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## CHAPTER-1

## PRESS TOOL

The press is a metal forming machine tool designed to shape or cut metal by applying Mechanical force or pressure.

The metal is formed to be desired shape without removal of chips.

The presses are exclusively intended for mass production work & they represents the fastest and most efficient way to form a sheet metal into finished products.

TYPES OF PRESSES:-

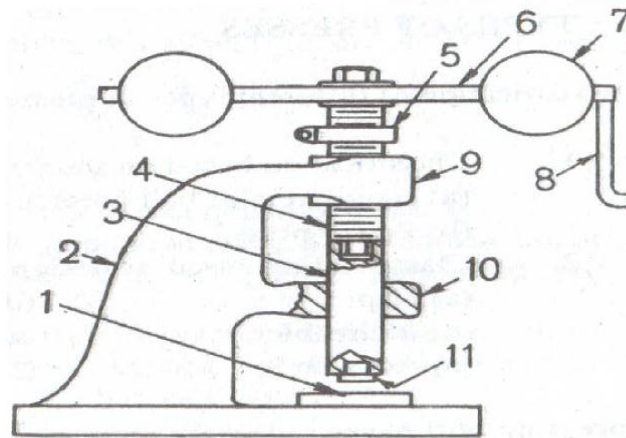
The classifications of different types of presses are given below:-

- (i) Classification based on source or power:-
  - (a) Hand press or ball press / fly press.
  - (b) Power press / power hammer.
- (i) Classification based on design of frame.
  - (a) Gap
  - (b) Inclined
  - (c) Adjustable
  - (d) Horn
  - (e) Start side
  - (f) Pillar

FLY PRESS:-

- The Fly press or ball press is the most simple of all presses & is operated by hand.
- The frame of the machine is a rigid 'c' shaped casting which is subjected to the severe thrust exerted by a ram.
- The typical shape of the frame leaves the front open which facilitates the feeding of the sheet metal below the ram from the side of the machine.

- The screw of the press operates in a nut, which is incorporated in the top end of the frame.



**Fly press**

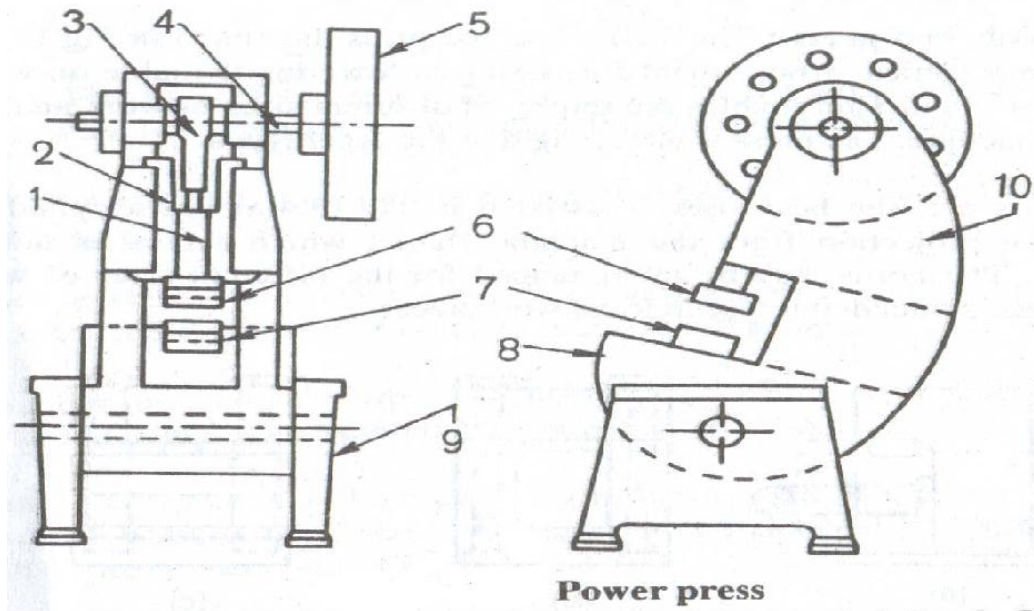
1. Die, 2. Frame, 3. Ram, 4. Screw, 5. Arrestor, 6. Arm, 7. Cast iron balls, 8. Handle, 9. Nut, 10. Guide, 11. Punch

- The two heavy cast iron balls are mounted at the two ends of the ram which is bolted to the screw, so that when the handle is turned it causes the screw to rotate within the nut.
- The connecting arrangement between the screw & the ram is such that when the screw is rotated, the ram only slides up and down within the guide.
- The sheet metal to be formed is placed between the punch and die.
- The press is operated by a sharp, practical revolution of the arm by pulling the handle & the kinetic energy is stored upon the two heavy balls mounted on the arm.
- As the ram is forced downward, the resistance offered by the plate against deformation is overcome by the tremendous thrust exerted by the punch on the plate at the expense of the stored energy to the desired shape.

#### POWER PRESS:-

- The Constructional, power press is similar to fly press the only difference is the ram instead of driven by hand is driven by power.

- The power press may be designated as mechanical or hydraulic according to the type of working merchandise use to transmit power is to ram.
- In a mechanical press the rotary motion offered from an electric motor is converted into reciprocating moment of the ram by using different mechanical uses.
- In hydraulic press the fluid under high pressure is pumped to one side of the piston and then the other in a hydraulic cylinder to drive the reciprocating moment.



- In above fig in the power press is driven by cranks & connecting rod mechanism the working of the press is similar to that of a hand press the punch is fitted to end of Ram & the die attached to the bolster plate. The flywheel is mounted the end of the crank shaft stores of the energy for maintaining Construct downward speed other ram when the sheet metal is pressed is to punch into to the die.

#### POWER PRESS PARTS:-

The different parts of power press are:-

- (1) Base
- (2) Frame
- (3) Bolster Plate

- (4) Ram or slide
- (5) Pitman
- (6) Crank Shaft or eccentric
- (7) Fly wheel
- (8) Clutch
- (9) Brake

**Base:-**

The base is the supporting member of the press and provides arrangement for fitting and clamping the frame in an inclined press.

**Frame:-**

All presses except the straight side type have “c” shaped frame to take up the vertical thrust of the ram.

**Bolster Plate:-**

The bolster plate is afloat fitted on the base or supporting the die block and other accessories of the press.

**Ram:-**

The Ram is the reciprocating member of the press that slides within the press and guides and supports the punch at bottom end.

**Pitman:-**

The pitman is the connecting rod in a crank or eccentric driven press, the position of stroke of the ram can be changed by altering the length of the connecting rod.

### **Crank eccentric or other driving Mechanism:-**

The rotary movement of the motor is converted into the reciprocating movement of the ram by crank and connecting rod eccentric and connecting rod, eccentric and connecting rod or many other mechanisms which are described in figure.

### **Fly wheel:-**

The flywheel is mounted at the end of the driving shaft and is connected to it through a clutch. The energy is stored up in the flywheel during the periods and it is expended to maintain the constant speed of the ram when the punch is pressed into the work. The fly wheel is directly coupled with the electric motor.

