ME6005 - PRODUCTION PLANNING AND COST ESTIMATION

UNIT I PRODUCTION PLANNING AND CONTROL

Demand forecasting – time series forecasting models – Delphi method of forecasting, aggregate production planning, master scheduling, bill of materials and material requirement planning; order control and flow control, routing, scheduling and priority dispatching; JIT; Kanban PULL systems

UNIT II ESTIMATING AND COSTING

Importance and aims of Cost estimation – Functions of estimation – Costing – Importance and aims of Costing – Difference between costing and estimation – Importance of realistic estimates – Estimation procedure.

UNIT III ELEMENT OF COST

Introduction – Material Cost – Determination of Material Cost Labour Cost – Determination of Direct Labour Cost – Expenses – Cost of Product (Ladder of cost) – Illustrative examples. Analysis of overhead expenses – Factory expenses – Depreciation – Causes of depreciation – Methods of depreciation – Administrative expenses – Selling and Distributing expenses – Allocation of overhead expenses.

UNIT VI PRODUCT COST ESTIMATION

Estimation in forging shop – Losses in forging – Forging cost – Illustrative examples. Estimation in welding shop – Gas cutting – Electric welding – illustrative examples. Estimation in foundry shop – Estimation of pattern cost and casting cost – Illustrative examples

UNIT V ESTIMATION OF MACHINING TIME

Estimation of machining time for Lathe operations – Estimation of machining time for drilling, boring, shaping, planning, milling and grinding operations – Illustrative examples.

Total 45

TEXT BOOK:

1. M. Adithan and B.S. Pabla, “Estimating and Costing”, Konark Publishers Pvt. Ltd. 1989.
2. A.K. Chitale and R.C. Gupta, “Product Design and Manufacturing”, Prentice Hall Pvt. Ltd.1997.

REFERENCES:

1 Nanua Singh, “System approach to Computer Integrated Design and Manufacturing”, John Wiley and Sons, Inc., 1996

2 Joseph G. Monks, “Operations Management, Theory & Problems”, McGraw Company, 1982.

3 S.N. Chary, “Production and Operations Management,” Tata McGraw Hill, 1994.

4 Adam & Ebert – “Production and Operations Management,” Prentice Hall of India, 1995.

5Banga T.R, Sharma S.C., “Mechanical Estimation and Costing”, Khanna Publishers,1993.

6 Mukhopadhyay S.K. ” Production planning and Control – Text and Cases” Prentice Hall of India Pvt. Ltd. 2007.

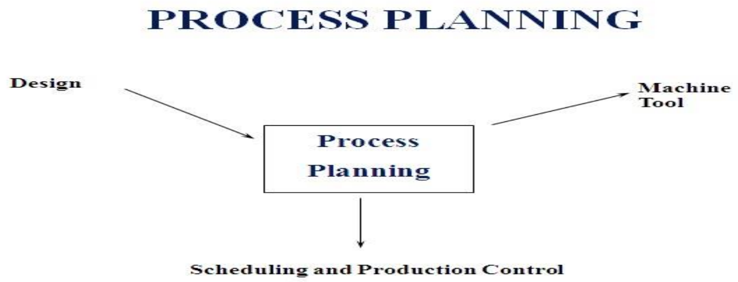
ME6005-PROCESS PLANNING AND COST ESTIMAION

COURSE MATERIL

UNIT 1: INTRODUCTION TO PROCESS PLANNING

1. PROCESS PLANNING

Process planning is a detailed specification which lists the operation, tools, and facilities usually accomplished in manufacturing department Also known as operations planning Systematic determination of the engineering processes and systems to manufacture a product competitively and economically



Definition

Process planning can be defined as an act of preparing a detailed processing documentation for the manufacture of a piece part or assembly

2.METHIDS OF PROCESS PLANNING

1. Manual Process planning
2. Computer Aided Process planning (CAPP)
   a. Retrieval CAPP system
   b. Generative CAPP system

2.1 MANUAL PROCESS PLANNING

Manually prepared
Task involves examining and interrupting engineering drawings, making decisions on machining process selection, equipment selection, operation sequence, and shop practices Dependent on judgment and experience of process planner

Advantages

Very much suitable for small scale companies
Highly flexible
Low investment costs

Disadvantages

Very complex
Time consuming
Requires large amount of data
Requires skilled process planner
More possibilities for human error
Increases paper work

Inconsistent process plans results in reduced productivity

2.2 COMPUTER AIDED PROCESS PLANNING (CAPP)

To overcome drawbacks of manual process planning Computer Aided Process planning (CAPP) is used Provides interface between CAD and CAM

Benefits

Process rationalization and standardization
Productivity improvement
Product cost reduction
Elimination of human error
Reduction in time
Reduced clerical effort and paper work
Improved legibility
Faster response to engineering changes
Incorporation of other application programs

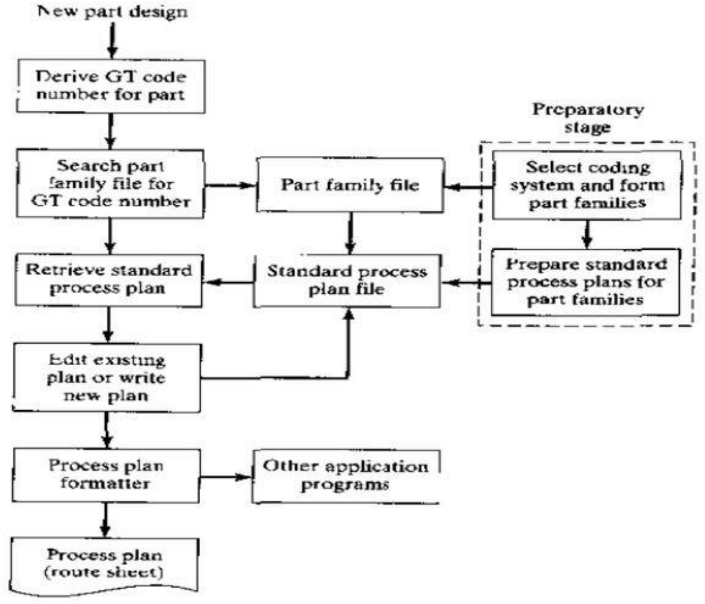
2.2.1 RETRIEVAL CAPP SYSTEM

It is also called as variant CAPP, widely used in machining applications Basic idea behind is, similar parts will have similar process plans Process plan for new part is created by recalling, identifying and retrieving an existing plan for a similar part, and making necessary modification for new part

Procedure For Retrieval Capp System

Retrieval CAPP system is based on principles of group technology (GT) and part classification and coding For each part family, standard process plan is prepared and stored in computer files Through classification and coding, code number is generated Standard plan is retrieved and edited for new part

Retrieval CAPP system



Advantages

Once a standard plan has been written, variety of parts can be planned Requires simple programming and installation Understandable, and planner has control of final plan Easy to learn and easy to use

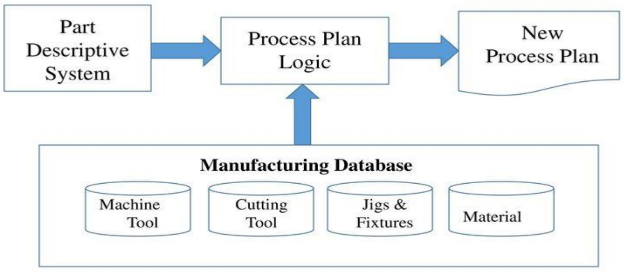
Disadvantages

Components to be planned are limited to similar components previously planned
Requires experienced process planners to modify the standard plan for specific component

2.2.2 GENERATIVE CAPP SYSTEM

In this approach computer is used to synthesize or generate each individual process plan automatically without reference to any prior plan Generates the process plan based on decision logics and pre -coded algorithms. Computer stores the rules of manufacturing and equipment capabilities Specific process plan for specific part can be generated without any involvement of process planner

Generative Approaches to CAPP



Components of Generative CAPP system

- Part descriptor
- Subsystem to identify machine parameters
- Subsystem to select and sequence individual operations
- Database
- Report generator

Advantages

- Generate consistent process plan rapidly
- New components can be planned as easily as existing components
- It has potential for integrating with automated manufacturing facility to provide detailed control information

Drawbacks

Complex and very difficult to develop

3 DRAWING INTERPRETATION

As explained earlier, the following charts and diagrams are used in method study.

1. Operation process chart (or) Outline process chart.
2. Flow process chart.
   (a) Material type
   (b) Operator type
   (c) Equipment type
3. Two-handed process chart. (or) Left hand-Right hand chart
4. Multiple activity chart.
5. Flow diagram.
6. String diagram.

3.1 Process Chart Symbols

The recording of the facts about the job in a process chart is done by using standard symbols. Using of symbols in recording the activities is much easier than writing down the facts about the job. Symbols are very convenient and widely understood type of short hand. They save a lot of writing and indicate clearly what is happening.

3.1.1. Operation

A large circle indicates operation. An operation takes place when there is a change in physical or chemical characteristics of an object. An assembly or disassembly is also an operation. When information is given or received or when planning or calculating takes place it is also called operation.

Example 1.1

Reducing the diameter of an object in a lathe. Hardening the surface of an object by heat treatment.

3.1.2. Inspection

A square indicates inspection. Inspection is checking an object for its quality, quantity or identifications.

Example 1.2

Checking the diameter of a rod. Counting the number of products produced.

3.1.3. Transport

An arrow indicates transport. This refers to the movement of an object or operator or equipment

from one place to another. When the movement takes place during an operation, it is not called transport.

Example 1.3

Moving the material by a trolleyOperator going to the stores to get some tool.

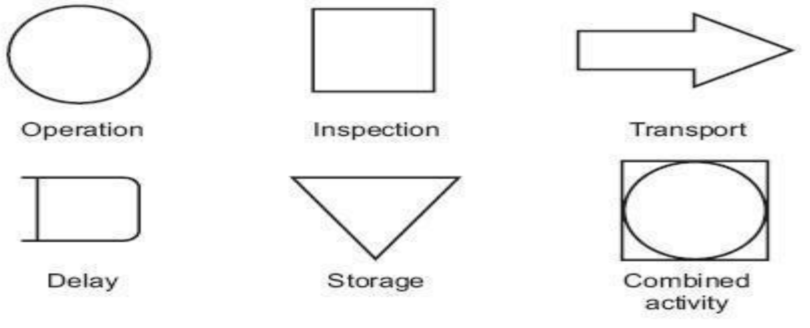


Fig. 1.1: Process chart symbols

3.1.4. Delay or temporary storage

A large capital letter D indicates delay. This is also called as temporary storage. Delay occurs when an object or operator is waiting for the next activity.

Example 1.4

An operator waiting to get a tool in the stores. Work pieces stocked near the machine before the next operation.

3.1.5. *Permanent storage*

An equilateral triangle standing on its vertex represents storage. Storage takes place when an object is stored and protected against unauthorized removal.

Example 1.5

Raw material in the store room.

3.1.6. *Combined activity*

When two activities take place at the same time or done by the same operator or at the same place, the two symbols of activities are combined.

Example 1.6

Reading and recording a pressure gauge. Here a circle inside a square represents the combined activity of operation and inspection.

3.2 Operation Process Chart

An operation process chart is a graphic representation of the sequence of all operations and inspections taking place in a process. It is also known as outline process chart. It gives a birds eye view of the overall activities. Entry points of all material are noted in the chart. An example of operation process chart is shown in the figure 1.2. Here the process of manufacture of electric motor is shown.

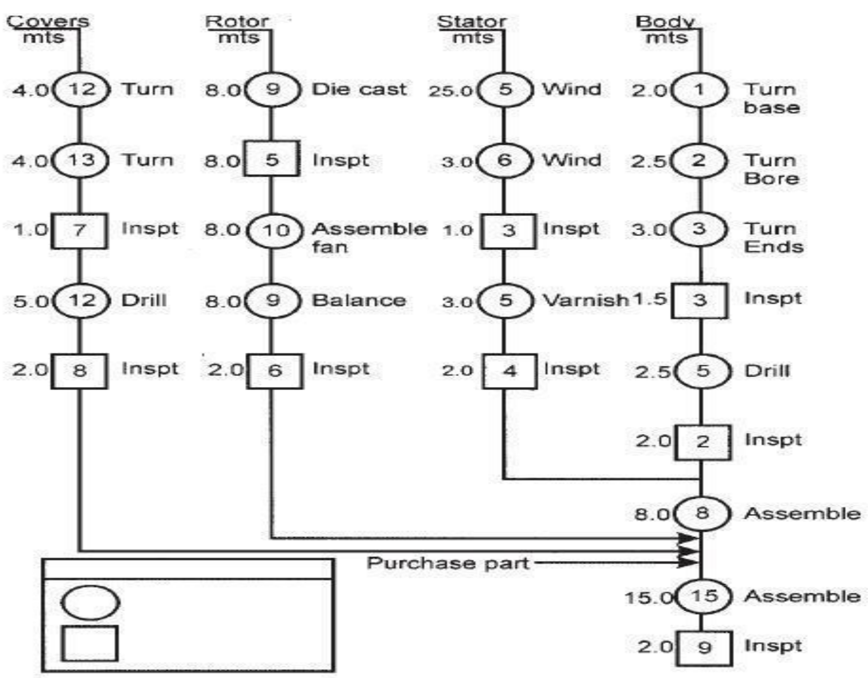


Fig. 1.2: Operation process chart

The conventions followed in preparing the chart are

1. Write title at the top of the chart.
2. Begin the chart from the right hand side top corner.
3. Represent the main component at the right extreme.
4. Represent the sequence of operations and inspections by their symbols. Connect them by vertical flow lines.
5. Record the brief description of the activity to the right side of the symbols.
6. Note down the time for each activity to the left of the symbol.
7. Number all operations in one serial order. Start from the right hand top (from number
8. Similarly number all inspections in another serial order (starting from 1).
9. Continue numbering, till the entry of the second component.
10. Show the entry of purchased parts by horizontal lines.

3.3 Flow Process Chart

A flow process chart is a graphical representation of the sequence of all the activities (operation, inspection, transport, delay and storage) taking place in a process. Process chart symbols are used here to represent the activities. There are three types of flow process charts. They are

Man type flow process chart

This flow process chart records what the worker does.

Material type flow process chart

This flow process chart records how the material is handled or treated.

Equipment type flow process chart

This flow process chart records how the equipment or machine is used.

Example 1.7

The activities of a stenographer in preparation of a letter are recorded in the operator type flow process chart shown in figure 1.3.

Chart No.	: 001	Date :	
Job	: Typing A letter	Charted by:	....
Chart begins	: Steno in her seat	Chart ends-putting the typed letter in the way	
Method	: Present/Proposed		

Sl. No.	*Description of the activities*	*Distance*	*Time in Sec.*	*Symbols*	*Remarks*
				O □ ⇒ D ∇	
1.	Steno in her seat	-	-		
2.	Hears the bell	-	3		
3.	Goes to manager's room	6m	10		
4.	Takes down dictation	-	120		
5.	Returns to her seat	6m	10		
6.	Prepares typewriter	-	15		
7.	Types the letter	-	150		
8.	Checks the matter	-	40		
9.	Goes to manager's room	6m	10		
10.	Waits till the manager signs	-	20		
11.	Returns to her seat	6m	10		
12.	Types envelope	-	20		
13.	Puts the letter inside envelope	-	5		
14.	Puts the envelope in dispatch tray	-	5		

Fig. 1.3: Flow process chart—operator type

The chart records the activities of the steno. Here, the manager calls the steno and dictates a letter. The steno takes notes of the letter, types it, gets the signature of the manager and sends it for dispatching. These activities are shown in the chart. This is operator type flow process chart. Considering the message in the letter as material, we can prepare the material type flow process chart.

