of assembling a product should be estimated to be charged in labour costs.

Cost of Tooling Equipments

Cost of tooling equipment needs to be estimated for adding as a direct expense item of each component It may be needed to compare costs of tooling equipment only. The procedure for determining the costs of tooling equipment is the same as that for the product except that the work is of small nature and the designing and drafting for the tooling equipment forms an extra requirement. Tooling equipment may be listed as patterns, cores, cutting and forming tools, gauges etc. While determining the costs the following functions must be taken into account.

1. Auxiliary Services

(a) Designing and drafting.

(b) Production planning and drafting.

(c) Procurement or fabrication of special patterns, core, boxes, flasks, or tools.

(d) Experimentation, development, testing or runoff.

2. Fabrication Functions

(a) Casting, forming, machining or finishing processes.

(b) Assembly.

(c) Painting, packing.

3. Direct Materials.

4. Direct expenses such as for painting etc.

5. Overheads.

Cost of Tool Set up

Sometimes the economics of tooling equipment is desired to be prepared for justifying the introduction of such equipment. Then in addition the cost of equipment its setting up costs are also needed for calculation purposes. Again, two tooling set-ups are compared in cost not upto cost of tooling equipment but upto setting-up stage.

The cost procedure for finding out the cost of tooling equipment is already discussed. The set-up costs are found from the labour cost for the set-ups. The set-up time is provided in the process planning sheet by the process planning department which prepares it as described in the handbooks of elemental times and contained in the Section 32.20.

Constituents of Cost

Whether it is a big product, a component or a tooling equipment all cost items can be conveniently grouped into three main constituents- Material Cost, Labour Cost, and Overheads. If designing or drafting has been prepared in the case of tool then charges of this item are included into the material, labour and overheads (also known as on-cost).

Material cost: There are two types of material costs viz. direct material cost and indirect material cost. Such materials which come into the plant and are directly applied to the product fall under the class of 'direct materials'. The cost of each item can be directly added to form the direct material cost. Any material which is not applied to the product in a direct form fall under the class of 'indirect-materials' viz. lubricating oil, cotton-waste, wiping cloth etc.

Labour cost: Labour engaged in a factory are also of two types - Direct Labour and Indirect Labour. Persons who actually process the materials in any shop either manually or with the help of any machines form the direct labour. All other categories of persons viz. foreman, supervisor, and those who are employed for maintenance and material handling are the class of indirect labour. Their wages form the labour cost.

Overheads(on-cost): All costs excluding direct material and direct labour that is incurred in the transforming of raw materials into the finished product and upto the stage of selling it to the vendor's shops come under this category. Indirect material and labour are also, included into this component. For further identification of cost elements this component is also considered as Direct On-Cost and Indirect On-Cost. The cost of manufacturing tooling and aids e.g. patterns , coreboxes , jigs, fixtures, inspecting devices are the direct on-cost of the component. Excluding the direct on-cost all other expenses are the part of the indirect on-cost, those are factory on cost, Administrative on-cost, Sales on-cost.

Components of factory on-cost:

i. Indirect materials like shop supplies, fuels, oils etc.

ii. Indirect labour like wages of workshop and office staff, drawing office etc.

iii. Miscellaneous expenses like taxes, insurance, depreciation, power and light, stationary etc.