### **Clutch:-**

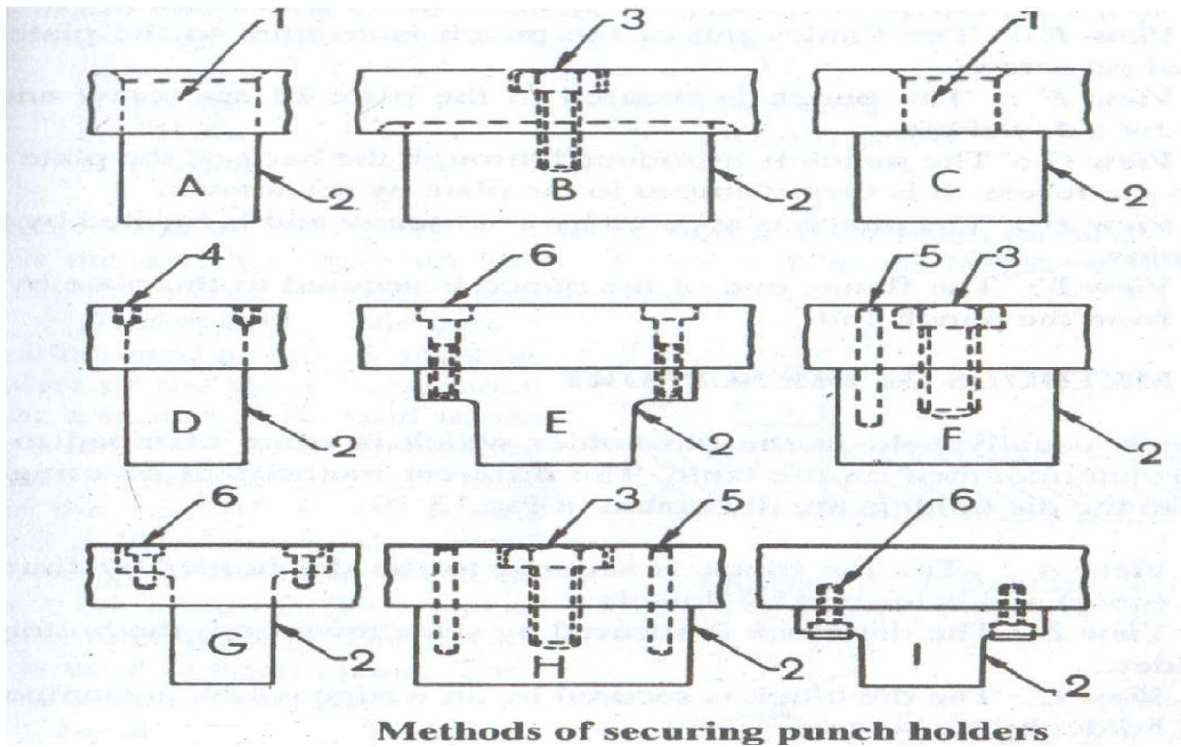
The clutch is used for connecting and disconnecting the driving shaft with the fly wheel when it is necessary to start or stop the movement of the ram.

### **Brakes:-**

The brakes are used to stop the movement of the driving shaft, immediately after it is disconnected from the flywheel.

### **METHODS OF PUNCHES SUPPORT:-**

The punches are usually held in steel punch plates of the punch holder which is again clamped to the lower end of the ram. The various methods of securing punches in punch plates are illustrated in fig.



**View A :-**

The punch is forced in the punch plate and the top end of the punch is flattened to fit in the countersunk recess.

**View B:-**

The punch is clamped in the punch plate by a set screw and is located by a slot cut in the punch plate.

**View C:-**

The shank end of the punch is forced in the punch plate and then the top end of the punch is flattened to fit in the countersunk recess.

**View D:-**

The punch is secured to the plate by grub screws.

**View E:-**

The flange end of the punch is secured to the plate by means of set screws.

**View F:-**

The punch is secured to the plate of set screw and is located by a dowel pin.

**View G:-**

The punch is introduced through the back of the plate and fits into the recess; it is then clamped to the plate by set screw.

**View H:-**

The punch is secured by a set screw and is located by two dowel pins.

**View I:-**

The flange end of the punch is secured to the plate by set screws from the punch end.

**Types of Dies and Operations:-**

Classification based on operations performed:-

- (i) Shearing :-
  - (a) Piercing
  - (b) Punching
  - (c) Perforating
  - (d) Blanking
  - (e) Cutting off

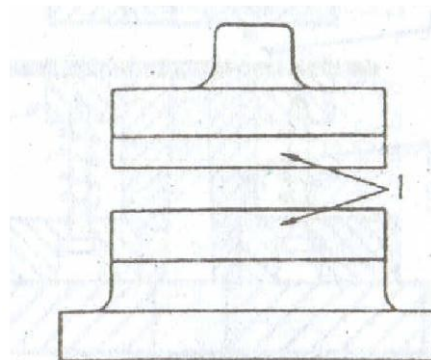


- (f) Parting
- (g) Notching
- (h) Slitting
- (i) Lancing.
- (ii) Bending
  - (a) Angle bending
  - (b) Curling
  - (c) Forming
  - (d) Plunging
- (iii) Drawing
  - (a) Cupping
- (iv) Squeezing
  - (a) Coining
  - (b) Embossing
  - (c) Flattening or plainshing.

## **2. CLASSIFICATION BASED ON CONSTRUCTION:-**

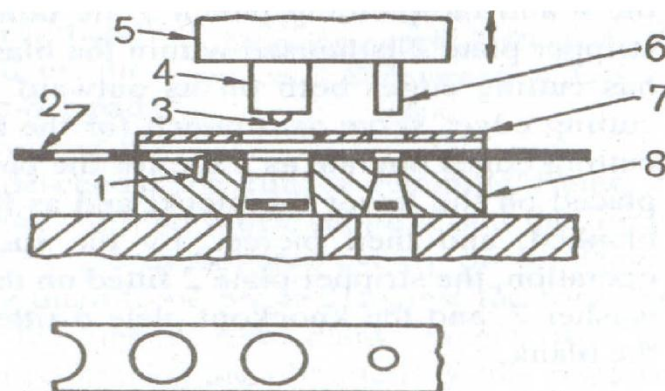
- (a) Simple
- (b) Follow or progressive
- (c) Compound

### SIMPLE DIE:-



- In a simple die only one operation is performed at each stroke of the ram. All the dies which are described before are simple dies.