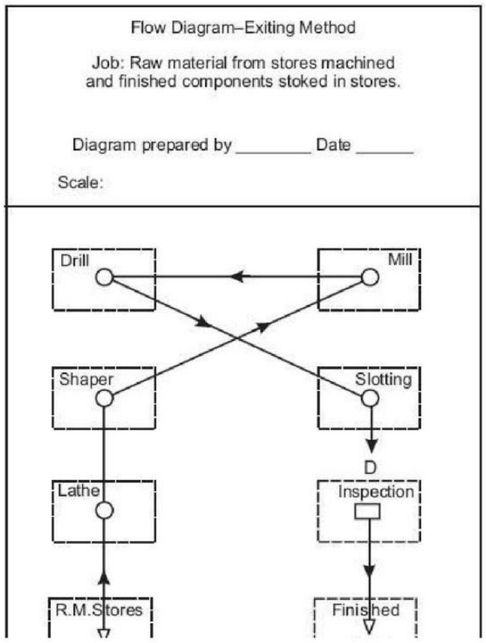
General guidelines for making a flow process chart

1. The details must be obtained by direct observation—charts must not be based on memory.
2. All the facts must be correctly recorded.
3. No assumptions should be made.
4. Make it easy for future reference.
5. All charts must have the following details:
   (a) Name of the product, material or equipment that is observed.
   (b) Starting point and ending point.
   (c) The location where the activities take place.

Flow Diagram

In any production shop, repair shop or any other department, there are movements of men and material from one place to another. Process charts indicate the sequence of activities. They do not show the frequent movements of men and material. If these movement are minimized, a lot of savings can be achieved in cost and effort. If the path of movement of material is not frequent and simple, a flow diagram is used for recording the movement.

A flow diagram is a diagram which is drawn to scale. The relative position of machineries, gang ways, material handling equipment etc. are drawn first. Then the path followed by men or material is marked on the diagram. Different movements can be marked in different colours. Process symbols are added to the diagram to identify the different activities at different work centers.



The flow diagram are used for the following purposes:

1. To remove unwanted material movement.
2. To remove back tracking.
3. To avoid traffic congestion.
4. To improve the plant layout.

Conventions adopted are

1. Heading and description of the process should be given at the top of the diagram.

2. Other information's like location, name of the shop, name of the person drawing the diagram are also given.

3. The path followed by the material is shown by a flow line.
4. Direction of movement is shown by small arrows along the flow lines.

5. The different activities are represented by the symbols on the flow lines. (Same symbols used in flow process chart are used here).
6. If more than one product is to be shown in the diagram different colours are used for

each path.

String Diagram

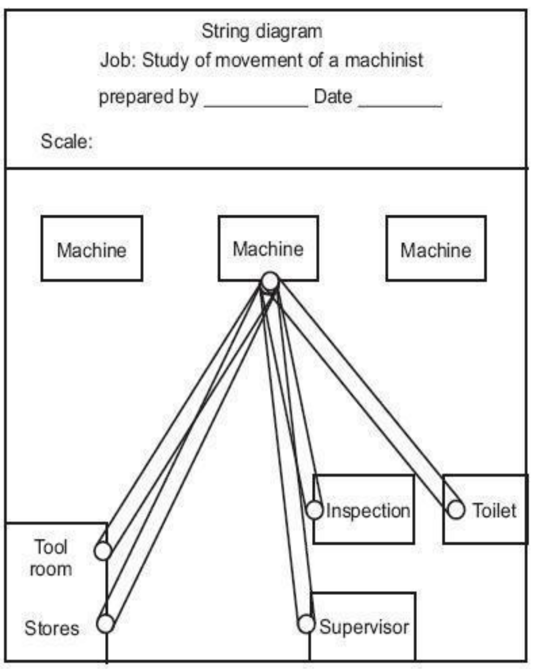


Fig. 1.7: String diagram

We make use of flow diagram for recording the movement of men or material when the movement is simple and the path is almost fixed. But when the paths are many and are repetitive, it may not be possible to record them in a flow diagram. Here a string diagram is used.

String diagram is a scaled plan of the shop. Location of machines and various facilities are drawn to scale in a drawing sheet. Pins are fixed at the various work centres in the drawing sheet. A continuous coloured thread or string is taken round the pins where the material or worker moves during the process.

Constructions

1. Draw the layout of the shop to scale in a drawing sheet.
2. Mark the various work centres like machines, stores, work bench etc. in the diagram.
3. Hold the drawing sheet on a soft board and fix pins at the work centres.
4. Tie one end of a coloured string to the work centre from which the movement starts.
5. Follow the path of the worker to different work centre and accordingly take the thread to different points on the drawing board.
6. At the end of the session note down the number of movements from one work centre to another.
7. Remove the string and measure the total length of the string. Multiply by the scale and get the actual distance of movement.

Applications

1. It is used for recording the complex movements of material or men.
2. Back tracking, congestion, bottlenecks, underutilized paths are easily found out.
3. It is used to check whether the work station is correctly located.
4. Used to record irregular movements.
5. Used to find out the most economical route.

MATERIAL EVALUATION

It has become a subject requiring study, because selection of material has become complicated by the great increase not only in the kinds of materials but also in the various forms in which any one material may be available. Material should be of right quality and chemical composition as per the product specifications. Shape and size of material should restrict the scrap (i.e., material removed for getting the product shape).

Bill of Material

The most common method of analyzing a product into component parts is through the use of bills of material or specification sheets. Bill of material is a means of determining, purchasing and production order requirements. It should indicate if the part is to be manufactured or purchased. The production control department uses the bill of material to determine manufacturing and scheduling dates. Process engineering uses it as a checklist to complete their work. Methods engineering uses it in the preparation of time allowances for assembling operations. Accumulations are made by the stores department according to the bill of material. They in turn set up the shortage lists for use by expediters of the production-control department.
Releases by assembly units are made by the finished stores department in accordance with the bills of material. The design of the bill of material varies slightly in minor details, depending upon the various uses made of it by individual companies. The information usually required on the bill of material form includes

1. The product name.

2. Product code identification.
3. Sheet number.
4. Use.
5. Date of preparation.
6. Name/initials of preparer.
7. Name/initials of checker.
8. Item numbers.
9. Make/purchase designations.
10. Subassembly part numbers and names.
11. Quantity requirements, and
12. Material used in each part.

Note: Bill of material is also known as part list.

Item switch, Y 30 — Sheet No.1 of 2,
Drawing = 5 — Assembly 5 HP motor
Date :

Part No.	*Part*	*No/item*	*Material*	*Quantity per item*	*Cost per item*	*Remarks*
SJ-64	Drive spring	2	Sprg steel	-	Rs.5/-	Purchase
Made by....................					Checked by.................	

The requirement of material is calculated as follows:
1. Material required for work already on hand = Q1
2. Material required for the new work as per the bill of material (including wastage) = Q2
3. Total material requirement = Q1 + Q2
4. Material available in stores = Q3
5. Additional material to be purchased = (Q1 + Q2) – Q3.

Selection of jigs, fixtures and other special attachments

These supporting devices are necessary:
• To give higher production rate.
• To reduce cost of production per piece.

Selection of cutting tools and inspection gauges:

They, respectively, are necessary to
• Reduce production time.
• Inspect accurately and at a faster rate.

Tools, jigs and fixture requirements

The tools requirements is worked out considering the following:
1. Number of tools already available.
2. Number of new tools required.
3. Time required for designing the new tools.
4. Taking (make or buy) decision for new tools.
5. Finding out when the new tools will be ready for use.

STEPS IN PROCESS SELECTION

Work measurement is a technique to establish the time required for a qualified worker to carry out a specified job at a defined level of performance.

Objectives of work measurement

1. To reduce or eliminate non-productive time.
2. To fix the standard time for doing a job.
3. To develop standard data for future reference.
4. To improve methods.

Uses of work measurements

1. To compare the efficiency of alternate methods. When two or more methods are available for doing the same job, the time for each method is found out by work measurement. The method which takes minimum time is selected.
2. Standard time is used as a basis for wage incentive schemes.
3. It helps for the estimation of cost. Knowing the time standards, it is possible to work out the cost of the product. This helps to quote rates for tenders.
4. It helps to plan the workload of man and machine.
5. It helps to determine the requirement of men and machine. When we know the time to produce one piece and also the quantity to be produced, it is easy to calculate the total requirement of men and machines.
6. It helps in better production control. Time standards help accurate scheduling. So the production control can be done efficiently.
7. It helps to control the cost of production. With the help of time standards, the cost of production can be worked out. This cost is used as a basis for control.
8. It helps to fix the delivery date to the customer. By knowing the standard time we will be able to calculate the time required for manufacturing the required quantity of products.

TECHNIQUES OF WORK MEASUREMENT

The different techniques used in work measurement are

1. Stop watch time study.
2. Production study.
3. Work sampling or Ratio delay study.
4. Synthesis from standard data.
5. Analytical estimating.
6. Predetermined motion time system.

Stop Watch Time Study

Stop watch time study is one of the techniques of work measurement commonly used. Here we make use of a stop watch for measuring the time.

Procedure for conducting stop watch time study

The following procedure is followed in conducting stop watch time study:

1. Selecting the job.
2. Recording the specifications.
3. Breaking operation into elements.
4. Examining each element.
5. Measuring using stop watch.
6. Assessing the rating factor.
7. Calculating the basic time.
8. Determining the allowances.
9. Compiling the standard time.

1. Selection of job

Time study is always done after method study. Under the following situations, a job is selected for time study:

1. A new job, new component or a new operation.
2. When new time standard is required.
3. To check the correctness of the existing time standard.
4. When the cost of operation is found to be high.
5. Before introducing an incentive scheme.
6. When two methods are to be compared.

2. Record

The following information's are recorded

1. About the product-name, product-number, specification.
2. About the machine, equipment and tools.
3. About the working condition-temperature-humidity-lighting etc. These informations are used when deciding about the allowances.
4. About the operator name-experience-age etc. This is needed for rating the operator.

3. Break down operation into elements

Each operation is divided into a number of elements. This is done for easy observation and accurate measurement. The elements are grouped as constant element, variable element, occasional element, man element, machine element etc.

4. Examine each element

The elements are examined to find out whether they are effective or wasteful. Elements are also examined whether they are done in the correct method.

5. Measure using a stop watch

The time taken for each element is measured using a stop watch. There are two methods of measuring. *viz*., Fly back method and Cumulative method. Cumulative method is preferable. The time measured from the stop watch is known as observed time. Time for various groups

of elements should be recorded separately. This measurement has to be done for a number of times. The number of observations depend upon the type of operation, the accuracy required and time for one cycle.

6. Assess the rating factor

Rating is the measure of efficiency of a worker. The operators rating is found out by comparing

his speed of work with standard performance. The rating of an operator is decided by the work study man in consultation with the supervisor. The standard rating is taken as 100. If the operator is found to be slow, his rating is less than 100 say 90. If the operator is above average, his rating is more than 100, say 120.

7. Calculate the basic time

Basic time is calculated as follows by applying rating factor

$$\text{Basic time} = \text{Observed time} \times \frac{\text{Operator rating}}{\text{Standard rating}}$$

$$BT = OT \times \frac{OR}{SR}$$

8. Determine the allowance

A worker cannot work all the day continuously. He will require time for rest going for toilet, drinking water etc. Unavoidable delays may occur because of tool breakage etc. So some extra time is added to the basic time. The extra time is known as allowance.

9. Compile the standard time

The standard time is the sum of basic time and allowances. The standard time is also known as allowed time.

Breaking a Job into Elements

It is necessary to break down a task (job) into elements for the following reasons:

1. To separate productive time and unproductive time.
2. To assess the rating of the worker more accurately.
3. To identify the different types of elements and to measure their timings separately.
4. To determine the fatigue allowance accurately.
5. To prepare a detailed work specification.
6. To fix standard time for repetitive elements (such as switch on or switch off of machine).

Classification of elements

1. Repetitive elements

It is an element which occurs in every work cycle of the job.

Example 1.9

Loading the machine, locating a job in a fixture.

2. Constant element

It is an element for which the basic time remains constant whenever it is performed.

Example 1.10

Switching on the machine, switching off the machine.

3. Variable element

It is an element for which the basic time varies depending on the characteristics of the product, equipment or process.

Example 1.11

Saving a log of wood-time changes with diameter or the work.

4. Occasional element

It is an element which does not occur in every work cycle of the job. It may occur at regular or irregular intervals.

Example 1.12

Regrinding of tools, re-setting of tools.

5. Foreign element

It is an element which is not a part of the job.

Example 1.13

Cleaning a job that is to be machined.

6. Manual element

It is an element performed by the worker.

Example 1.14

Cleaning the machine, loading the machine.

7. Machine element

It is the element automatically performed by a power driven machine.

Example 1.15

Turning in a lathe using automatic feed.

General rules to be followed in breaking down a task into elements

1. Element should have a definite beginning and ending.
2. An element should be as short as possible so that it can be conveniently timed. The shortest element that can be timed using a stop watch is 0.04 mt.
3. Manual elements and machine elements should be separately timed.
4. Constant element should be separated from variable elements.
5. Occasional and foreign elements should be timed separately.

Measuring Time with a Stop Watch

There are two methods of timing using a stop watch. They are

1. Fly back or Snap back method.
2. Continuous or Cumulative method.

1. Fly back method

Here the stop watch is started at the beginning of the first element. At the end of the element the reading is noted in the study sheet (in the WR column). At the same time, the stop watch hand is snapped back to zero. This is done by pressing down the knob, immediately the knob is released. The hand starts moving from zero for timing the next element. In this way the timing for each element is found out. This is called observed time (O.T.) .

2. Continuous method

Here the stop watch is started at the beginning of the first element. The watch runs continuously throughout the study. At the end of each element the watch readings are recorded on the study sheet. The time for each element is calculated by successive subtraction. The final reading of the stop watch gives the total time. This is the observed time (O.T.).

CALCULATION OF BASIC TIME

Basic time is the time taken by an operator of standard performance (rating of 100). A man whose work is observed, may be a slow worker or a fast worker. His rating may be less than 100 or above 100. The observed time cannot be taken as the basic time. Here the rating factor is applied and basic time is calculated as follows.

$$\text{Basic time} = \text{Observed time} \times \frac{\text{Operator rating}}{\text{Standard rating}}$$

For example, assume that observed time for an operation is 0.7 mts. The rating of the Operator is found to be 120.

$$\text{The Basic Time or Normal Time} = 0.7 \times \frac{120}{100} = 0.84 \text{ mts.}$$

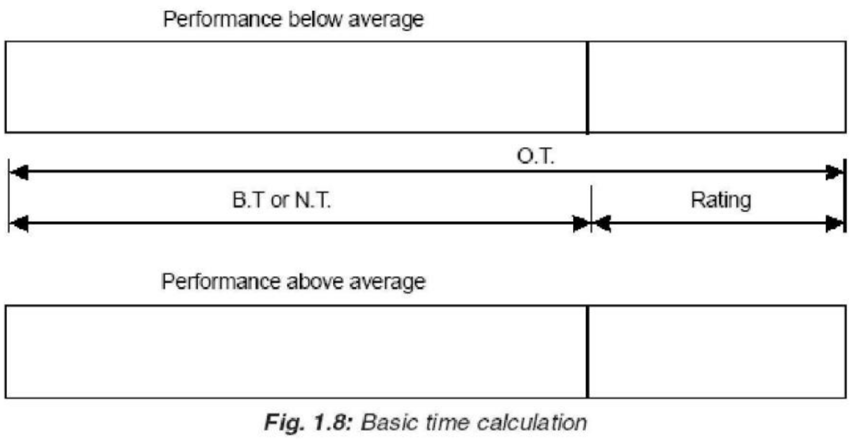


Fig. 1.8: *Basic time calculation*

ALLOWANCES

Various types of allowance are;

1. Rest and personal allowance.
2. Process allowance.
3. Contingency allowance.
4. Special allowance.
5. Policy allowance.

CALCULATION OF STANDARD TIME

Standard time or allowed time is the total time in which a job should be completed at standard performance. It is the sum of normal time (basic time) and allowances. Policy allowance is not included.

Standard time is worked out in a stop watch time study in the following manner.

Observed time

This is the actual time observed by using a stop watch. The observed time of an operation is The total of the elemental times.

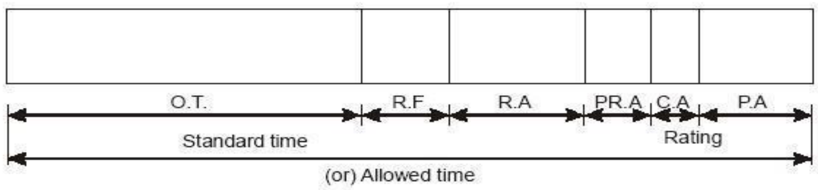
The time study for the same job is conducted for a number of times. The average of the observed times is calculated.

Basic or normal time

Basic time is the time taken by a worker with standard performance. Basic time is calculated from the observed time by applying the rating factor.