### FOLLOW OR PROGRESSIVE DIE:-

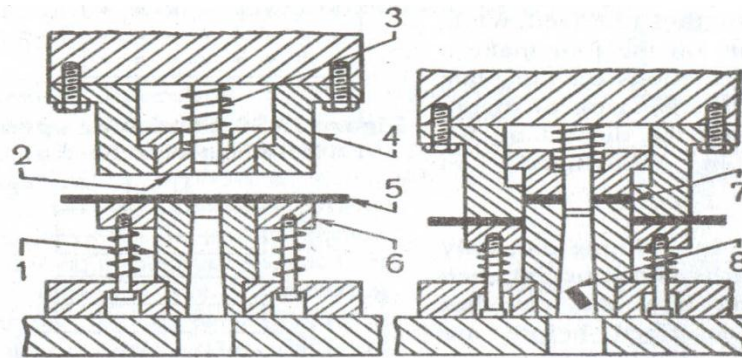


- |                   |                   |
|-------------------|-------------------|
| 1. Stop           | 5. Ram            |
| 2. Sheet metal    | 6. Piercing punch |
| 3. Pilot          | 7. Stripper       |
| 4. Blanking punch | 8. Die            |

- In a progressive die two or more operations are performed simultaneously at a single stroke of the press by mounting separate sets of dies and punches at two or more different stations.
- The metal is progressed from one station to the other till the complete part obtained. The progressive punching and the blanking die is illustrated in fig.

### COMPOUND DIE:-

- In a compound die two or more cutting operations are accomplished at one station of the press in every stroke of the ram.
- The blanking die and the piercing punch and bolted to the ram. The spring loaded stripper plate is housed within the blanking die. The lower die, body has cutting edges both on its outward and inward surfaces. The outside cutting edges operate as a die for the piercing punch.



[COMPOUND DIE]

- |                   |                 |
|-------------------|-----------------|
| 1. Lower die      | 5. Sheet metal  |
| 2. Stripper plate | 6. Knkout plate |
| 3. Piercing punch | 7. Washer       |
| 4. Blanking die   | 8. Waste        |

- The sheet metal is place on the lower the block and as the ram descends, the plate is first blanked and then pierced by the successive dies sets.

### ADVANTAGES & DISADVANTAGES OF DIES & PUNCHES:-

#### ADVANTAGES:-

- Requires minimal space in the press.
- Leaves all burrs in one direction.
- Superior accuracy between holes & trim edges.
- More economical to build than a progressive die.
- Die casting dies retain their accuracy for a very long time.
- High surface finish is obtained& often no further finishing is required.

#### DISADVANTAGES:-

- The limited space which ends to leave die components this & weak. This contracts the loads shock on punches & matrixes resulting in tooling failures.

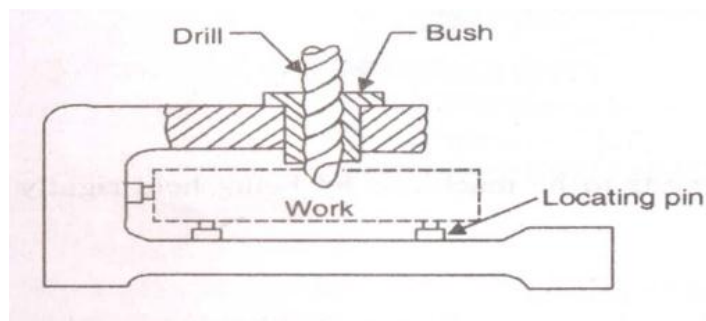
- All metals & alloys cannot be cast.
- The cost of M/C &, dies & other equipment used is high.
- Not economical for small quality production.
- Heavy casting cannot be cast.
- Special precautions cannot be cost.
- Special precautions are necessary for evacuation of air from die cavity otherwise cause porosity.

## CHAPTER-2

## JIGS AND FIXTURE

### JIG:-

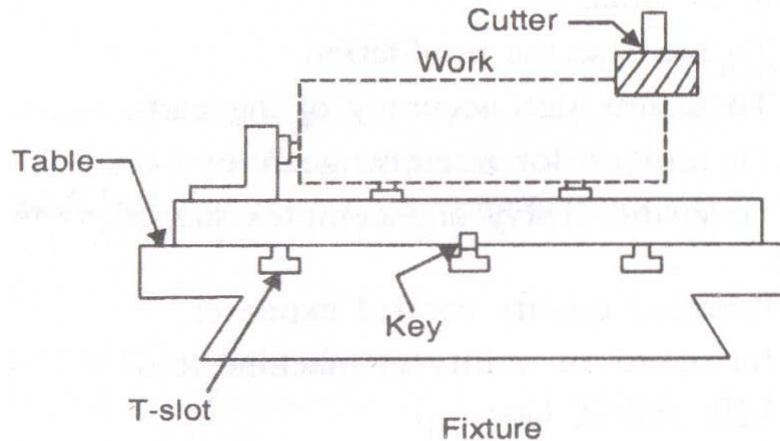
- A Jig may be defined as a device which holds and locates a work piece and guides and controls one or more cutting tools.
- The holding of the work & guiding of the holes are such that they are located in two positions relative to each other.



(JIG)

### FIXTURE:-

- A fixture may be defined as a device which holds & locates a workpiece during an inspection or for a manufacturing operation.
- The fixture does not guide the tool.



#### Difference between Jig & Fixture:-

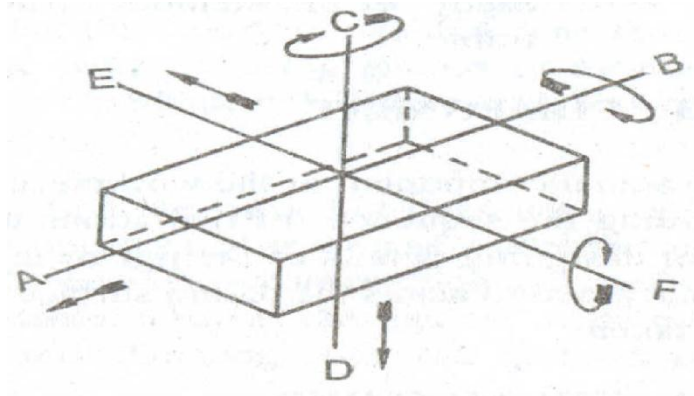
- A fixture holds & position the work doesn't guide the tool, where as a jig holds, locates and as well as guide the tool.
- The fixtures are generally heavier in construction & are bolted rigidly on the machine table where as the Jigs are made lighter for quicker handling & clamping with the table is often necessary.
- The fixtures are employed for holding work in moiling grinding planning or turning operations where are the jigs are used for holding the work is guiding the tool particularly is drilling reaming or tapping operations.

#### Advantage of using of Jig & Fixture:-

- To reduce the cost of production as their use eliminates the laying out of work and setting up or tools.
- To increase the production.
- To assure high accuracy of the parts.
- To provide for interchange ability.
- To enable heavy and complex- shaped parts to be machined by being hold rigidly to a machine.
- Reduce quality control expenses.

- Increased versatility of machine tool.
- Less skilled labour.
- Saving labour.
- Their use partially automates the m/c tool there by lowering the rate of accidents.