Basic time or

$$\text{Normal time} = \text{Observed time} \times \frac{\text{Rating of the operator}}{\text{Standard rating } (100)}$$



OT	–	Observed time	PRA	–	Process allowance
RF	–	Rating factor	CA	–	Contingency allowance
RA	–	Rest allowance	PA	–	Policy allowance

Fig. 1.9

Allowed time or standard time

The standard time is obtained by adding the following allowances with the basic or normal time.

1. Rest and personal allowance or relaxation allowance.
2. Process allowance or unavoidable delay allowance.
3. Contingency allowance.
4. Special allowance.

Policy allowance may be added to the standard time if the management wants.

PRODUCTION STUDY

There are many factors to be considered when selecting production equipment for a particular component. The factors considered in this chapter include the machine's physical size, construction and power. These in turn will be factors in determining the speeds and feeds available and the maximum depth of cut the machine is capable of. Another factor is the number and type of tools available for the production equipment under consideration. All of the aforementioned factors will ultimately have some effect on the production rate, batch size and economic viability of the production equipment. Therefore, most of these factors will be incorporated into a five-step selection procedure for production equipment.

Once the equipment decision has been made, the tooling for the operations identified previously during the process selection must be selected. In its broadest sense, the word 'tooling' in manufacturing refers not only to cutting tools, but also to work holders, jigs and fixtures (also known as durable tooling). However, this chapter will focus firmly on the selection of cutting tools (also known as consumable tooling) for manufacturing processes and work holders, jigs and fixtures will be covered in a subsequent chapter. The justification for this focus on cutting tools is that the majority of secondary processing will be material removal processes, more commonly known as machining. A successful machining process relies on the selection of the proper cutting tools for the operation at hand and is in fact the most critical element in the machining system. Among the factors to be considered in selecting appropriate tooling include workpiece material, type of cut, part geometry/size, lot size, machining data, machine tool characteristics, cutting tool materials, tool holding and quality/capability requirements.

Production equipment for specific processes

Although there is a huge amount of processing equipment, and variables of such equipment, the problem of selecting a suitable machine is easier than selecting a suitable process. In fact, with the process already selected, the range of machine tools to select from is already narrowed. Some of the factors used to select a suitable process will be used again to select a suitable machine, for example, surface finish and machine accuracy. These factors can be categorized as either technical or operational factors.

1.Technical factors

The focus of the technical factors is to ensure the machine tool selected is capable of producing the part to the required specification. The main factors considered are: Physical size - the machine tool must be of a sufficient size to cope with the dimensions of the workpiece and be physically able to carry out the desired processing.

2.Operational factors

The focus of the operational factors is really about the available resources and how they can be used cost-effectively to fulfill the master production schedule (MPS). From this perspective, the factors considered are more operations management issues than processing planning issues. The factors include:

Batch size -just as every process has an economic batch quantity (EBQ) that must be achieved before it can be considered economically viable, so too does specific machinery. A common approach is to compare different machines for a given batch size using a break-even analysis to see which is most economic. This will be considered in more depth in Chapter 9 when considering the economics of process planning.

Capacity- as equally important as the EBQ is the production rate of the machines under consideration. All machines are capable of achieving a particular output per unit time. Therefore, parts must be assigned to machines capable of output that can match the MPS requirements.

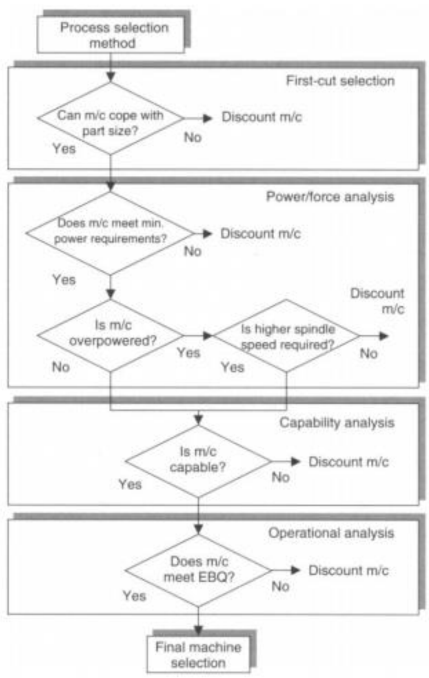
Availability- this can be defined on two levels. The first definition is that of whether the machine required is already being used or not, that is, is it available or unavailable. However, in terms of equipment effectiveness, availability can be defined as the proportion of time a machine is actually available to perform work out of the time it should be available (Nicholas, 1998). This, in turn, relates to the overall efficiency and reliability for the machine.

MACHINE SELECTION METHOD

Even though there are various factors that must be considered in the selection of a suitable machine for a given job, relatively speaking it is still an easier task than the initial process selection. This is based on a preliminary machine selection method developed by Halevi and Weill (1995).

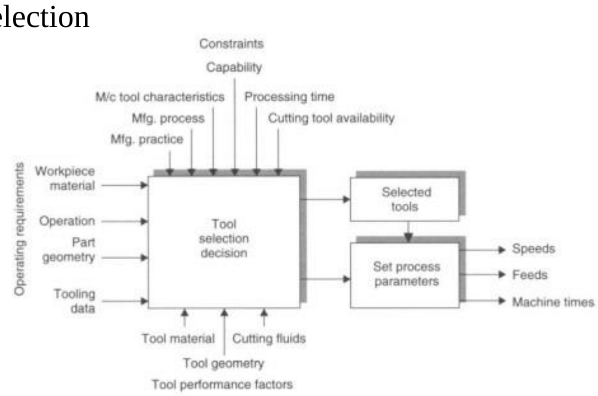
1 First cut selection
2 Power/force analysis
3 Capability analysis
4 Operational analysis
5 Final selection

TOOLING FOR SPECIFIC PRODUCTION EQUIPMENT



FACTORS IN TOOLING SELECTION

1.Constraints On Tool Selection



Factors Affecting Tooling Performance

Generally, the kind of surface finish produced by the cutting operation depends on the shape of the tool and the path it takes through the material. However, when the cutting edge of the tool starts to wear, the surface finish gained will deteriorate and the cutting forces will rise. Signs that significant tool wear has occurred are indicated by excessive vibration and chatter during machine tool operation and increased power requirements. The three basic factors that determine tool performance are

- the tool material
- the tool geometry
- the use of cutting fluids

TOOLING SELECTION METHOD

In the previous section, the factors affecting the selection of suitable tooling were considered. In this section, a method for tool selection will be outlined which incorporates the selection factors. This is a five-stage process as follows:

1.Evaluation of process and machine selections- Provided the selection of processes and machines is satisfactory, the range of tools that can be used should be limited to those suitable for the processes and machines selected. Therefore, this limits the initial list of possible suitable tooling.

2. Analysis of machining operations- A specific machine will carry out every operation required. Each machine tool to be used will have specific tool types to carry out certain operations. Therefore, this analysis should enable the identification of specific tool types for specific operations.

3. Analysis of workpiece characteristics - The focus of the workpiece analysis is on the workpiece material and geometry and the capability in terms of dimensional and geometric accuracy and surface finish. The analysis of the first two characteristics enables suitable tool materials and geometry (in terms of size and shape) to be identified. The third characteristic allows the tool type and geometry to be refined further to suit the operations.

4.Tooling analysis- Using the tooling data available, the general tooling specifications generated at the third stage can be translated into a statement of tooling requirements for the job, that is, a tooling list. This will obviously reflect whatever tooling is actually available for the operations required.

5. Selection of tooling - There are two routes that the tool selection can take at this point. If single-piece tooling is being used, then a suitable toolholder should be selected before fully defining the tool geometry and material. However, if insert-type tooling is being used then the following steps should be followed (Black et al., 1996):

(i) select clamping system;
(ii) select tool holder type and size;
(iii) select insert shape; 206 Process Planning
(iv) select insert size;
(v) determine tool edge radius;
(vi) select insert type;
(vii) select tool material.

Once all of the above is completed, the machining parameters can be calculated as previously illustrated in Fig. 5.35. These will be the speeds, feeds and machining times for each operation. All of the above factors will have a significant influence on the determination of these parameters.

UNIT II

PROCESS PLANNING ACTIVITIES

2.1 Process Parameters

We can analyze a process through different ***parameters***.

Input rate gives the entering rate of jobs; in **[Q/T]**

Output rate *(i.e.* ***flow rate, production rate, throughput rate****)* gives the exit rate of jobs

Capacity is the maximum output rate possible; **[Q/T].**

Cycle time (CT) is the reciprocal of capacity; in **[T/Q].**

Actual cycle time is the reciprocal of output rate; in **[T/Q].**

Minimum Manufacturing Lead Time (MLT) (flow time) is the fastest processing time for a transaction to go through the process, when the process is empty; in **[T].**

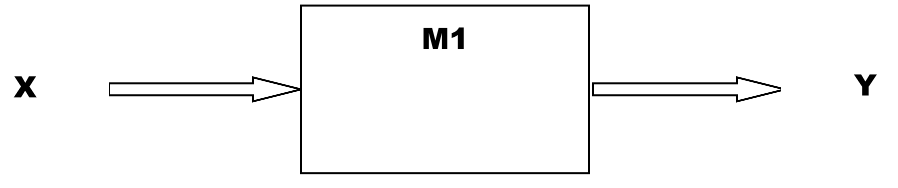
Average Manufacturing Lead Time (MLT) (flow time) is the average time required for a transaction to go through the process; in **[T].**

Work-In-Process (WIP) is the *average (over time)* number of transactions in the process; in **[Q].**

We will also use ***Gantt Charts*** to depict information pictorially. The horizontal axis of a Gantt chart generally represents time scale. In a machine based Gantt chart, different machines (resources) are plotted along the vertical axis and machine utilization is shown. In a job based Gantt chart, jobs (transactions) are plotted on the vertical axis to show the progress of each job. We will generally use machine-based charts.

Example 1.1

A service involves one machine (M1) performing a single task and it takes exactly 4 minutes per task. Component "X" is processed at M1 and comes out as product Y.



We will analyze three situations:

(a) A new component is scheduled every 10 minutes.

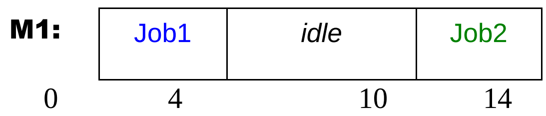
(b) A new component is scheduled every 4 minutes.

(c) A new component is scheduled every 3 minutes.

We will assume that in each case, the first component entering the system will be called job 1, the second one job 2, and so on.

Part (a):

The Gantt chart is as follows:

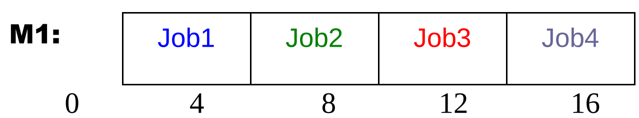


Since each job enters the system every 10 minutes, the input rate will be 1/10 **[units / min]**. The output rate will be 1/10 **[units / min].** The actual cycle time is 10 **[min / units]**. The average MLT is 4 **[min].**

Notice in the Gantt chart that between time units 4 to 10, the machine is ***idle***.

Part (b):

We draw a Gantt chart for the situation.

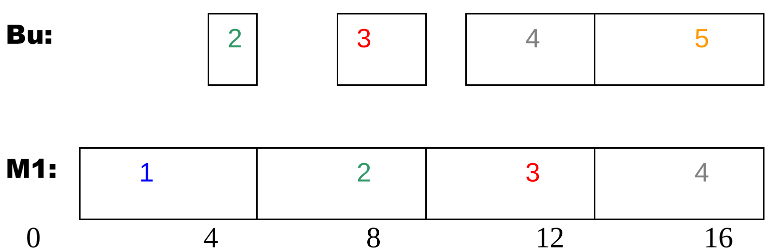


Since each job enters the system every 4 minutes, the input rate is 1 / 4 **[unit / min].**

Job 1 will go immediately to M1. After 4 minutes, job 1 will be released from M1, Job 2 will enter the system at the same time and will go to M1. Also, the output rate will be same as the input rate, i.e. Output rate = 1 / 4 **[unit / min]** = 15 **[units / hour].** The actual cycle time is 4 **[min / units]**. The average MLT is 4 **[min].**

Part (c):

In this case we will need a buffer.



Since each job enters the system every three minutes, the input rate will be 1/3 **[unit / min]** or 20 **[units / hour].** However, M1 can process jobs every 4 minutes. So the output rate will be only 1/4 **[unit / min]** = 15 **[units / hour].** In fact, in the Gantt chart for first few jobs, we can see that some jobs need to be placed in the buffer (Bu). Job 1 goes directly to M1 at 0 and comes out at 4. Job 2 arrives in the system at time 3, stays in the buffer for 1 minute. Job 3 stays in the buffer for 3 minutes. You can see that every subsequent job stays one more minute in the buffer that the previous job and we won't be able draw all theses jobs in the buffer.

The actual cycle time is 4 **[min / units]**. The minimum MLT is 4 **[min].** The average MLT tends to infinity as time goes to infinity. In fact, each successive transaction stays 1 minute longer and the system never becomes stable. In fact any process will not become stable if the input rate is greater than the system capacity.

2 JIGS AND FIXTURES

Jigs and fixtures are devices used to locate and hold the work that is to be machined. A jig is a guiding device, and a fixture is a holding device. A jig or fixture can be designed for a particular job. The form to be used depends on the shape and requirements of the workpiece that is to be machined.

There are generally two types of jigs used: the clamp jig and the box jig. Various names are applied to jigs (such as drilling, reaming, and tapping) according to the operation to be performed. Clamp jigs are sometimes called open jigs. Frequently, jigs are named for their shape, such as plate, ring, channel, and leaf.

A fixture anchors the workpiece firmly in place for the machining operation, but it does not form a guide for the tool. It is sometimes difficult to differentiate between a jig and a fixture, since their basic functions can overlap in the more complicated designs.

A plate jig consists of a plate, which contains the drill bushings, and a simple means of clamping the work in the jig, or the jig to the work. Where the jig is clamped to the work, it sometimes is called a clamp-on jig.

An indexing fixture can be used for machining operations that are to be performed in more than one plane. It facilitates location of the given angle with a degree of precision.

2.1 How do jigs and fixtures differ

Jigs	Fixtures
1. It is a work holding device that holds,supports and locates the workpiece and guides the cutting tool for a specific operation	1. It is a work holding device that holds, supports and locates the workpiece for a specific operation but does not guide the cutting tool
2. Jigs are not clamped to the drill press table unless large diameters to be drilled and there is a necessity to move the jig to bring one each bush directly under the drill.	2. Fixtures should be securely clamped to the table of the machine upon which the work is done.
3. The jigs are special tools particularly in drilling, reaming, tapping and boring operation.	3. Fixtures are specific tools used particularly in milling machine, shapers and slotting machine.
4. Gauge blocks are not necessary.	4. Gauge blocks may be provided for effective handling.
5. Lighter in construction.	5. Heavier in construction.

2.2 ADVANTAGES OF JIGS AND FIXTURES

PRODUCTIVITY:

Jigs and fixtures increases the productivity by eliminating the individual marking, positioning and frequent checking. The operation time is also reduced due to increase in speed, feed and depth of cut because of high clamping rigidity.

INTERCHANGEABILITY AND QUALITY:

Jigs and fixtures facilitate the production of articles in large quantities with high degree of accuracy, uniform quality and interchangeability at a competitive cost .

SKILL REDUCTION:

There is no need for skillful setting of work on tool. Jigs and fixtures makes possible to employ unskilled or semi skilled machine operator to make savings in labour cost.

COST REDUCTION:

Higher production, reduction in scrap, easy assembly and savings in labour cost results in ultimate reduction in unit cost.

2.3 FUNDAMENTAL PRINCIPLES OF JIGS AND FIXTURES DESIGN

LOCATING POINTS: Good facilities should be provided for locating the work. The article to be machined must be easily inserted and quickly taken out from the jig so that no time is wasted in placing the work piece in position to perform operations. The position of work piece should be accurate with respect to tool guiding in the jig or setting elements in fixture.
FOOL PROOF: The design of jigs and fixtures should be such that it would not permit the work piece or the tool to inserted in any position other than the correct one.
REDUCTION OF IDLE TIME: Design of Jigs and Fixtures should be such that the process, loading, clamping and unloading time of the work piece takes minimum as far as possible.
WEIGHT OF JIGS AND FIXTURES: It should be easy to handle, smaller in size and low cost in regard to amount of material used without sacrificing rigidity and stiffness.

JIGS PROVIDED WITH FEET: Jigs sometimes are provided with feet so that it can be placed on the table of the machine.
MATERIALS FOR JIGS AND FIXTURES: Usually made of hardened materials to avoid frequent damage and to resist wear. Example- MS, Cast iron, Die steel, CS, HSS.

CLAMPING DEVICE:

It should be as simple as possible without sacrificing effectiveness. The strength of clamp should be such that not only to hold the work piece firmly in place but also to take the strain of the cutting tool without springing when designing the jigs and fixtures.

2.4 ESSENTIAL FEATURES OF JIGS AND FIXTURES

- Reduction of idle time – Should enable easy clamping and unloading such that idle time is minimum
- Cleanliness of machining process – Design must be such that not much time is wasted in

cleaning of scarf's, burrs, chips etc.

・Replaceable part or standardization – The locating and supporting surfaces as far as possible should be replaceable, should be standardized so that their interchangeable manufacture is possible

・Provision for coolant – Provision should be there so that the tool is cooled and the swarfs and chips are washed away

・Hardened surfaces – All locating and supporting surfaces should be hardened materials as far as conditions permit so that they are not quickly worn out and accuracy is retained for a long time

・ Inserts and pads – Should always be riveted to those faces of the clamps which will come in contact with finished surfaces of the work piece so that they are not spoilt

・ Fool-proofing – Pins and other devices of simple nature incorporated in such a position that they will always spoil the placement of the component or hinder the fitting of the cutting tool until the latter are in correct pos

・Economic soundness – Equipment should be economically sound, cost of design and manufacture should be in proportion to the quantity and price of producer

・ Easy manipulation – It should be as light in weight as possible and easy to handle so that workman is not subjected to fatigue, should be provided with adequate lift aids

・ Initial location – Should be ensured that work piece is not located on more than 3 points in anyone plane test to avoid rocking, spring loading should be done

・ Position of clamps – Clamping should occur directly above the points supporting the work piece to avoid distortion and springing

・Clearance – Sufficient amount of clearance should be provided around the work so that operator's hands can easily enter the body for placing the work piece and any variations of work can be accommodated

・ Ejecting devices – Proper ejecting devices should be incorporated in the body to push the work piece out after operation

・ Rigidity and stability – It should remain perfectly rigid and stable during operation. Provision should be made for proper positioning and rigidly holding the jigs and fixtures

・ Safety – The design should assure perfect safety of the operator

2.5 FACTORS TO BE CONSIDERED FOR DESIGN OF JIGS AND FIXTURES

1. Component- Design to be studied carefully Ensure work is performed in a proper sequence Maximum operations should be performed on a machine in single setting

2. Capacity of the machine- Careful consideration to be performed on type and capacity of machine.

3. Production requirements- Design to be made on basis of actual production requirements. Then comes decision on manual and automatic tooling arrangements.

4. Location-

• Location should ensure equal distribution of forces throughout all sequence of operation.
• Location should be hard resistant, wear resistant and high degree of accuracy.
• Movement of work piece should be restricted.
• Should be fool proofed to avoid improper locations of the work piece.
• Should facilitate easy and quick loading of work piece.
• Redundant locators should be avoided.
• Sharp corners must be avoided.
• At least one datum surface should be established.

5. Loading and Unloading arrangements- There should be adequate clearance for loading and unloading. Hence process becomes quick and easy. Size variation must be accepted. It should be hardened material and non sticky.

6. Clamping arrangements- Quick acting clamps must be used as far as possible. The clamping should not cause any deformation to the work piece It should always be arranged directly above points supporting the work. Power driven clamps are favoured as they are quick acting, controllable, reliable and operated without causing any fatigue to the operators.

Features of clamps:
Clamping pressure should be low
Should not cause distortion
Simple and fool proof
Movement of clamp should be minimum
Case hardened to prevent wear
Sufficiently robust to avoid bending

7. Clearance between Jig and Component- To accommodate various sizes if work Chips to pass out of the opening between them

8. Ejectors- To remove work from close fitting locators. Speeds up unloading of the part from the tool and hence production rate.

9. Base and Body construction- Methods used: Machining, Forging and machining, Casting, Fabricating, Welding.

10. Tool guiding and cutter setting- By adjusting the machine or using cutter setting block, the cutter is set relative to the work in a fixture. The drill bushes fitted on jig plates guides the tools.

11. Rigidity and vibration- Must possess enough rigidity and robustness. Should not vibrate as it may lead to unwanted movement of work piece and tools.

12. Safety- Operation should be assured full safety.

13. Cost- Should be simple as possible. Cost incurred should be optimum.

14. Materials generally used-

Sl. No	**Part Name**	**Material**
1	Jig body	CI
2	Stud	MS
3	Drill/Bush	Gun metal
4	Pin	MS
5	Nut	MS

3 SELECTION OF QUALITY ASSURANCE METHODS

Based on the capability of the process being employed, the process planner will determine which are the most appropriate quality assurance (QA) tools and techniques to employ. These will range from basic measurement tools such as callipers, micrometers and gauges to the use of coordinate measuring machines (CMMs). Also covered will be the application of statistical process control (SPC) methods. Although SPC and process capability studies will most probably be designed and carried out by quality engineering, it is essential that the process planner has an understanding of these in order to enter into meaningful dialogue with regards to process capability. In fact, the process planner will have to liase closely with the quality function on a number of issues with regards to the process plan. These include:

- identifying inspection locations;
- identifying appropriate inspection and testing methods;
- the frequency of inspection and testing;
- evaluation of inspection and test data;
- identifying corrective action where appropriate.

3.1 Quality management systems and principles

A quality management system is generally accepted to be the 'procedures put in place to ensure that quality is promoted throughout every activity in the organization' (Fox, 1995). A specific definition of a quality management system is: A management system to direct and control an organization with regard to quality (ISO 9000). It should be noted that in the context of this definition the quality management system is just one of a number of management systems within the organization put in place to meet the organizational objectives. The quality management system should have two objectives (Burman, 1995):

- To define performance standards for all activities compatible with the products being manufactured, the customer's requirements and doing so at minimum cost;
- To operate on the basis of continuous improvement to maintain a competitive advantage. Based on these two objectives, the performance standards are set and continuously improved in recognition of the changing market demands in terms of customer requirements and level of competition. For any quality management system to be successful in meeting the above objectives, there must be clear underlying principles. These principles must enable the systematic management of the organization and help it maintain and improve upon its success. A framework of eight quality management principles has been developed to enable this continuous improvement for an organization (MacNee *et al.,* 2000):

Customer focus- recognizing that organizations rely upon customers for their success. Therefore, organizations should endeavor to understand their present needs and to anticipate their future needs. Furthermore, organizations *Selection of quality assurance methods* 329 should not only strive to meet customer requirements but strive to exceed their expectations.

Leadership - helping to establish common objectives and direction for the organization. Proper leadership should develop an organizational culture of involvement at different employee levels to achieve the common objectives.

Involvement of people- at all levels, not only in meeting the common objectives, but to help realize the full potential of their abilities for the benefit of the organization.

Process approach- allows resources and operations to be managed more efficiently.

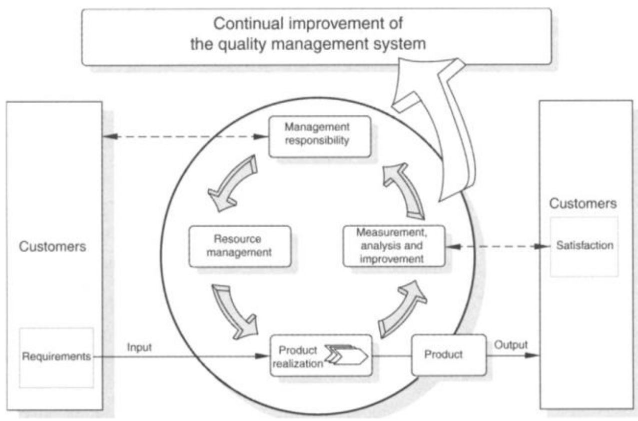
Systems approach to management- which identifies and understands the complexity of the sub-systems and processes that interact within the organization, thus improving the organization's ability to meet its objectives.

Continuous improvement- of an organization's overall performance. This should not only be an objective of the quality management system, but also be recognized as an organizational objective.

Factual approach to decision-making- which allows effective decision making based on the analysis of data and information.

Mutually beneficial supplier relationships - recognizing the need to manage the supply chain to minimize waste and maximize added value.

3.2 ISO 9000:2000

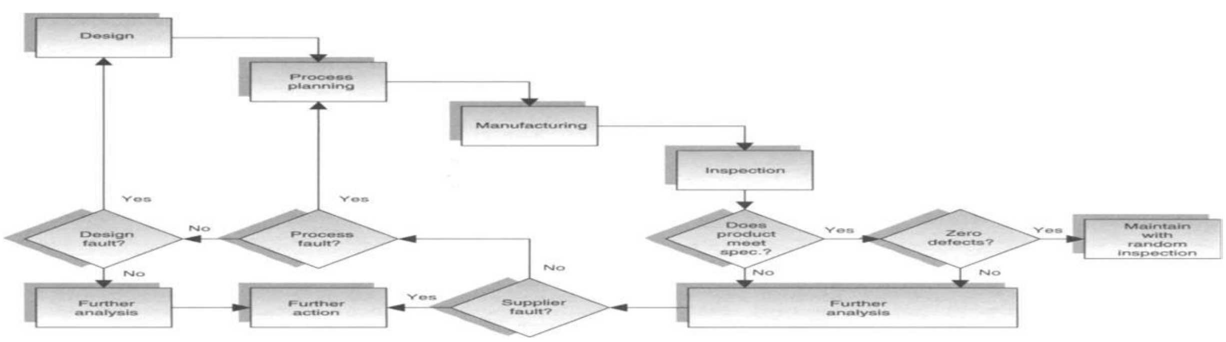


Model of a process-based quality management system (courtesy of British Standards Institute)

If the family of standards is used as outlined above, that is, as a consistent pair of standards, the following are considered as the potential benefits (MacNee *et al.*, 2000):

- a quality management system that is fully integrated into an organization's business practices; improved awareness of customer requirements and expectations;
- better organizational communications;
- streamlined documentation for the quality management system;
- focus on measurement and results as opposed to simply compliance;
- continuous improvement of the system itself;
- improved ability to consistently meet customer requirements;
- Improved customer satisfaction.

3.3 QUALITY IN MANUFACTURING



4 SET OF DOCUMENTS FOR PROCESS PLANNING

The following information's are required to do the process planning effectively:
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.

5 ECONOMICS OF PROCESS PLANNING

Manufacturing costs play an important part in the successful design and manufacture of a product. Based on the model of added value, the manufacturing costs must be less than the value added to allow a profit to be made. Therefore, the costing of the design and manufacture of a product is vital in ensuring success. In addition, costs are very often used for making decisions for the design and manufacture of a product. The types of decisions that can be made based on costs are:

- the type of material to be used for a product;
- the type of manufacturing process to be used for a product;
- how many of a product to manufacture;
- whether to make or buy in a product/part;
- the design of a product.

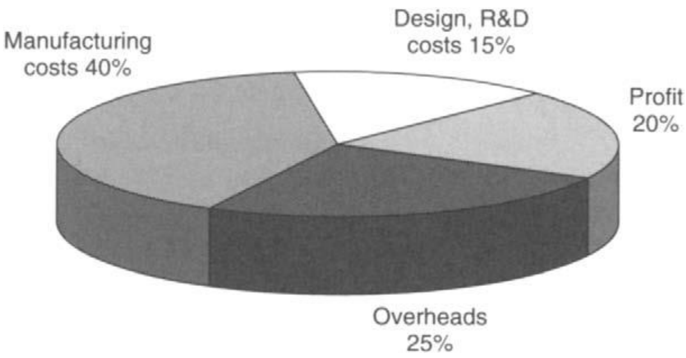
5.1 What do manufacturing organizations use financial information for?

In order to operate efficiently as described above, the manufacturing organization must use financial information and techniques, most of which comes under the classification of management accounting, for three basic purposes:
Control- financial information is used to help control the manufacturing system efficiently, including the preparation of budgets and cost analysis. The manufacturing engineer carries out a cost analysis during the process planning phase.
Decision making - based on proposed or alternative courses of action, probable costs and effects on profits are analyzed, that is, 'what if' scenarios are evaluated. This type of activity is also carried out during the process plan. Typical decisions to be made are about the type of manufacturing process to be used, the quantity to be produced, whether to 'make or buy' a component and the type of material to be used.
Reporting and recording- involves the compilation and upkeep of financial records and statements such as profit and loss accounts and for tax purposes and monthly management accounts. The focus of this chapter will be firmly on cost control during manufacture and the use of financial data for decision making with regards to process planning.

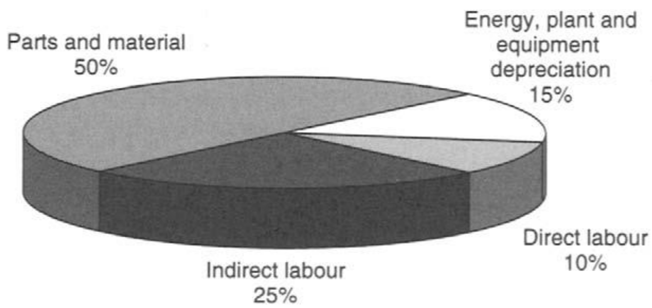
5.2 What costs are associated with manufacturing?

Various costs contribute towards the selling price of a finished product. These are manufacturing costs, design/R&D costs, overheads (typically marketing, sales, customer service and administration costs) and the profit margin. They are illustrated in Fig. 9.1 with typical percentages used to show the contribution each makes to the final selling price (DeGarmo *et al.*, 1988; Mair, 1993).

Cost elements of product selling price



Elements of manufacturing costs



Example 1 *A small drive shaft is produced using a CNC lathe. The machine operator's hourly rate is s per hour The time taken to machine the drive shaft is 15 min. The order is for 1500 units. Calculate the direct labour cost for producing the drive shafts.*

Solution

Hourly rate = s

Direct labour hours = 1500 x (15/60) h = 375 h

Direct labour cost = Hourly rate x Direct labour hours

= s X 375

= s

Direct material is all the material purchased and used in the finished product, including any scrap/waste incurred. Examples of these are sheet steel and sub-assemblies for the automobile industry. This can be calculated by multiplying the material cost per unit by the number of units produced, that is,

Direct material cost = Material cost/unit x Number of units produced

Example 2 *In Example 1, the steel billet used for manufacturing the drive shaft costs s per unit (the order is for 1500 units) including chuck allowance and scrap. Calculate the direct material costs.*

Solution

Material cost/unit = s
Number of units = 1500
Direct material cost = Material cost/unit X Number of units
= s 1.67 X 1500
= s

TABLE : *Examples of indirect costs*

Indirect materials	*Indirect labour*	*Indirect expenses*
Lubricating oil	Shop floor	supervision Factory rent
Maintenance materials	Maintenance	Factory rates
Plant spares	Store men	Plant insurance

CASE STUDY

Example 2.12 ***A mild steel spindle is shown in Fig.2.11, is required to be manufactured in a workshop. Present the various activities involved in process planning.***

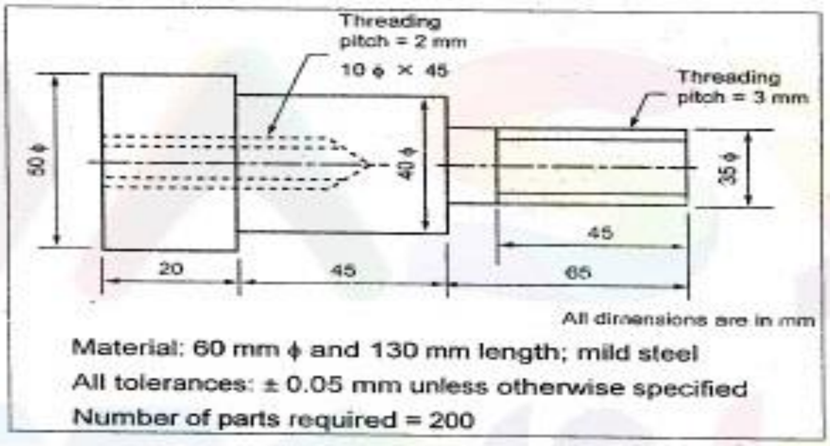


Fig. 2.11. Spindle

Solution: As discussed in Section 1.3, the various activities to be carried out to manufacture the mild steel spindle shown in Fig.2.11, are give

1. The given component drawing is carefully analysed to identify and list out the key features of the part. The important features of the component identified from the drawing interpretation are:
   (i) The spindle has to be manufactured from 60 mm ϕ and 130 mm length stock.
   (ii) The spindle consists of the three concentric cylinders.
   (iii) One internal thread and one external thread are to be cut.