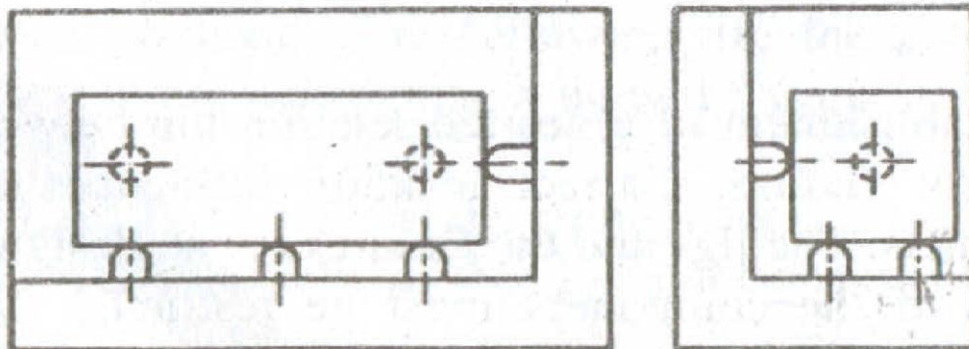
**PRINCIPLE OF LOCATIONS:-**



Six degree freedom of a rectangular block

- The location refers to the establishment of a desired relationship between the workpiece & the jig or fixture. Correct location influences the accuracy of the finished product.
- The jig & the fixtures are so designed that all possible movements of the components must be restricted.
- The determination of the locating points & clamping of the work piece serve to restrict the movements of the components in any direction, while setting it at the correct position relative to the jig.
- The locating points are determined by first finding out the possible degrees of freedom of the work piece, which are then restrained by suitable arrangement which served as locations.
- In order to study the complete location of the workpiece within a jig and fixture let us consider the work pieces in the above space.

- The work pieces in assume to have through and flat faces. In a state of freedom it may move in either of the two opposite direction along three mutually perpendicular  $xx, yy, zz$ .
- The six moments are called “movement of translocation”.
- The work pieces can rotating in either of two opposite directions around each axis, clock wise & antilock wise. This six moment are called “rotational moment”.
- The sum of these two types of moments gives the 12 of freedom of a work places in space.



Six point location location of a rectangular block

- To confine the work piece accurately & positively in another fixed body (jig or fixture) the movement of the work piece in any of the twelve degrees of freedom must be restricted.
- (a) The workpiece in resting on three pins A, B & C which are inserted in the base of the fixed body.
- The work piece cannot rotate about the axes  $xx$  &  $yy$  and also it cannot move down word. In this way the five degrees of freedom 1, 2, 3, 4 & 5 have been arrested.
- (b) Two more pins D & E are inserted in the fixed body in a plane perpendicular to the plane containing the pins A, B and C. Now the work piece cannot rotate about the Z-axis is and also it cannot move towards the left. Hence, the addition of pins D and E restrict three more degrees of freedom namely 6, 7 & 8.
- (c) The another point in the 2<sup>nd</sup> vertical face of the fixed body, arrests degree of freedom. Thus 6 locating pins 3 in the base of the fixed body, arrests degree of the fixed body 2 in

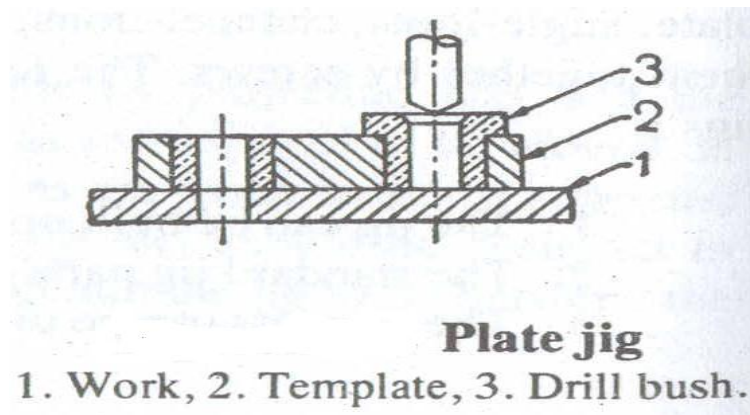
the vertical plane & line another vertical plane the 3 planes being perpendicular plane the 3 planes being perpendicular to one another, restrict nine degrees of freedom.

(d) The three degrees of freedom namely 10, 11 & 12 are still free. To restrict these degrees of freedom needed. But this will completely enclosed the work piece making its loading unloading into the jig or fixture impossible, Due to this these remaining 3 degrees of freedom may be arrested by means of a clamping device.

The above method of locating a work piece in a jig or a fixture is called 3-2-1 principle of 6 point location principle.

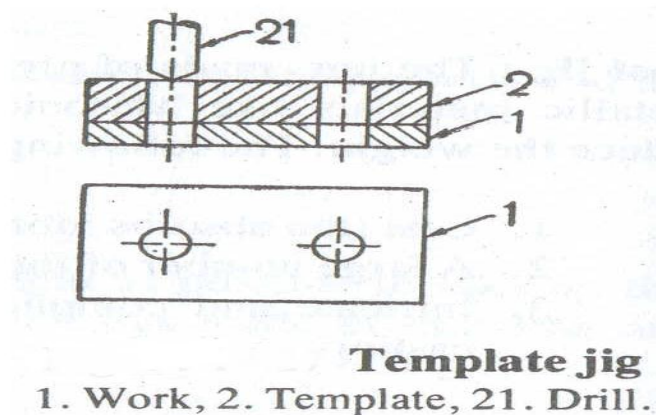
### Various types of Jigs:-

(a) **Plate jig:-**



- The plate Jig is an improvement of template jig by incorporating drill bushes on the template. The plate jigs are employed to drill holes on large parts maintain accurate spacing with each other.

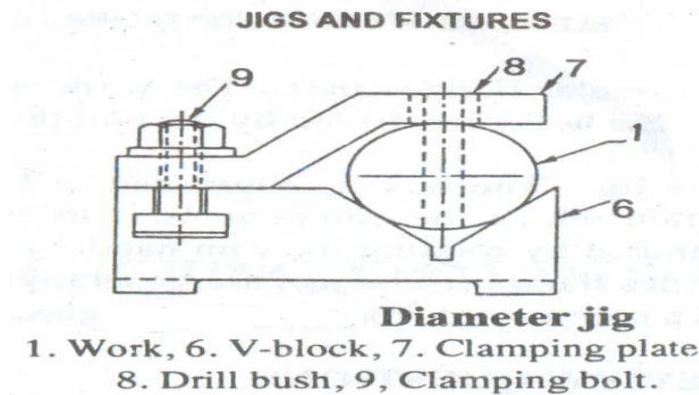
(b) **Template Jig:-**





- The template jig is the simplex of all types. A plate 2 having holes at the desired position. Such as template which is fixed on the component 1 to be drill. The drill 21 is guided to through these holes of template 2 & the required holes are drilled on the work piece at the relative positions with each other as on the template.

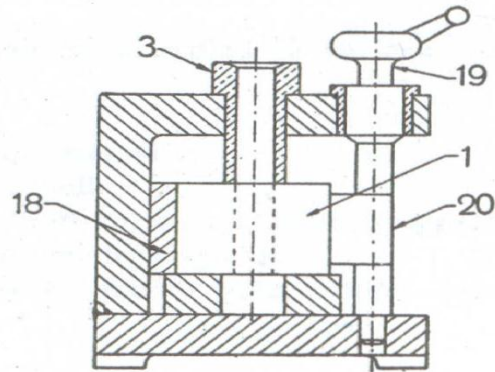
(c) **Diameter jig:-**



- The diameter jig is used to drill radial holes on a cylindrical or spherical work pieces. The work 1 is placed on the fixed v-bolt 6 & then clamped by the clamping place – 7 which also locates the work. The tool is guided through the drill bush 8 which is set radially with the work.