(iv) Material of the component is mild steel.
(v) The dimensional tolerance is ± 0.05 mm
(vi) Number of parts to be made = 200

2. The next step is identification of the operations involved and the sequence of operation. To manufacture the given spindle, the following operations are to be carried out.
   (i) ***First operation:*** Turning from 60 mm ϕ to 50 mm ϕ for 130 mm length.
   (ii) ***Second operation:*** Turning from 50 mm ϕ to 40 mm ϕ for 110 mm length.
   (iii) ***Third operation:*** Turning from 40 mm ϕ to 35 mm ϕ for 65 mm length.
   (iv) ***Fourth operation:*** Drilling a 10 mm ϕ hole for a 45 mm length.
   (v) ***Fifth operation:*** Internal threading
   (vi) ***Sixth operation:*** External threading

3. Based on the operations identified, the machines, cutting tools and measuring and checking instruments are appropriately selected, as shown below.

Sl.No.	Operation	Machine	Tool
1.	Turning to 50 mm ϕ	Centre lathe	Single point cutting tool
2.	Turning to 40 mm ϕ	Centre lathe	Single point cutting tool
3.	Turning to 35 mm ϕ	Centre lathe	Single point cutting tool
4.	Drilling of 10 mm ϕ hole	Centre lathe	Twist drill
5.	Internal threading (Tapping)	Tap	Tap and tap wrench
6.	External threading	Centre lathe	Die with die holder and collet
Measuring and checking instruments: Steel rule, vernier caliper, depth gauge, thread plug gauge, ring thread gauge.			

4. The cutting speed, feed and depth of cut for the operations are to be appropriately selected from the data book. The suggested processing parameters are:

Cutting speed for turning = 28 m/min
Cutting speed for thread cutting = 10 m/min
Cutting speed for drilling = 30 m/min
Feed for turning = 1 mm/rev
Feed for drilling = 0.25 mm/rev
Depth of cut = 3 mm

5. The process planning is complete with the documentation of all the above details in the route sheet.

INTRODUCTION

Cost estimation may be defined as the process of forecasting the expenses that must be incurred to manufacture a product.

These expenses take into consideration all expenditures involved in design and manufacturing with all the related service facilities such as pattern making, tool making as well as portion of the general administrative and selling costs. Cost estimates are the joint product of the engineer and the cost accountant.

Estimating is the calculation of the costs which are expected to be incurred in manufacturing a component in advance before the component is actually manufactured.

Costing may be defined as a system of accounts which systematically and accurately records every expenditure in order to determine the cost of a product after knowing the different expenses incurred in various department.

REASONS FOR DOING ESTIMATES

Cost estimates are developed for a variety of different reasons. The most important reasons are shown below.

Should the product be produced? When a company designs a new product, a detailed estimate of cost is developed to assist management in making an intelligent decision about producing the product.

This detailed estimate of cost includes an estimate of material cost, labour cost, purchased components and assembly cost. In addition to product cost, many other elements must be estimated. These include all tooling costs.

A cost estimate must be developed for jigs, fixtures, tools, dies and gauges. Also, the cost of any capital equipment must be entered into the estimate. These figures are usually supplied through quotation by vendors.

An estimate of this nature will include a vast amount of details, because if management approves the project, the estimate now becomes the budget.

Estimates as temporary work standards. Many companies that produce product in high volume, such as automotive companies, will use estimates on the shop floor as temporary work standards.

Temporary work standards are replaced with time studied work standards as rapidly as possible.

IMPORTANCE OF ESTIMATING

Estimating is of great importance to a concern because it enables the factory owner to decide about the manufacturing and selling policies.

It is obvious that too high estimates will not get jobs to the firm by quoting higher rates according to over estimate whereas under estimating will put the owner to a loss and will lead the concern to utter failure.

So, estimation should be carried out accurately. The persons preparing estimates should be highly qualified and experienced. They should be chosen from shops or should be first trained in all the shop methods and their estimates preparation.

OBJECTIVES OR PURPOSE OF ESTIMATING

The main purpose or objective of estimating are

- To establish the selling price of a product.
- To ascertain whether a proposed product can be manufactured and marketed profitably.
- To determine how much must be invested in equipment.
- To find whether parts or assemblies can be more cheaply fabricated or purchased from outside (make or buy decision).
- To determine the most economical process, tooling or material for making a product.
- To establish a standard of performance at the start of project. For feasibility studies on possible new products.
- To assist in long term financial planning.
- To prepare production budget.
- To help in responding to tender enquiries.
- To evaluate alternate designs of a product.
- To set a standard estimate of costs.
- To initiate programs of cost reduction that result in economics due to the use of new materials, which produce lower scrap losses and which create savings due to revisions in methods of tooling and processing, and
- To control actual operating costs by incorporating these estimates into the general Plan of cost accounting.

FUNCTIONS OF ESTIMATING

(i) To calculate the cost of new material needed to manufacture a product.

(ii) To find the cost of parts to be purchased from outside vendors.

(iii) To find the cost of equipment, machinery, tools, jigs and fixtures etc. required to be purchased to make the product.

(iv) To calculate the direct and indirect labour cost associated with the manufacture of the product, based upon work study.

(v) To calculate various overhead charges associated with the product.

(vi) To decide about the profit to be charged, taking into consideration other manufacturers of same product in the market.

(vii) To calculate the selling price of the product.

(viii) To maintain records of previous estimating activities of the company for future references.

(ix) To decide the most economical method of making the product.

(x) To submit cost estimates with the competent authority for further action.

COST ACCOUNTING OF COSTING

It is the determination of an actual cost of a component after adding different expenses incurred in various departments or it may be defined as a system which systematically records all the expenditures to determine the cost of manufactured products.

The work of cost accountings begins with the pre-planning stage of the product. It ends only after the whole lot of the product has been fully manufactured. Costing progresses with the progress of the product through the plant.

IMPORTANCE OF COSTING

Costing is an essential work for the efficient management of any enterprise and gives most useful information for the preparation of financial accounts.

It enables a business not only to find out what various jobs or processes have costed but also what they should have costed.

It indicates where losses are wastage are occurring before the work is finished, so that immediate action may be taken to avoid such loss or waste. Also all expenditure are localized and thereby controlled in the light of information provided by the cost records.

Costing shows which type of output will yield a profit and which type does not. Thus, it makes up the deficiency.

A planned system of cost accounting will point out the weak spots and thus enable the administration to have a clear picture and show up immediately the essential facts in such a way that the responsible persons can put forth their efforts to bring improvements and reduce costs.

Costing has proved so beneficial that nowadays almost every concern has adopted the cost accounting system.

AIMS OF COST ACCOUNTING

The purpose of costing are:

1. To compare the actual cost with the estimated cost to know whether the estimate had been realistic or not.
2. Wastages and undesirable expenses are pointed out requiring corrective measures.
3. The costing data helps in changing the selling price because of change in material cost of labour cost etc.
4. It helps to locate the reasons for the increase or decrease of loss of profits of a company.
5. It helps in determining the discount on catalogue or market price of the product.
6. The actual cost helps the company to decide whether to continue with the manufacture of a product or to buy it from outside.
7. It helps the enterprise to prepare its budget.
8. The costing data helps to formulate policies and plans for the pricing of a new job.
9. It helps in regulating from time to time the production of a job so that it may be profitable to the company.

METHODS OF COSTING

(a) Process costing.
(b) Job costing.
(c) Batch costing.
(d) Hybrid costing systems.

(a) Process costing

Process cost sheet						
Accounting Period……………..						
Date Ref. Mat. Labour Over/head Cost-Center-I				*Cost Center-2*		
(OH)	*Mat.*	*Labour*	*O.H.*	*Mat.*	*Labour*	*O.H.*

• This method is employed when a standard product is being made which involves a number of distinct processes performed in a definite sequence.

Introduction to Cost Estimation 83

• In oil refining, chemical manufacture, paper making, flour milling, and cement manufacturing etc., this method is used.

• The object i.e., record and trace cots for each distinct stage.

• While costing, the by-products of each process should be considered.

• This method indicates the cost of a product at different stages as it passes through various processes.

• The total time spent and materials used on each process, as well as services such as power, light and heating are all charged. For this purpose cost sheet may be employed.

The process cost sheet is a summary of all operations for the month. The current operating charges are entered on the sheet showing

1. The transfer cost from the previous operation.
2. The costs incurred by each operation showing materials, labour and overhead in separate columns.

This separation of transfer cost and conversion cost is extremely important for the charges incurred by a department are its measures of efficiency.

The sheet can be used as a basis for:

1. Closing entries at the end of each month.
2. Operating statements, without need to lookup the ledger accounts.

Within the cost ledger an account is kept for each process. The direct material, direct labour and factory overhead costs are transferred from the process cost sheet. There are debited to the process account, and then any completed units are credited to cover the transfer to the next process. The balance on the account represents the work -in-progress at the end of the period, which, of course, becomes the opening balance for the next period.

(b) Job costing or order costing

- Job costing is concerned with finding the cost of each individual job or contract. Examples are to be found in general (job order) engineering industries, ship building, building contracts, etc.
- The main features of the system is that each job has to be planned and costed separately.
- Overhead costs may be absorbed on jobs on the basis of actual costs incurred or on predetermined costs.
- The process of determining in advance what a job or order will cost is known as estimating.

It involves consideration of the following factors for each job/order:

1. Materials requirements and prices to arrive at the direct material cost.
2. Labour hours and rates to determine labour costs.
3. Overhead costs.
4. Percentage added to total cost to cover profit.

A record of above costs per unit time is kept in separate cost sheets.

(c) Batch costing

- Batch costing is a form of job costing. Instead of costing each component separately, each batch of components are taken together and treated as a job. Thus, for example, if 100 units of a component, say a reflector are to be manufactured, then the costing would be as far a single job. The unit price would be ascertained by dividing the cost by 100. 84 Process Planning and Cost Estimation
- Besides maintaining job cost sheets it may also be necessary to keep summary sheets on which the cost of each component can be transferred and the cost of the finished product can be calculated. This applies in general engineering where many hundreds of components may go towards making the finished machine or other product.

(d) Hybrid costing systems

- Many costing systems do not fall nearly into the category of either job costing or process costing. Often systems use some features of both main costing systems.
- Many engineering companies use batch costing, which treats each batch of components as a job and then finds the average cost of a single unit.
- Another variation is multiple costing, used when many different finished products are made.

Many components are made which are subsequently assembled into the completed article, which may be bicycles, cars, etc. Costs have to be ascertained for operations, processes, units and jobs, building together until the total cost is found.

- Different names may be used to describe either process costing or job costing. Thus, for example, unit costing is the name given to one system where there is a natural unit, such as sack of flour, a barrel of beer etc.
- In unit costing method, the expenses on various items are charged per unit quantity or production.
- Operation costing is a variation of unit costing, and is used when production is carried out on a large scale, popularly known as mass production.
- Operation costing is the term applied to describe the system used to find the

cost of performing a utility service such as transport, gas, water or electricity.
• In this method, the cost per unit is found on the basis of operating expenses incurred on various items of expenditure.
• Unit costing, operation costing and operating costing are variations of process costing.
• Contract or terminal costing is the name given to job costing employed by builders and constructional engineers.
• All these methods ascertain the actual cost.

Departmental costing method

In big industries like steel industry or automobile industry each department is producing independently one or more components. Departmental costing method is used in such industries and the actual expenditure of each department on various products is entered on the separate cost sheet and the costing for each department is separately undertaken.

DIFFERENCE BETWEEN COST ESTIMATING AND COST ACCOUNTING

Point of comparison	*Cost estimating*	*Cost accounting*
1. Type of cost	It gives an expected cost of the product based on the calculations by means of standard formulae or certain established rules.	It gives actual cost of the product based on the data collected from the different expenditures actually done for a product.
2. Duration of process	It is generally carried out before actual production of a product. Due to certain unforeseen or unexpected expenses coming to light at a later stage, estimate may be modified or revised.	It usually starts with the issue of order for production of a product and ends after the product is dispatched for sale. For sale commitments like free repair or replacement, the process continues upto the expiry period of guarantee or warranty because the overhead expenses incurred in the above case will be included in the production cost.
3. Nature of quality	A qualified technical person or engineer having a thorough knowledge of the drawings and manufacturing process is required. Thus, it is a technical work, instead of a clerical one.	It can be done by a person qualified for accounts instead of a technical person. The cost accountant develops his knowledge of technical person. The cost accountant develops his knowledge of technical terms and process while working. Thus, this work instead of being of technical nature is more of a clerical nature.
4. Main objectives	*(i)* To set standard for, with actual cost. *(ii)* To help in setting up market price for a proposed product to be manufactured. *(iii)* To decide whether it is economical to buy or manufacture a product under prevailing market conditions. *(iv)* To facilitate in filling up of tenders or quotation of products for supply. After receipt of supply order from the buyers the production will be started.	*(i)* To help in comparison of cost with estimates to know if they are over, under realistic as well as to know where the actual costs involve unnecessary wastage of men, materials, machines and money. *(ii)* To facilitate the budget preparation as well as to provide cost data for future estimates of new products of their pricing plans. *(iii)* To facilitate in deciding output targets time to time. *(iv)* To facilitate in meeting certain legal obligations or regulations.

DIFFERENCE BETWEEN FINANCIAL ACCOUNTING AND COST ACCOUNTING

• Accounting information is vital for showing the indebtedness of a business accounting uses words and figures to communicate the transactions which have been entered into.

• Both financial accounting and cost accounting are concerned with the recording of transactions so as to enable to calculate profit (or loss) for one or more transactions and to show the assets and liabilities owned or incurred by the business.

• Financial accounting is concerned with the external transactions and, therefore, record all dealings with the outside world. Any purchase or sale of goods and services and fixed assets, whether for cash or on credit are covered.

• Cost accounting, on the other hand, deals with the internal affairs of a business. It attempts to show the results of the operations carried out and emphasizes throughout the measurement and achievement of efficiency.

• Fixed assets, workers and materials are brought together with the object of transforming the resources employed and thereby obtaining a saleable product or service.

• Generally special attention is paid to the control aspect of the quantities and prices of the resources necessary for the transformation.

ELEMENTS OF COST INTRODUCTION

The total cost is made up of three main elements (figure 3.1).

1. Material.
2. Labour.
3. Expenses.

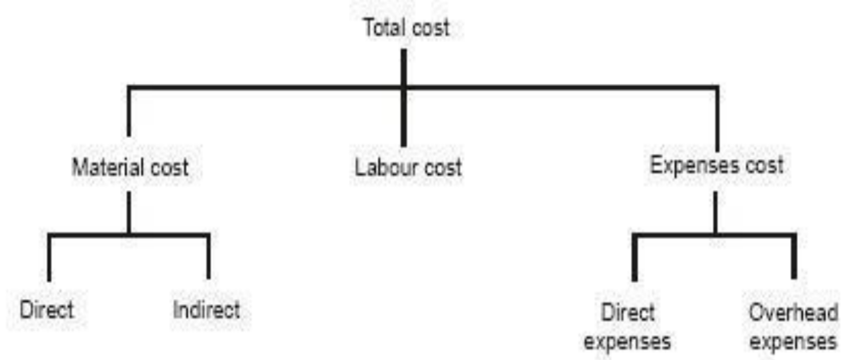


Fig. 3.1

MATERIAL COST

Material cost consists of the cost of materials which are used in the manufacture of product. It is divided into the following:

Direct Material Cost

It is the cost of those materials which are directly used for the manufacture of the product and become a part of the finished product.

The procedure for calculating the direct material cost is as follows:

(i) From the product drawing, make a list of all the components required to make the final product.

(ii) Calculate the volume of each component from the drawing dimensions after adding

machining allowances, wherever necessary.

(iii) The volume of component multiplied by the density of material used gives the weight of the material per component.

(iv) Add process rejection and other allowances like cutting allowance to get the gross weight per component.