(d) **Box jig:-**

- The box jig is of box like construction with in which the components are located the bottom 18. The work 1 is clamped by rotating the can handle which also locates it the drill bush 3 guides the tool. The jigs are generally employed to drill a no of holes on a component form different angle.

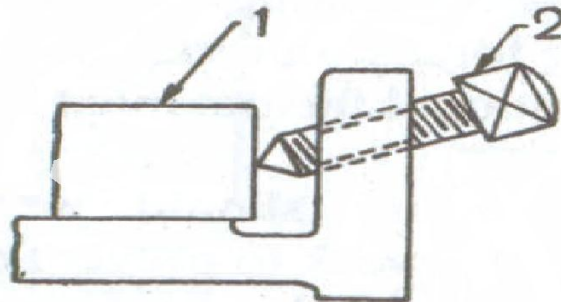


**Box jig**

1. Work, 3. Drill bush, 18. Buttons,  
19. Cam handle, 20. Cam.

**Various type of Fixture:-**

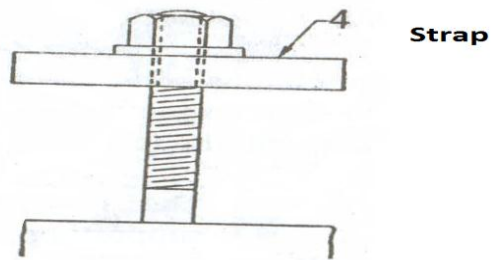
**(a) Screw :-**



**1. Work      2. Screw**

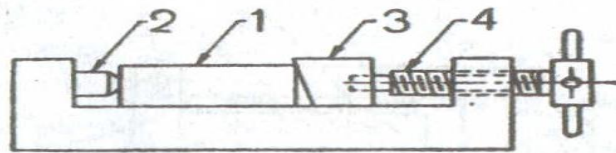
- The screw clamp is used to grip the work on its edges. This type of clamping arrangement enables the top surface of the work to be machined without any difficulty. Through the clamping method is quite simple, it Posses following defects.
  - (i) Longer time is required for clamping or unclamping the work.
  - (ii) The clamping force changes from the component to component.
  - (iii) Large effort is required to clamp a work.
  - (iv) Indentation marks are left on the edges of the work by the pointed ends of the screws.

(b) **Flats :-**



- The flat clamp supports the work by the clamp face which is pressed against the work by tightening the nut. There are several types of flat clamps.

(c) **Wedge Clamp:-**



**Wedge clamp**

1. Work, 2. Button, 3. Wedge, 4. Screw.

- The wedge clamp is employed to grip the work 1 by the wedge block 3, which is made to slide by rotating the screw. The wedge block grips the work against to the fixed bottom 2 fitted on the other end of the jig body.

## CHAPTER-3    INSTALLATION & TESTING OF MACHINE TOOLS

### ALIGNMENT TEST FOR LATHE:-

The following alignment tests are conducted on the lathe.

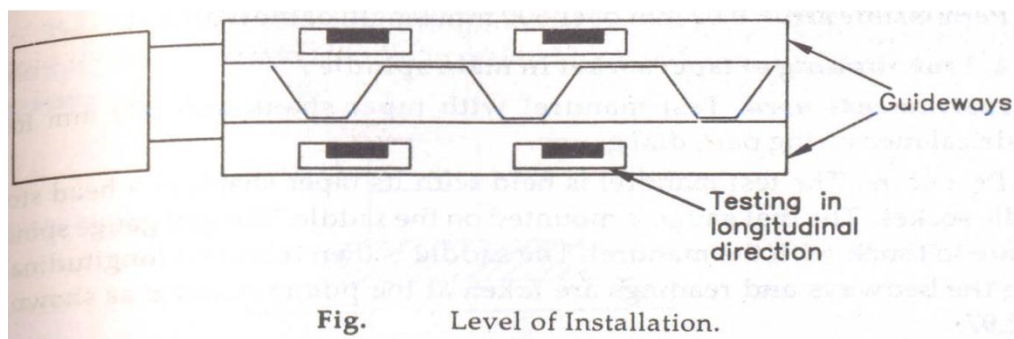
1. Levelling of the installation.
2. Straightness of saddle in horizontal plane.
3. Alignment of both the centres in the vertical planes.
4. True running of taper socket in main spindles.
5. Parallelism of main spindle to the saddle movement.
6. True running of locating cylinder of main spindle.
7. True running of head stock centre.
8. Axial slip of lead screw

(i) Test for levelling of installation:-

- (a) In longitudinal direction.
- (b) In transverse direction.

Instruments used:- Spirit level, gauge block to suit the guide ways of the lathe bed.

Procedure:- The gauge block with the spirit level is placed on the bed ways on the front position, back position and in the cross wise direction. The position of the bubble in the spirit level is checked and the readings are taken. The setup for testing the bed of a centre lathe is shown in figure.



**Permissible errors:-** Front guide ways 0.02 mm / meter convex only. Rear guide ways, 0.01 to 0.02 convexity. Bed level in cross-wise direction  $\pm 0.02$ mm / meter. No twist is permitted. The errors in level may be corrected by setting wedges at suitable points under the support feet or pads of the machine.

(ii) Straightness of saddle in horizontal plane:-

Instruments used:- Cylindrical test mandrel (600 mm long), dial indicator.

Procedure:- The material is held between centres. The dial indicator is mounted on the saddle. The spindle of the dial indicator is allowed to touch the mandrel. The saddle is then moved longitudinally along the length of the mandrel. Readings are taken at different places.

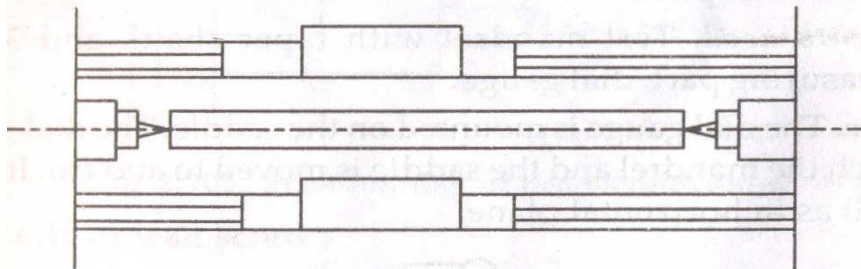


Fig. Straightness of Saddle.

**Permissible error:-** 0.02 mm over length of mandrel.

(iii) Alignment of both the centres in the vertical planes:-

Instrument used:- Cylindrical mandrel (600 mm long), dial gauge.

Procedure:- The test mandrel is held between centres. The dial indicator is mounted on the saddle in vertical plane as shown in figure:-

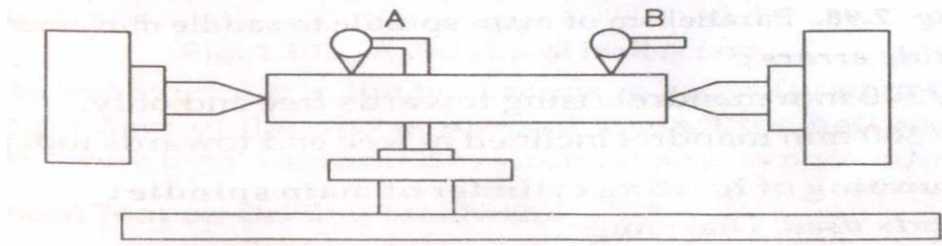


Fig. Alignment for both centres in vertical plane.

Then the saddle along with the dial gauge is travelled longitudinally along the bed ways, over the entire length of the mandrel and the readings are taken at different places.

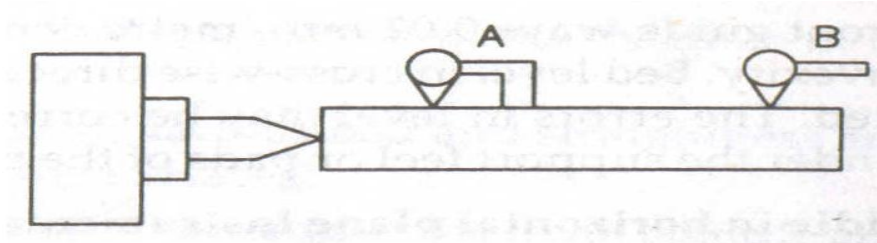
**Permissible error:-** 0.02 mm over 600 mm length of the mandrel.

(iv) True running of taper socket in main spindle:-

Instruments used:- Test mandrel with taper shank and 300 mm long cylindrical measuring part, dial gauge.

Procedure:- The test mandrel is held with its taper shank in a head stock spindle socket. The dial gauge is mounted on the saddle. The dial gauge spindle is made to

touch with the mandrel. The saddle is then travelled longitudinally along the bed ways and readings are taken at the points A and B as shown in figure.



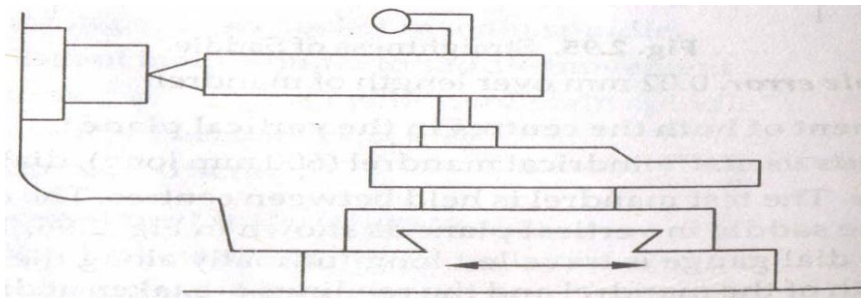
**Permissible errors:-** Position A, 0.01 mm; Position B, 0.02mm.

(v) Parallelism of main spindle to saddle movement:-

- (a) In a vertical plane
- (b) In horizontal plane

Instrument used:- Test mandrel with taper shank and 300mm. Long cylindrical measuring part, dial gauge.

Procedure:- The dial gauge is mounted on the saddle. The dial gauge spindle is made to touch the mandrel and the saddle is moved to and fro. It is checked in vertical as shown in horizontal plane.



Parallelism of main spindle to saddle movement.

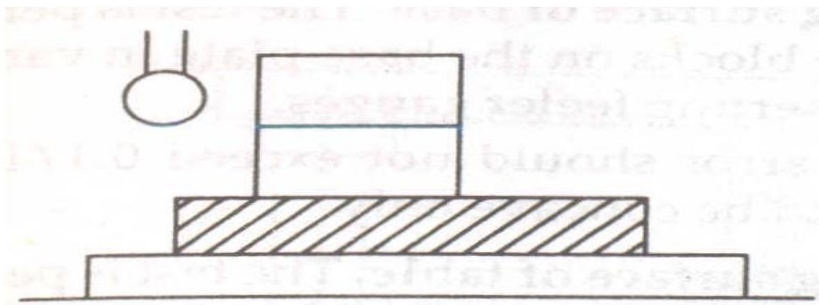
**Permissible error.**

- (a) 0.02 / 300 mm mandrel rising towards free end only.
- (b) 0.02 / 300 mm mandrel inclined at free end towards tool pressure only.

(vi) True running of locating cylinder of main spindle:-

Instrument used:- Dial gauge.

Procedure:- The dial gauge is mounted on the bed, touching at a point on main spindle. The main spindle is rotated by hand and readings of dial gauge are taken.

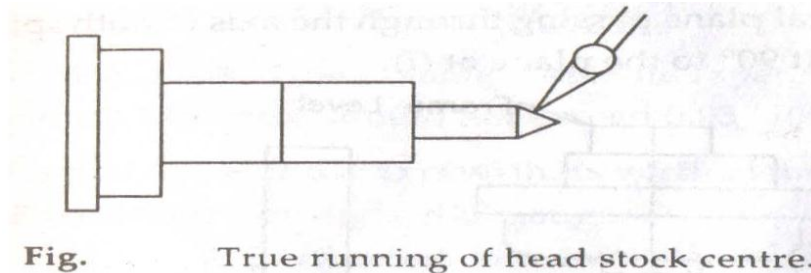


**Permissible error.** 0.01mm.

(vii) True running of head stock centre:-

Instruments used:- Dial gauge.

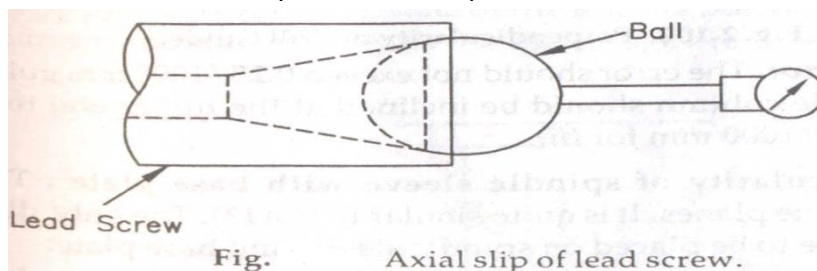
Procedure:- The live centre is held in the tail stock spindle and rotated. Its trueness is checked by means of dial gauge.



**Fig.** True running of head stock centre.

(viii) Axial slip of lead screw:-

The thrust face and collars of the lead screw must be exactly square to the screw axis, otherwise a cyclic endwise movement is set up which is of the same nature as the axial slip in the main spindle.



**Fig.** Axial slip of lead screw.

In order to test axial slip in the lead screw, a ball is fitted in the end of lead screw and the plunger of the dial is pressed against the ball as shown in above fig. The lead screw is rotated and deviation, if any, is noted down.