(v) Multiply the gross weight by the rate of material per unit weight to get the cost of raw material per component.

(vi) The cost of raw material for all the components is, similarly, calculated and added up which gives the cost of direct material for the product.

Indirect Material Cost

In addition to direct materials a number of other materials are necessary to help in the conversion of direct materials into final shape. Though these materials are consumed in the production, they don_t become part of the finished product and their cost cannot be directly booked to the manufacture of a specific product. Such materials are called indirect materials.

The indirect materials include oils, general tools, greases, sand papers, coolants, cotton waste etc. The cost associated with indirect materials is called indirect material cost.

Depending upon the product manufactured, the same may be direct materials for one concern and indirect materials for others.

LABOUR COST

It is the expenditure made on the salaries, wages, overtime, bonuses, etc. of the employees of the enterprise. It can be classified as

Direct Labour Cost

Direct labour is one who actually works and processes the materials to convert it into the final shape. The cost associated with direct labour is called direct labour cost.

The direct labour cost can be identified and allocated to the manufacture of a specific product. Examples of the direct labour are the workers operating lathes, milling machines or welders, or assemblers in assembly shop. The direct labour cost may be allocated to a product or job on the basis of time spent by a worker on a job.

Determination of Direct Labour Cost

Determination of labour is much more complicated problem than calculating material cost. To find the labour cost one must have the knowledge of all the operations which are carried out for production of the product, tools and machines to be used and the departments in which the product is to be manufactured.

For calculating time required for a particular job following considerations should be taken into account:

(a) Setup time.
(b) Operation time.
  (i) Handling time.
  (ii) Machining time.
(c) Tear down time
(d) Down (or) lost time.
(e) Miscellaneous allowances:
(i) Personal allowance.
(ii) Fatigue allowance.
(iii) Tool sharpening and changing allowance.
(iv) Checking allowance.

(v) Other oiling and cleaning.

(vi) Filling coolant reservoirs.

(vii) Disposing of scraps and surplus stocks.

Setup time

Before starting any operation, first we have to set the job, tools and other auxiliary equipment. So, set up time is the time required for setting and fixing the jobs and tools on the machine.

Time to study the drawings, blueprints, time to make adjustment for getting the required size are all included in set up time. This time is also known as setting time.

Man (or) handling time

This is the time the operator spends loading and unloading the work, manipulating the tools and the machine and making measurements during each cycle of operation.

Machinery time

This is the time during each cycle of operation that the machine is working or the tools are cutting.

Example

Let us take the example of a drill press operation which has the following sequence of elements of handling and machining

Pick up part Place the jig Fit in the jig Position under drill Advance drill to work	Handling time
Drill hole through part	Machining time
Clear the drill from the work Move jig into clear position Release part from jig Remove part from jig	Handling time

Tear down time

Tear down time is the time required to remove the tools from the machine and to clean the tools and the machine after the last component of the batch has been machined. This time is usually small.

It will seldom run over 10 minutes on the average machine in the shop. It may require only a few minutes to tear down a set up on a drilling press and 10 to 15 minutes on the turret lathe. In exceptional case, it may go up to as high as 30 minutes on very large boring mills and large milling machines.

Down (or) lost time

This is the unavoidable time lost by the operator due to breakdowns, waiting for the tools and materials etc.

Miscellaneous allowances (allowances in estimation)

A worker cannot work for 8 hours continuously without rest. Also efficiency decreases as the time passes due to fatigue etc. He also requires for tool sharpening, checking measurements and personal calls. All these allowances come under this category. These allowances generally consumes 15 to 20% of total time.

(a) Personnal allowances

This is the time allowed for a worker for his personal needs like going to rest rooms, smoking, having a cup of tea, going to Lavatories to take water for personal cleanliness etc. This is generally about 5% of the total working time.

(b) Fatigue

The efficiency of the worker decreases due to fatigue (or) working at a stretch and also due to working conditions such as poor lighting, heating (or) ventilation. The efficiency is also affected by the psychology of the worker. It may be due to domestic worries, job securities etc. For normal work, the allowance for fatigue is about 5% of the total time. This allowance can be increased depending upon the type and nature of work and working conditions.

(c) Total sharpening and changing allowance

It is the time required to remove the tool and its holder, to walk up to the grinder to grind the tools, to come back to the machine and then to fix the tool again in the machine.

(d) Checking allowance

It is the time taken for checking the dimensions. Rough dimensions take less while accurate dimensions require more time. This allowance should be considered only when the operator is doing checking only and no work on the machine. If the checking is done during machining time it should not be considered. The checking times for the various instruments are given below to check one dimension.

With rule	0.10	minute
Vernier caliper	0.50	minute
Inside caliper	0.10	minute
Outside caliper	0.05	minute
Inside micrometer	0.30	minute
Outer micrometer	0.15	minute
Depth micrometer	0.20	minute
Dial micrometer	0.30	minute
Thread micrometer	0.25	minute
Plug gauge	0.20	minute
Snap gauge	0.10	minute

(e) Oiling and cleaning

It is the time required for cleaning the machine and to lubricate its various parts for smooth functioning of the machine.

(f) Filling coolant reservoirs

It is the time required for filling the reservoirs of the coolant which are used for cooling the jobs and tools.

(g) Disposing off scraps and surplus stocks

It is the time consumed for disposing off the scraps and other surplus stocks.

The miscellaneous allowances should be added to the set up, the operation and tear down times to complete the element.

Indirect Labour Cost

Indirect labourer is one who is not directly employed in the manufacturing of the product but his services are used in some indirect manner.

The indirect labour includes supervisors, foreman,storekeeper, gatekeeper, maintenance, staff, crane driver etc. The cost associated with indirect labour is called indirect labour cost.

The indirect labour costs cannot be identified with a particular job or product but are charged on the total number of products made during a particular period in a plant.

EXPENSES

Apart from material and labour cost in each factory there are several other expenditures such as cost of special layouts, designs, etc. hire of special tools and equipments; depreciation charges of plants and factory building; building rent; cost of transportation, salaries and commissions to salesman etc.

All these expenditures are known as overheads or expenses. So, from above it is clear that

Direct Expenses

Direct expenses also known as chargeable expenses include any expenditure other than direct material or direct labour incurred on a specific cost unit. These are the expenses which can be charged directly to a particular job and are done for that specific job only. For example, hire of special tools and equipment, cost of special jigs and fixtures or some special patterns and its maintenance cost,

costs of layouts, designs and drawings or experimental work on a particular job etc.

Indirect Expenses (Overheads)

These are known as overhead charges, burden or on cost. All the expenses over and above prime cost are indirect expenses. Overhead is the sum of indirect labour cost, indirect material cost and other expenses including service which cannot be conveniently charged to specific cost unit. These can be further classified as

1. Production expenses/Factory expenses.
2. Administrative expenses.
3. Selling expenses.
4. Distribution expenses.

(i) Production expenses

These expenses cover all indirect expenditures incurred by the undertaking from the receipt of the order until its completion ready for dispatch. Production expenses are also known as factory on cost, production overhead, factory overhead, work on cost, works overhead etc. Some examples of factory expenses or production expenses are:

(i) Rent, rates and insurance chargeable against the works.

(ii) Indirect labour example: supervision such as salaries of foreman, supervisors, factory manager etc.

(iii) Consumable stores and all forms of indirect material such as cotton waste, grease, oil etc.

(iv) Depreciation, maintenance and repair of buildings, plant, machine tools etc.,

(v) Power such as steam, gas, electricity, hydraulic or compressed air, internal transport etc.

(ii) Administrative expenses

These expenses include all the expenses on managerial or administerial staff for the planning and policy making work. Some examples of administrative expenses are:

(i) Salaries of directors and managing directors.

(ii) Salaries of cost, finance and secretary office staff including clerks and peons.

(iii) Expenses of direct amenities like telephone, coolers and other modern equipments.

(iv) Travelling expenses for attending meetings etc.

(v) Charges for electric consumption for light, heating and cooling.

(vi) Stationary, auditing expenses.

(vii) Insurance of building and employees, repairs, maintenance and depreciation of building and furniture.

(iii) Selling expenses

These consist of the expenditures spent towards securing orders, and finding or retaining markets for the products manufactured. Following is the list of selling expenses:

(i) Advertising and publicity expenses.
(ii) Salaries of the sales department staff including sales manager, salesman etc.
(iii) Travelling expenses of sales engineers.
(iv) Cost of preparing tenders and estimates.
(v) Expenses of making blocks and posters.
(vi) Sales stock storage charges.

(iv) Distribution expenses

These are the expenses which are paid for the distribution of the product. It includes the expenditure made on holding finished stock, packing cost and dispatching them to the customer. This type of expenses include

(i) Finished stock storages.
(ii) Lost of packing.
(iii) Loading, unloading charges, freight and warfare.
(iv) Expenses of transportation and vehicles.
(v) Salaries of dispatch clerks and labour's.

COST OF PRODUCT (LADDER OF COST)

The elements of cost can be combined to give following types of cost:

1. Prime cost: It consists of direct material cost, direct labour cost and direct expenses.
   Prime cost = Direct material cost + Direct labour cost + Direct expenses.
   Prime cost is also called as direct cost.
2. Factory cost: It consists of prime cost and factory expenses.
   Factory cost = prime cost + factory expenses.
   Factory cost is also named as works cost.
2. Office cost: It consists of factory cost and administrative expenses.
   Office cost = Factory cost + Administrative expenses
   It is also named as manufacturing cost (or) cost of production.
4. Total cost: It includes manufacturing cost and selling and distribution expenses. Total cost = Manufacturing cost + selling and distribution expenses.

Selling price

If the profit is added in the total cost of the product, it is called selling price. The customers get the articles by paying the price which is named as selling price.

Selling price = Total cost + Profit

= Total cost – Loss

Making price (or) catalogue price: Some percentage of discount allowed to the distributors of product is added into the selling price. The result obtained is called the market price (or) catalogue price (figure 3.2).

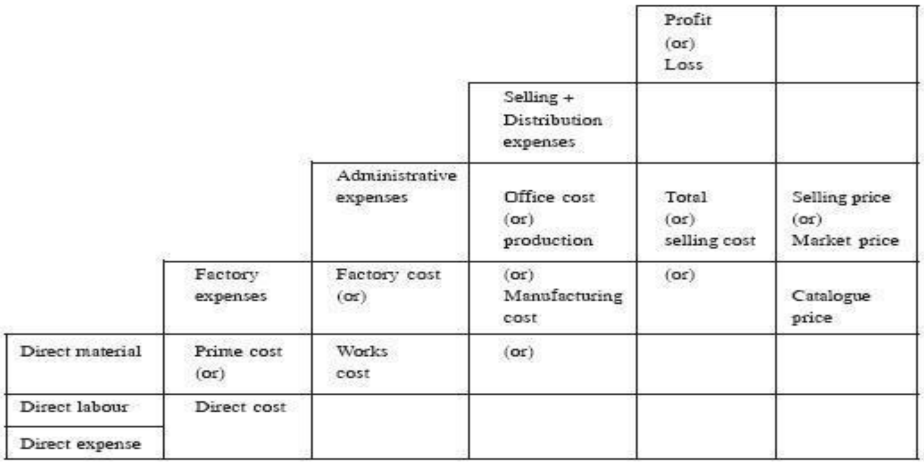


Fig. 3.2: Ladder of cost

DEPRECIATION

Fixed assets like plant and machinery etc. are used in the business for the purpose of production or providing services. With the passage of time and utilization, value of such fixed assets decreases. Value of portion of fixed assets utilized for generating revenue must be charged during a particular accounting year to ascertain the true cost. This portion of cost of fixed asset allocated is called depreciation.

Depreciation means reduction in value of asset or in the utility due to passage of time, natural wear and tear, exhaustion of the subject matter.

Causes of Depreciation

- Lapse of time.
- natural wear and tear.
- exhaustion of the subject matter.
- Obsolescence of technology.

Objectives of Providing for Depreciation

- To ascertain the true results of operations.
- To present true and fair value of the fixed asset.
- To accumulate funds for the replacement of the asset.

Factors in measurement

Estimation of exact amount of depreciation is not easy.
Generally following factors are considered in calculation of depreciation.

1. Cost of asset including expenses for installation etc.
2. Estimated useful life of the asset.
3. Estimated scrap value (if any) at the time of useful life of the asset.

Methods of providing depreciation

1. Straight Line method (SLM).
2. Reducing Balance Method RBM.

3. Machine Hour Method.
4. Production Units Method.

Straight Line method

In this method, an equal amount is written off every year during the working life of the asset to nil or its residual value at the end of its useful life.

SLM: The underlying assumption of this method is that the particular asset generates equal utility during its lifetime.

Depreciation = Cost of Asset-Scrap Value/ Useful Life

Example

Cost of machinery: 18000
Installation Charges:2000
Useful Life of Asset: 5 Years
Calculate Depreciation as per SLM
Depreciation = 20000-0/5 years
Depreciation = 4000 p.a.

Reducing Balance Method

Under this method, a fixed percentage of diminishing value of the asset is written off each year. The annual charges of the depreciation decrease from year to year.

Written Down Value (WDV) = (Acquisition Cost – Depreciation)
Depreciation = WDV * Depr Rate
RBM: The main advantage of this method is that total charge to total revenue is uniform when the depreciation is high, repairs are negligible and as the repairs increases the burden of depreciation gets lesser and lesser.
RBM:
For First Year Depreciation = Acquisition value * Rate For Second Year on words
Depreciation = Written down value * Rate

Example
Cost of machinery: 50000
Scrap Value of machine:5000
Useful Life of Asset: 10 Years
Depreciation %: 15% p.a.
Calculate Depreciation as per reducing balance method for first 2 years

RBM:
For First Year Depreciation = 50000 * 15% = 7500
For Second Year Depreciation = 42500 * 15% = 6375

Machine Hour Method

Where it is possible to keep a record of the actual running hours of each machine, depreciation may be calculated on the basis of hours worked.

The machine hour rate of depreciation is calculated after estimating the total numbers of hours that machine would work during its whole life. Under machine hour method Depreciation is calculated for each hour the machine works.

Example Solution:

Cost of machine: 500000
Estimated working hours: 40000
Scrap Value: 10000
The pattern of distribution of effective working hours:

Year	Hours
1-2	5000 per year
3-5	7000 per year
6-8	3000 per year

Compute depreciation p.a.
1-2=5000/40000 X (500000 − 10000) = 61250 p.a.
3-5=7000/40000 X (500000 − 10000)= 85750 p.a.
6-8=3000/40000 X (500000 − 10000)= 36750 p.a.

Production Unit Method

Under this method depreciation is determined by comparing annual production with the estimated total production.
The amount of depreciation is computed by the using following formula:
Depreciation for the period=depreciable amount x Production during the period Estimated total production.

UNIT 4

COST ESTIMATION

TYPES OF ESTIMATE

Estimates can be developed in a variety of different ways depending upon the use of the estimates and the amount of detail provided to the estimator.

Every estimator should understand every estimating method and when to apply each, because no one estimating method will solve all estimating problems.

Guesstimates

Guesstimates is a slang term used to describe as estimate than lacks detail. This type of estimate relies on the estimators experience and judgment. Usually, the tool and die estimator is estimating tool cost without any tool or die drawings. The estimator typically works from a piece part drawing and must visualize what the tool or die looks like. Some estimators develop some level of detail in their estimate.

Material cost, for example, is usually priced out in some detail, and this brings greater accuracy to the estimator by reducing error. If the material part of the estimate has an estimating error of plus or minus 5 per cent and the reminder of the estimate has an estimating error of plus or minus 10 per cent, the overall error is reduced.

Budgetary

The budgetary estimate can also be a guesstimate but is used for a different purpose. The budgetary estimate is used for planning the cost of a piece part, assembly, or project.

This type of estimate is typically on the high side because the estimator understands that a low estimate could create real problems.

Using Past History

Using past history is a very popular way of developing estimates for new work. Some companies go to great lengths to ensure that estimates are developed in the same way actual cost is conducted.

This provides a way past history in developing new estimates. New advancements in Group technology now provide a way for the microcomputer to assist in this effort.

Estimating in Some Detail

Some estimators vary the amount of detail in an estimate depending on the risk and dollar Amount of the estimate. This is true in most contract shops. This level of detail might be at the operation level where operation 10 might be a turning operation and the estimator would estimate the setup time at 0.5 hours and the run time at 5.00 minutes. The material part of the estimate is usually calculated out in detail to reduce estimating error.

Estimating in Complete Detail

When the risk of being wrong is high or the dollar amount of the estimate is high, the estimator will develop the estimate in as much detail as possible.

Detailed estimates for machinery operations, for example, would include calculations for speeds, feeds, cutting times, load and unload times and even machine manipulations factors.

These time values are calculated as standard time and adjusted with an efficiency factor to predict actual performance.

Parametric Estimating

Parametric estimating is an estimating method developed and used by trade associations. New housing constructions can be estimated on the basis of cost per square.

There would be different figures for wood construction as compared with brick and for single strong construction as compared with multilevel construction.

Some heat-beating companies price work on a cost per pound basis and have different cost curves for different heat-treating methods.

Project Estimating

Project estimating is by far the most complex of all estimating tasks. This is especially true if the project is a lengthy one. A good example of project estimating is the time and cost of developing a new missile.

The project might take 5 years and cost millions of dollars. The actual manufacturing cost of the missile might be a fraction of the total cost.

Major projects of this nature will have a PERT network to keep track of the many complexities of the project. A team of people with a project leader is usually required to develop a project estimate.

STANDARD DATA

Standard data are defined as standard time values for all the manual work in an estimate standard data provide the opportunity for the estimator to be consistent in developing an estimate.

How Standard Data are Developed?

Standard data are developed in a variety of ways depending on the industry that uses them. Experience shows that it is easier to develop standard data for machinery operation as compared with fabrication operation.

This is because machinery operations can be calculated by using speeds, feeds and lengths of cut to determine time values.

Most of the work content of a fabrication operation is manual effort rather than machine time, and for this reason reliable standard data for the fabrication industry are difficult to find. Listed below are the basic methods used to develop standard data.

Past History

Many companies use past history or actual performance on joules produced to develop standard data.

Developing standard data this way rarely considers the best method of organizing work. This method is popular in smaller companies that do not have industrial engineers or time study engineers.

Time Study

Larger, well-organized companies will develop standard data from stop-watch time studies. Time studies are used to establish rates of production.

However, when time studies are also used to establish standard data, care must be taken in defining element content so work content can be isolated.

Time study engineers must be taught how to establish the element content of their studies in a way that will permit the development of standard data.

Predetermined Time Standards

Another approach in the development of standard data is to use one of the many predetermined time standard systems like MTM or MOST.This method has its advantages and disadvantages. The chiefly advantage is consistency of data, and the chief disadvantage is the amount of time necessary to develop the data. Some predetermined time standard systems are now computerized, which shortens the development time.

Standard Data Specific to a Shop and Lot Size

It should be pointed out that ―all standard data are specific to a given shop and lot size.‖ Standard data developed in a high-production shop under ideal methods are of little value to a job shop that runs lot, sizes of 10 parts each. The reverse is also true.

The use of efficiency factors or off standard factors can assist in using the same data for both conditions, but this is less than ideal.

The reverse use of learning curves, that is, backing up the curve, is a better method of reprising work for small lot sizes using this method, the same standard data can be used for high and low production.

MATERIALS AVAILABLE TO DEVELOP AN ESTIMATE

Materials available for developing an estimate vary widely depending on what is being estimated. In most cases the quality of the estimate will depend on the amount of materials to make the estimate.

Estimating materials shown below is a listing of the materials available for making an estimate.

No drawings

In many cases there are no drawings of what is being estimated. One clear example of this is tool estimating. The estimator will develop an estimate for a progressive die, for example, by reviewing the price part drawing. Some die estimators will develop a strip layout for the part and then estimate the die cost station by station.

Sketches

Sometimes sketches of the parts represent the only information available. This is typically true for a budgetary estimate.

Line drawings

Loftings or line drawings are used for estimating in some industries. The pleasure boat industry represents an example. A full-scale lofting of a deck and hull is used to estimate both the material and labour for a new fiber glass boat.

Complete drawings

Complete drawings and specifications are available for estimating some work. The aircraft industry is one good example.

Many times the estimator will spend more time reading the specifications than developing the estimate. This is necessary because the specifications will often determine the part process.

ESTIMATION OF DIFFERENT TYPES OF JOBS

Estimation of Forging Shop

Losses in Forging

It is well known that some metal is always lost in the different operations of forging and this lost metal must be added to the net weight before calculating the material cost. The different losses to be considered are:

(i) Scale loss.
(ii)Flash loss.
(iii) Tonghold loss.
(iv)Sprue loss.
(v) Shear loss.

(i) Scale loss

This is the material lost because of the surface oxidaton in heating and forging the piece. When iron is heated at a high temperature in atmospheric conditions a thin of iron oxide is formed all round the surface of the heated metal which goes as a waste. The iron oxide film is known as scale and it falls from the surface of the metal on being beaten up by the hammer. Scale loss depends upon the surface area, heating time and the type of material. For forgings under 5 kg loss is 7.5 per cent of the net weight, and for forgings from 5 to 12.5 kg and over an addition of 6 per cent and 5 per cent of the net weight is necessary for scale loss.

(ii) Flash loss

There is a certain quantity of metal which comes between the flat surfaces of the two dies after the die cavity has been filled in. This material equal to the area of the flat surface is a wastage. For finding the flash loss, the circumference is determined which multiplied by cross-sectional area of flash will give the volume of the flash. The volume multiplied by material density gives the flash loss. Generally, it is taken as 3 mm thick and 2 mm wide all round the circumference.

(iii) Tonghold loss

This is the loss of material due to a projection at one end of the forging to be used for holding it with a pair of tongs and turning it round and round to give the required cross section in drop forging. About 1.25 cm and 2.5 cm of the size of the bar is used for tonghold. The tonghold loss is equal to the volume of the protections. For example, the tonghold loss for a bar of 2 cm diameter will be

$$= \frac{\pi}{4} (\ )2^{\ 2} \times 1.25 \text{ cu.cm}$$

(iv) Sprue loss

The connection between the forging and tong hold is called the sprue or runner. The material loss due to this portion of the metal used as a contact is called sprue loss. The sprue must be heavy enough to permit lifting the work piece out of the impression die without bending. The sprue loss is generally 7.5 per cent of the net weight.

(v) Shear loss

In forging, the long bars or billets are cut into required length by means of a sawing machine. The material consumed in the form of saw-dust or pieces of smaller dimensions left as defective pieces is called shear loss. This is usually taken as 5% of the net weight. From above we see that nearly 15 to 20% of the net weight of metal is lost during forging. And as already said these losses must be added to the net weight to get the gross weight of the material.

Forging Cost

The cost of a forged component consists of following elements:

(i) Cost of direct materials.

(ii) Cost of direct labour.

(iii) Direct expenses such as due to cost of die and cost of press.

(iv) Overheads.

(I) Direct material cost

Cost of direct materials used in the manufacture of a forged component are calculated as follows:

(i) The net weight of forging

Net weight of the forged component is calculated from the drawings by first calculating the volume and then multiplying it by the density of the metal used.

Net weight = Volume of forging × Density of metal.

(ii) Gross weight

Gross weight is the weight of forging stone required to make the forged component. Gross weight is calculated by adding material cost due to various factors discussed above, to the net weight.

Gross weight = Net weight + Material loss in the process.

In case of smith or hand forging, only scale loss and shear loss are to be added to net weight but in case of die forging all the losses are taken into account and added to net weight.

(iii) Diameter and length of stock

The greatest section of forging gives the diameter of stock to be used and

Length of stock = Gross weight / X − Sectional area of stock × Density of material

(iv) The cost of direct metal is calculated by multiplying the gross weight by price of the raw material

Direct material cost = Gross weight × Price/kg.

(II) Direct labour cost

Direct labour cost is estimated as follows:

Direct labour cost = t × l

Where t = Time for forging per piece (in hrs) l = Labour rate per hour

It is very difficult to estimate the exact time to forge a component. In practice the forging time per component is estimated based on the production of eight hours or a day.

(III) Direct expenses

Direct expenses include the expenditure incurred on dies and other equipment, cost of using machines and any other items, which can be directly identified with a particular product. The method of apportioning die cost and machine cost is illustrated below:

Apportioning of die cost
Let cost of die = Rs. X
No. of components than can be produced using.
This die (i.e., die life) = y components
Cost of die/component = Rs. x/y
Apportioning of machine (press) cost
Let cost of press = Rs. A
Life of press = B n year = n × 12 × 4 × 5 × 8 = 1920 n hours
(Assuming 8 hours of working per day, 5 days a week and 4 weeks a month in 12 months of year)
Hourly cost of production = A/B
No. of components produced per hour= N
Cost of using press per component A = Rs
BN This excludes cost of power consumed and other consumables.

(IV) Overheads expenses

The overheads include supervisory charges, depreciation of plant and machinery, consumables, power and lighting charges, office expenses etc. The overheads are generally expressed as percentage of direct labour cost.

The total cost of forging is calculated by adding the direct material cost, direct labour cost, direct expenses and overhead.

Solved Problems

Estimation of forging cost

Example

Three hundred pieces of the bolt are to be made from 25 mm diameter rod. Find the length of each bolt before upsetting. What length of the rod is required if 4% of the length goes as scrap?

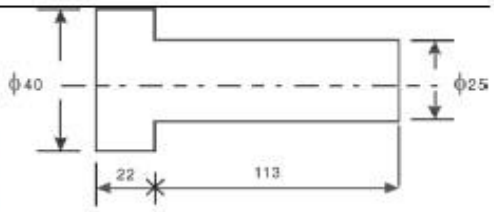


Fig. 5.16

Solution

Volume of head of the bolt $= \frac{\pi}{4} D^2 \times L$

$D = 40$

$L = 22$ mm

$= \frac{\pi}{4} (40)^2 \times 22 = 27{,}646\ mm^2$

Length of material required for making the head

$= \frac{\text{Volume}}{\text{Area}}$

Area $= \frac{\pi}{4} D_1^2 = \frac{\pi}{4} (25)^2 = 490.6\ mm^2$

∴ Length of bar $= \frac{27.632}{490.6} = 56.35$ mm

Total length required for forming $= 56.35 + 113 = 169.35$ mm

Length of rod required for making 300 bolts $= \frac{169.35 \times 300}{1000} = 50.8$ metre

Considering loss 4%,

Total length required $= 50.8 + .4 \times 50.8 = 71.12$ metre

Estimation of Welding Shop

Welding Cost

Cost procedure

In estimation welding cost of a job, the different items which are to the taken into account are material, labour and tooling cost.

Material cost

In this, costs of all materials are included used in fabrication progress like metallic sheet or plate stock costing stampings, forging etc. Another major item is the consumable electrode or weld wire used to provide for the additional metal in the weld groove. This quantity is determined by the crosssectional area, length and the particular welding process. In case of gas welding cost of gases like oxygen and acetylene consumed are taken into consideration.

Table 5.1

Plate thickness	***Welding technique***	***Filler rod dia***	***O_2 Consump-tion in cu***	***Acetylene consump-***	***Welding time per***	***Length of filler rod in metre***
In mm		In mm	m/hr	m/hr	Min	
1	Leftward	1.00	0.04	0.02	9 to 11	1.0
2	Leftward	2.0	0.10	0.04	10 to 12	1.5
3	Leftward	2.5	0.2	0.07	12 to 13	1.6
4	Leftward	3.0	0.15	0.10	13 to 15	2.6
5	Leftward	3 to 4	0.21	0.14	15 to 17	4.0 to 1.8
5	Rightward	2.5	0.3	0.20	16 to 18	3.3
6	Rightward	3.0	0.4	0.25	18 to 20	3.4
8	Rightward	4.0	0.5	0.30	20 to 28	3.6
10	Rightward	5.0	0.7	0.50	30 to 35	4.5
15	Rightward	6.0	1.0	0.60	45 to 50	6.8
20	Rightward	6.0	1.2	0.80	60 to 67	10.0
25	Rightward	6.0	1.6	0.90	85 to 100	16.0

Labour cost

Under this category, costs of all persons are directly related to the making of weldment. First of all welding times are calculated and from that the labour cost is calculated. The labour cost is subdivided into following groups:

(i) Preparation

The cost of preparing raw materials for welding would include preparing of edges according to requirements machining of welded joints to shape, and the cleaning of the foreign material from the surface to be welded.

(ii) Set-up

This includes assembling the parts in the welding fixture, heating prior to welding etc.

Plate thick-ness in mm	*Nozzle dia in mm*	*O_2 pressure, kg/cm²*		*Consumption, m³/hr O_2*		*C_2H_2*		*Cutting speed m/hr*	
		Hand	*Machine*	*Hand*	*Machine*	*Hand*	*Machine*	*Hand*	*Machine*
3	0.8 to	11.0-1.65	1.0-2.0	1.3-1.4	1.2-1.4	0.20-0.25	0.18-0.25	30-45	30-50
5	1	0.75-1.50	0.75-2.0	1.8-2.0	0.8-2.0	0.15-0.20	0.12-0.20	20-30	18-32
10	1 or 15	1.5-2.0	1.5-3.5	1.2-2.4	1.0-2.4	0.20-0.25	0.15-0.25	15-30	15-30
15	1.5	1.7-2.5	1.5-3.5	3.4-4.5	3.4-4.5	0.30-0.45	0.33-0.42	18-27	18-30
5	1.5	3.1-2.8	2.0-2.8	3.6-5.0	3.6-5.0	0.36-0.47	0.35-0.47	18-28	18-30

(iii) Material deposition

This is determined by the rate of weld deposit, weld joint preparation, number of passes required for the weld.

(iv) Post welding operation

This includes the cost for the removal of excess of weld metal, slag, rough or finish machining to weldment dimensions. Cost of heat treatment operations after welding such as annealing, normalising, hardening etc., are also including under this.

(v) Finishing

Cost of cleaning welded portion for surface finish is considered under finishing cost. ***Tooling cost*** Under this item would be the costs of welding fixtures, machining fixtures and machining template.

Example

Estimate the time required for making an open tank size 50 × 50 × 50 cm by gas welding size of sheets used is 50 × 40 × 0.3 cm. Welding to be done on inner surface only. Assume fatigue allowances to be 5%.

Solution

Length of portion where welding is required to be done, which is clear in figure 5.23.

$$= AB + BC + CD + DA + AE + BF + CG + DH$$

$$= 50 \times 8 = 400 \text{ cm} = 4 \text{ m}$$

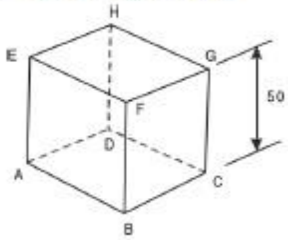


Fig. 5.23

As we are required to weld plates of 3 mm thickness which is less than 5 mm thickness hence we shall adopt left ward welding technique.

From table, welding speed is 12 min/m for 3 mm thick plates.

Time required for making one tank 12 × 4 =48 min

Considering fatigue allowance =5%

Actual time taken by welder for wedling one tank = 48 × 1.05 = 50.4 min

Example 5.35

Estimate the material cost for welding 2-flat pieces of ms 15 × 6 × 1 cm size at an angle of 90° by gas welding. Neglect preparation cost and assume

Cost of O_2	=	Rs. 12/m³	Cost of C_2H_2	=	Rs. 70/m³
Of filler metal	=	Rs. 15/kg	Cost of filler metal =		Rs. 12/kg

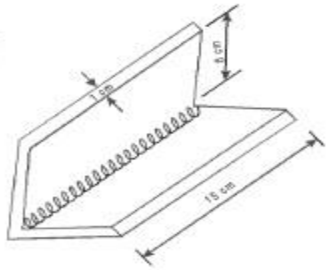
Example

Estimate the material cost for welding 2-flat pieces of ms 15 × 6 × 1 cm size at an angle of 90° by gas welding. Neglect preparation cost and assume

Cost of O_2	=	Rs. 12/m³	Cost of C_2H_2	=	Rs. 70/m³
Of filler metal	=	Rs. 15/kg	Cost of filler metal =		Rs. 12/kg

Solution

As the thickness of the plates to be welded is more than therefore right ward welding method is adopted. From table, for 10 mm thick plates.