## ALIGNMENT TEST ON DRILLING MACHINES:-

There are two types of drilling machines:-

- i. Alignment test on pillar type drilling m/c.
  - ii. Alignment test on radial drilling m/c.
- (i) Alignment test on pillar type drilling m/c:-

(1) Flatness of clamping surface or base:-

The test is performed by placing a straight edge on two gauge blocks on the base plate in various positions and the error is noted down by inserting feeler gauges.

**Permissible error:-** The error should not exceed 0.1/1000 mm clamping surface and the surface should be concave only.

(2) Flatness of clamping surface of table:-

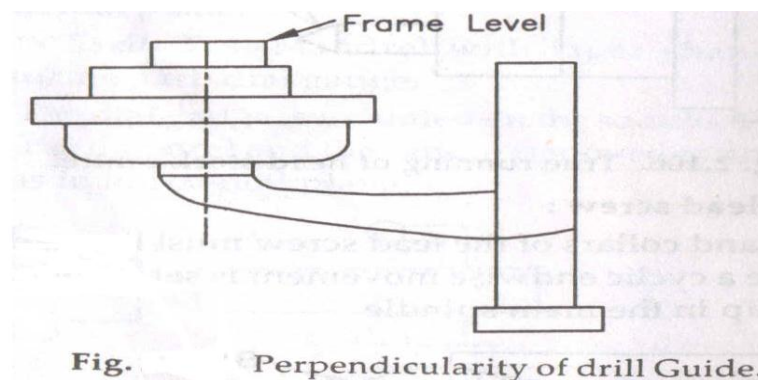
The test is performed by placing a straight edge on two gauge blocks on the table in various positions and the error is noted down by inserting feeler gauges. In this permissible error is same as in flatness of clamping surface of base (i.e., 0.1/1000 mm).

(3) Perpendicularity of drill guide to the table base plate:-

Instrument used:- Frame level.

Procedure:- The squareness of the drill head guide to the table is tested. The test is performed by placing the frame level on guide column and table and the error is noted by noting the difference between the readings of two level. The level is measured in two conditions.

- (i) In a vertical plane passing through the axis of both spindle and column.
- (ii) In plane at 90° to the plane at (i)





**Permissible error:-** The error should not exceed 0.25/1000 mm guide column for (i) and the guide column should be inclined at the upper end towards the front only and 0.15/1000 mm for (ii).

(4) Perpendicularity of spindle sleeve with base plate:-

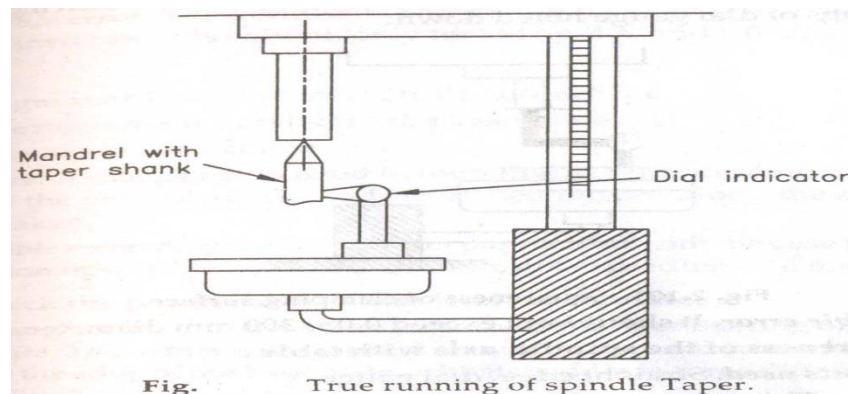
This test is performed in both the planes. It is quite similar to test (3). The only difference is that frame levels are to be placed on the spindle sleeve and base plate.

**Permissible error:-** The error should not exceed 0.25/1000 mm for plane (i) and the sleeve should be inclined towards column only, and 0.15/1000 mm for plane(ii).

(5) True running of spindle taper:-

Instrument used:- Test mandrel, dial gauge.

Procedure:- the test mandrel is placed in the tapered hole of spindle and a dial indicator is fixed on the table and its feeler made to scan the mandrel. The spindle is rotated slowly and readings of indicator noted down.



**Permissible error:-** the error should not exceed 0.03/100mm for machines.

(6) Parallelism of the spindle axis with its vertical movements:-

Instruments used:- Test mandrels, dial gauges

Procedure:- this test is performed into two planes(A) and(B) at right angles to each other. The test mandrel is fitted into the taper hole of the spindle and the dial gauge is fixed on the table with feeler touching the mandrel.

The spindle is adjusted in the middle position of its travel. The spindle is moved in upper and lower directions of the middle position with slow vertical feed mechanism and the readings of the dial gauge are noted down.

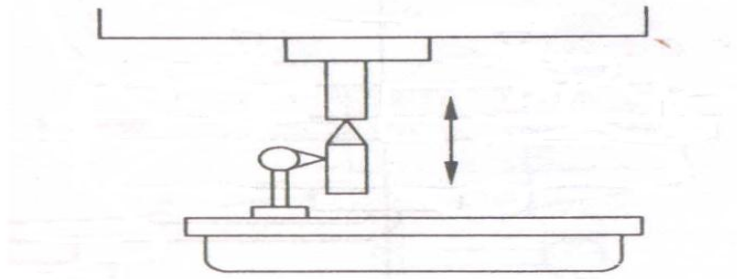


Fig. Parallelism of the spindle.

**Permissible error:-** 0.03/100mm for plane (A). 0.05/300mm for plane(B).

(7) Squareness of clamping surface of the table to its axis:-

Instruments used:- Dial gauge.

Procedure:- The dial indicator is mounted in the tapered hole of the spindle and its feeler is made to touch the surface of the table. The table is then moved slowly and the readings of the dial gauge noted down.

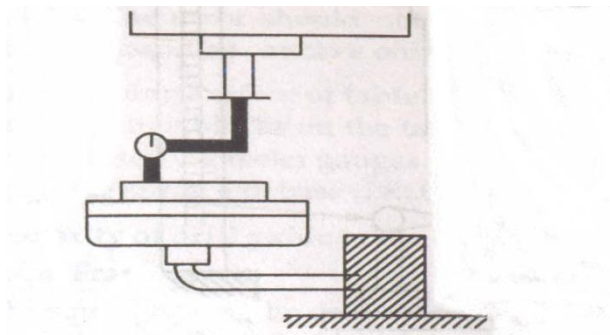


Fig. Squareness of clamping surface.

**Permissible error:-** It should be not exceed 0.05/300mm diameter.

(8) Squareness of the spindle axis with table:-

Instruments used:- Straight edge, dial gauge.

Procedure:- This test is performed by placing the straight edge in positions AA' and BB'.

• The work table is arranged in the middle of its vertical travel.