O_2 consumption = 0.7 cu m/hr

C_2H_2 consumption = 0.5 cu m/hr

Length of filler rod required 4.5 m/m of welding

Filler rod dia = 5 mm

Welding time = 30 min/m of welding

Time required to weld 15 cm length

$$= \frac{15}{100} \times 30 = 4.5 \text{ min}$$

Fig. 5.24

(i) Amount of oxygen consumed at 0.7 cu m/hr $= \frac{4.5}{60} \times 0.7 = 0.053$ cu.m

Cost of oxygen at Rs. 12/cu.m = 0.053 × 12 = Rs. 0.636/-

(ii) Now amount C_2H_2 consumed in 4.5 min

@ 0.5 cu m/hr $= 0.5 \times \frac{4.5}{60}$ = 0.0375 cu.m

Cost of C_2H_2 at Rs. 70/m³ = 0.0375 × 70 = Rs. 2.63

(iii) Length of filler rod required for 15 cm job at 4.5 m/metre welding = 0.15 × 4.5 = 0.675 m. But for 10 mm thick plates; filler rod dia = 5 mm. Weight of fuller rod consumed = Volume × Density

$\frac{\pi}{4} \times 0.5^2 \times 67.5 \times 7$ gm = 0.0928 kg

Cost of filler rod at Rs. 15/kg = 15 × 0.0928 = Rs. 1.392

Total material cost = 0.636 + 2.63 + 1.39

= Rs. 4.658.

Estimation of Foundry Shop

1 Estimation of Pattern Cost

After finding the volume of rough wood by the process described in the previous article, it is multiplied by the existing price per unit volume to obtain the cost of wood required for the pattern of furniture. The labour cost for the work is more difficult to determine, since the process in values a lot of manual work. Similar works undertaken previously are taken as guides in this respect. Experience tells us that a good pattern-maker, working entirely manually, can finish the work on 0.025 m3 of wood in 8 hours. Other charges are usually taken in proportion to either the material cost or the labour cost.

2 Foundry Losses

- Losses influence strongly the economies of production of castings.
- Losses occur mainly during melting because of oxidation or volatilization of alloying elements and the entrapment of molten metal in the dross or slag removed from the furnace or crucible.
- Melting losses are most serious when they occur in costly alloys.
- Melting losses vary with the type of foundary and its conditions such as raw material, melting practice, composition of alloy etc.

Time to weld 200 mm length200 = = 0.08 hrs
1000 × 2.5

Oxygen consumed = 0.08 × 0.8 = 0.064 cu. m

Acetylene consumed = 0.08 × 0.8 = 0.064 cu. m

- Highest melting losses occur when the surface area to volume ratio of the charge is more i.e., in a scrap charge containing large proportion of turnings, swarf and fines (and that too heavily contaminated).
- Furnace type and design also affect melting losses.
- Rotary and reverberatory furnaces, owing to more pronounced contact of melt with furnace atmosphere and constant renewal of metal surface are susceptible to higher losses than a crucible furnace with a small bath area.
- Losses in the melting of cast iron in cupola are lesser than obtained in air furnace.

• In the melting of steel, cupola converter practice produces highest losses of the order of 12.5% whereas they are only 3 to 5% in electric are furnace and about 1% in high frequency induction heating furnace.
• Melting losses depend upon the time of exposure of molten metal to the furnace atmosphered.
• Melting losses and gas contamination can be minimized by carrying out melting at a fast rate and with minimum of disturbance.
• Melting losses can also be reduced by avoiding, excessive liquid metal temperatures and too many liquid metal transfers.
• In brief, a proper care and close control of melting conditions will definitely help in lowering melting losses.

3 Steps for Finding Costing Cost

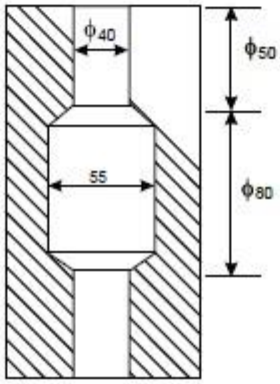
1. Calculate the volume of the casting from the past drawing, as explained earlier.
2. Multiply the volume by the density of the part material in order to arrive at net weight of the casting.
3. Calculate the weight of metal lost in oxidation in the furnace and as sprues, gates, risers etc. This metal loss is roughly 10% of the net weight of the casting.
4. Calculate the weight of foundry process scrap.
5. Add (2), (3) and (4) above to get total weight.
6. Calculate cost of metal by multiplying the total weight with the cost per unit weight of the metal.
7. Calculate process scrap return value and deduct it from the cost of metal in order to arrive at Net direct material cost.
8. Calculate indirect material cost by estimating the amount of coke, flux, etc., required to melt and cleanse the molten metal for casting.
9. Calculate direct and indirect labour costs.
    (a) Cost of making moulds.
    (b) Cost of making and baking cores.
    (c) Cost of firing the furnace
    (d) Cost of melting metal.
    (e) Cost of pouring molten metal into the moulds.
    (f) Cost of removing solidified castings from the moulds.
    (g) Cost of fettling and finishing of castings.
    (h) Cost of heat-treatment, if any.
10. Cost of inspection

Example

Estimate the cost of production of the job.

Material - CI casting 70 mm φ × 150 mm long

Cost of CI Rs. 500/kg.



Weight of material (CI) = 0.0075 kg/cm³

Turning at Rs. 0.85/cm³ of metal removed Facing

at Rs. 0.85/cm³ of metal removed.

Drilling and boring Rs. 2.00/cm³ of metal removed.

Solution

Formulae,

Volume of 40 φ hole

$$\frac{\pi}{4}\,(\ )4^2 \times 5 \text{ cm}^3 = 62.83 \text{ cm}^3$$

Volume of taper hole

$$\pi \times 120.85 \;\text{———}\; \square 4_2 + (5.5)_2 + 4 \times 5.5\square\square = 15.19 \text{ cm}_3$$

Fig. 5.32

Volume of 55 φ hole (E)

$$= \frac{\pi}{4} \times 5.5^2 \times (8 - 2 \times 0.85) = 149.67 \text{ cm}^3$$

Total volume of the hole = Volume of material removed in drilling and boring

1. Volume of rough casting $V_1 = \frac{\pi}{4} \times 7^2 \times 15 = 577.3 \text{ cm}^3$
2. Volume of the solid job after turning and facing i.e., before drilling and boring

$$V_2 = \frac{\pi}{4} \times (\ )6^2 \times (4 + +64) = 395.84 \text{ cm}^3$$
$$= 395.84 \text{ cm}^3$$

3. Volume of material removed in turning and facing

$$= V_1 - V_2 = 181.43 \text{ cm}^3$$

4. Weight of rough casting $= 4.33$ kg

Costing

Cost of CI at Rs. 5 per kg labour charges

$= 5 \times 4.329 =$ Rs. 21.65 (a)

Turning and facing Rs. 0.85/cm³ of metal removed

$= 0.75 \times 181.43 =$ Rs. 136.07 (b)

For drilling and boring Rs. 1/cm³ of metal removed

$= 1 \times 227.69 =$ Rs. 227.69 Cost

of production of the job = Rs. 385.41.

ESTIMATION OF MACHINING TIME

Introduction

In general all components or products manufactured in the workshop, required one or more machining operations to be done on them. Hence, the products have to travel through the machine shop to attain their final shape and size. The machining operations necessary for a job may be of different types, such as turning, shaping, planing, drilling, milling, boring and grinding.

In estimating the time requires to perform an operation on a work piece by any machine, the following factors must be considered.

1. Set up time.
2. Operation time.
3. Tear down time.
4. Personal allowance.
5. Fatigue allowance.
6. Checking allowance.
7. Miscellaneous allowance.

1. Set up time

This takes into account the time required to prepare the machine for doing the job, together, with the time taken to study the blueprint. The time to prepare the machine, in turn, includes the time to install and adjust the tools in the machine, as well as to make the machine ready to start the work.

2. Operation time

The sum of handling time and machining time for a job is called operation time. It is the duration of time that elapses between output of two consecutive units of production. It is also called cycle time.

3. Tear down time

Tear down time takes into account the time necessary to remove from the machine all tools and accessories, such as jigs and fixtures, gauges and instruments etc. The time required for clearing operational chips from the machine table and clearing of the machine itself are included on this. Tear down time is generally 10-15 minute per shift of 8 hrs.

4. Personal allowance

The time allowed for workers to meet their personal needs, such as going to the urinal, drinking water, smoking, washing their hands, etc., is known as personal allowance. It is generally 5 to 7% of the total working hours in a day.

5. Fatigue allowance

The long working hours and poor working conditions such as poor lighting, poor ventilation etc., cause fatigue and effect the efficiency of worker is fatigue decreases the worker capacity to work. The allowance for fatigue is taken depending upon the type of work.

Importance of Machine Time Calculation

To find the manufacturing cost of a particular job which requires one or more machining operations, the calculation of machining time is important. After determining the total time for machining, and knowing the machining cost per unit time, the total cost of machining can be worked out. Machining time is calculated by applying certain basic formulae, tables of variables and constants.

The basic formula used is

Machining time = Travel of the tool necessary/Feed × rpm

1. Travel of the tool

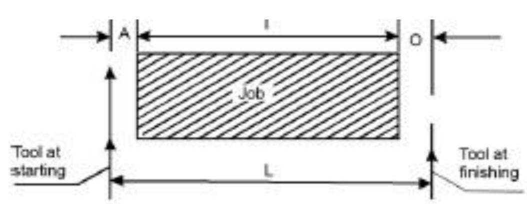
This is determined from the dimensions in the actual drawing of the part to be manufactured. The necessary allowances for the tool approach and over-run for clearing the tool off the job are taken into account with the actual length of the work, to find the travel of the tool.

If actual length of the work = l

Amount of tool approach = A

Amount of tool over run = O

Then, travel of the tool L = l + A + O



2. Feed

Feed is the distance that the tool travels into the job in one revolution if the work or the distance that the table holding the work travels is one stroke of the tool. In metric units, feed is usually expressed in mm/revolution or mm/stoke. Feed depends on the depth of cut, fitness of the work desired, rpm of the job, etc.

3. Depth of cut

It is the penetration of the cutting tool into the job in a single cut. In metric units, the depth of cut is expressed in mm. The depth of cut depends upon the fitness of the job required, such as higher depth of cut for rough cut and smaller depth of cut for finish cut.

4. RPM

It represents the number of revolutions of the m/c spindle in one minute. Thus it is the number of revolutions per minute of the job or of tool.

5. Cutting speed

The cutting speed can be defined as the relative surface speed between the tool and the job.

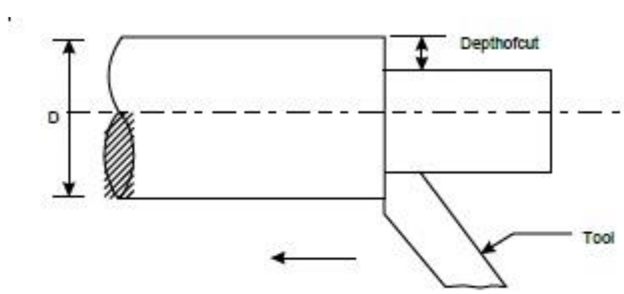
It is expressed in metres per minute (mpm).

For example, if a job of diameter D mm is revolving at a speed of N rpm, then πDN

Cutting speed V =--------------------m/min
1000

Calculation of Machining Time for Different Lathe Operations

Turning

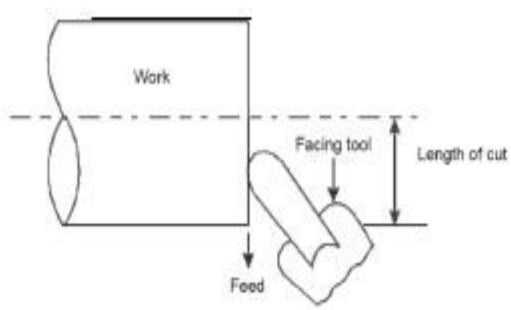


Time of turning, $T_m = \dfrac{L \pm A \pm O}{N \times f}$

Where,
L = Tool distance
N = Number of revolution/minute
A = Tool approach mm
O = Tool over travel, mm
f = Feed/revolution, mm/rev.
d = Diameter of blank after turning
It turning operation, the depth of cut should not exceed 3 mm for rough cuts and 0.75 mm for finishing cuts.

Facing

Number of cuts=D – d/2 × Depth of cut
Where ,D = Diameter of given blank,



$$T_m = \frac{l}{f \times N} \text{ min}$$

Where $N = \frac{1000 \times V}{\pi \times D_{av}}$

Here, of cut $= \frac{D}{2}$

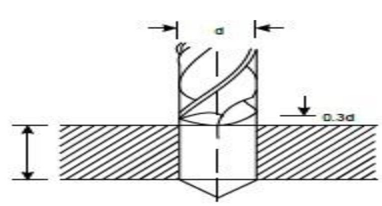
Other turning operation

For turning operation like chamfering, knurling, forming etc., the machining time formula is the same.

$$T_m = f \times l N = \frac{\text{Length of cut}}{\text{Feed} \times \text{rpm}}$$

Where $N = \frac{1000 \times V}{\pi \times D}$

Machining Time Calculation for Drilling Lathe and Boring Drilling



Drilling is the operation of production a hole in an object by forcing a drill against it. The time taken to drill a hole depends upon the cutting speed and feed given to the tool. Due allowances must be made for the distance. The drill must travel before the cut commences. Some holes are drilled to a specified depth. Such holes are called blind holes.

Time for drilling blind holes Tm = lf++0.3Nd

l + 0.5d Time for drilling through holes Tm = f + N

Where l = Depth of hole

f = Feed d = Diameter

Boring

The finishing or enlarging of internal diameter of a hole, which has been previously drilled by a boring tool, is called the boring operation.

Time taken for boring operation= Length of cut Feed × rpm

Machining Time Calculation for Milling Operation

Depending upon the different requirements of the different jobs, various milling operations are adopted. But all operate on same principle.

$$N = 1000 \times V/\pi \times D$$

Total table travel Time for one cut Tm = Table feed min

Where, Total tabel travel = Length of job + Added table travel

Table feed min = Feed/tooth × Number of teeth × rpm min

The approach is the distance the cutter must be engaged before the full depth of cut is reached.

(a) When cutter diameter is less than the width of the work.

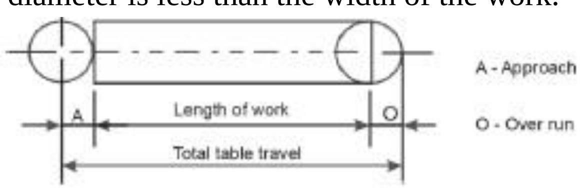
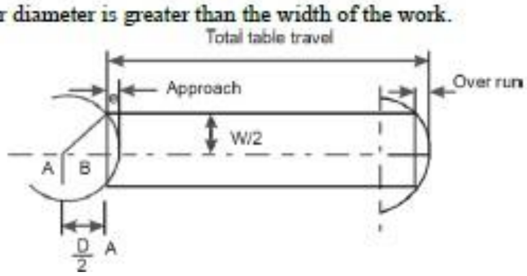


Fig. 5.41

Approach = 0.5 d

(b) When cutter diameter is greater than the width of the work.



Slab milling operation

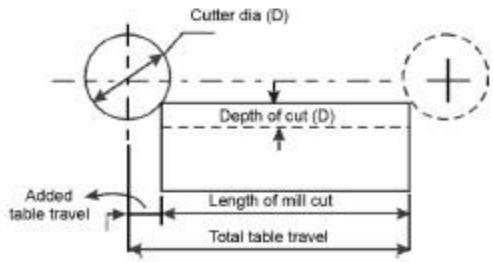


Fig. 5.43

Added table travel $\sqrt{Dd} -$

$d^2 \underline{D}$

when d < 2

Where d = Depth of cut

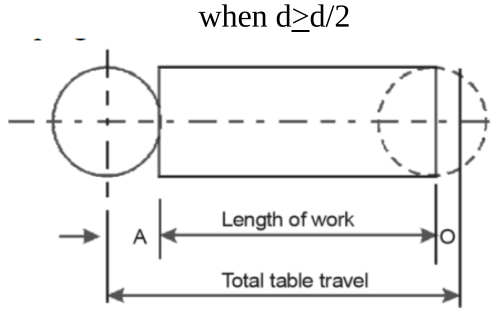
D = Diameter of the cutter

If the depth of cut equals or exceeds the cutter radius the added table travel will be equal to radius of the cutter.

Added table travel = D/2

For finishing pass, the cutter is permitted to travel beyond the end of the work piece, so the trailing edges give the same wiping action to the entire surface.

when d≥d/2



Added table travel = A + O

= 2 D d× −d2 D

when d < 2