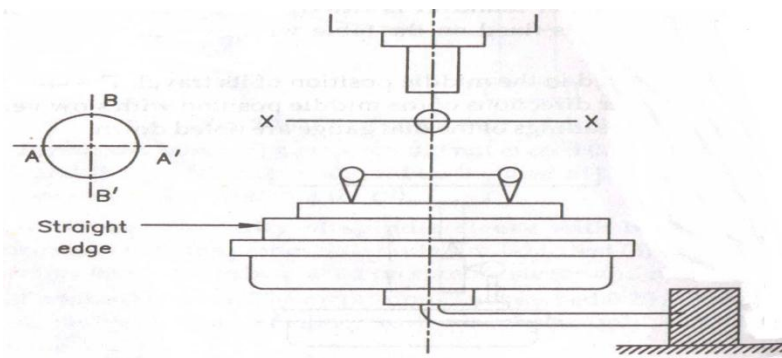


Fig. Squareness of the spindle axis.

The dial gauge is mounted in the tapered hole of the spindle and its feeler is made to touch the straight edge first at A and readings are taken. Then the spindle is rotated by  $180^\circ$  so that the feeler touches at point A' and again the reading is taken. The difference of these two readings is the error in squareness of spindle axis with table. Similar readings are taken by placing the straight edge in position BB'.

**Permissible error:-** The permissible errors are 0.08/300mm with lower end of spindle inclined towards column only for set up AA' and 0.05/300mm for set up BB'.

(ii) Alignment test on radial drilling m/c:-

(1) Saddle movement parallel to the base plate:-

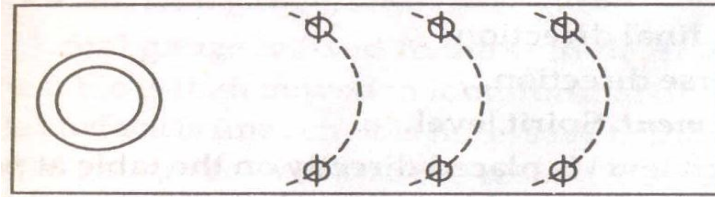
Instrument used:- Dial gauge

Procedure:- A dial gauge is fixed to the spindle, with its plunger bearing on the surface of the base plate, the saddle is then moved along the arm and the readings are taken.

**Permissible error:-** Any deviation from parallelism with the base plate should be on inclination upward towards the column, not exceeding 0.16mm per meter.

(2) To check the parallelism of arm itself as it rotates:-

A dial gauge is fixed in the spindle, with its plunger bearing on the surface of the base plate. The arm is then rotated slowly on the column and the readings are taken near the edge of the base plate, with its saddle in three different positions as shown in fig.

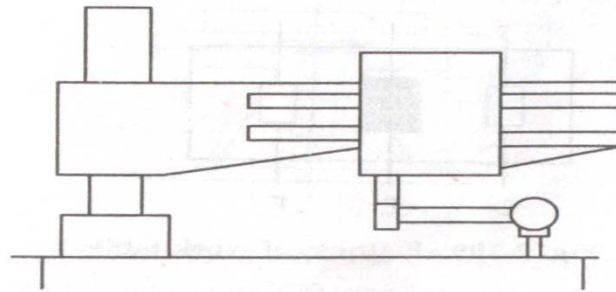


**Fig.** Parallelism of arm movement.

**Permissible error:-** 0.16mm per meter.

(3) Spindle and feed movement square with base plate:-

Instrument used:- Dial gauge with suitable attachment for fixing horizontal rod to the spindle.



**Fig.** Squareness of spindle and base plate.

Procedure:- To check the squareness of the spindle, a horizontal rod is fixed to the spindle, with a dial gauge, attached at a radius of about 300mm, as shown in fig. The plunger of the dial gauge is arranged to bear on the base plate and is brought into the two positions shown in the figure by rotation of the spindle. Readings should be taken with the spindle in four different positions, namely near to and remote from the column with the arm first low and then high up on the column.

**Permissible error:-** in any position, the departure from squareness should not exceed 0.16mm per meter.

(4) Squareness of the feed motion:-

Instruments used:- Dial gauge, true square.

Procedure:- the dial gauge is held in the spindle with its plunger horizontal and rearing on the dial gauge readings, as the spindle is moved up and down, measure the error. The test should be performed with the spindle near to the column and also at the end of the arm.

## ALIGNMENT TEST ON MILLING MACHINE:-

### (1) Flatness of work table:-

- (a) In longitudinal direction
- (b) In transverse direction

Measuring instrument:- Spirit level

Procedure:- A spirit level is placed directly on the table at points about 25 to 30 apart at A, B, C for longitudinal tests and D, E and F for the transverse test. After that the readings are noted.

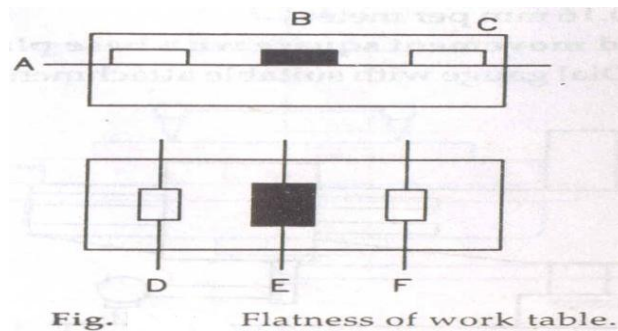


Fig. Flatness of work table.

**Permissible error:-** Direction A-B-C,  $\pm 0.04\text{mm}$

Direction D-E-F,  $\pm 0.04\text{mm}$

### (2) Parallelism of the work table surface to the main spindle:-

Instrument used:- Dial indicator, test mandrel 300mm long, spirit level.

Procedure:- The table is adjusted in the horizontal plane by a spirit level and is then set in its mean position longitudinally. The mandrel is fixed in the spindle taper. A dial gauge is set on the machine table, and the feeler adjusted to touch the lower surface of the mandrel.

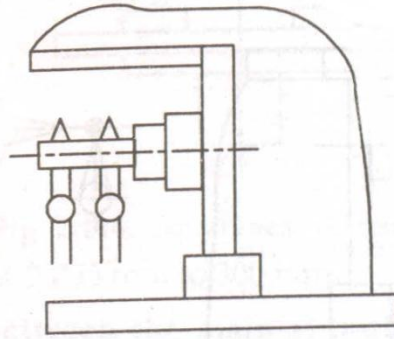


Fig. Parallelism of the work table surface.

**Permissible error:-** 0.02/300mm

(3) Parallelism of the clamping surface of the work table in its longitudinal motion:-

Instruments used:- Dial gauge , straight edge

Procedure:- A dial gauge is fixed to the spindle. It is adjusted to touch the table surface. The table is then moved in longitudinal direction and readings are noted. If the table surface is uneven, it is necessary to place a straight edge on its surface and the dial gauge feeler is made to rest on the top surface of the straight edge.

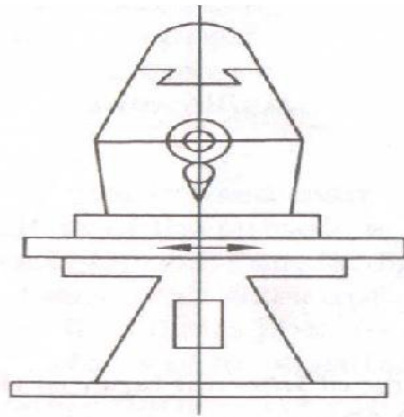


Fig. Parallelism of Clamping surface.

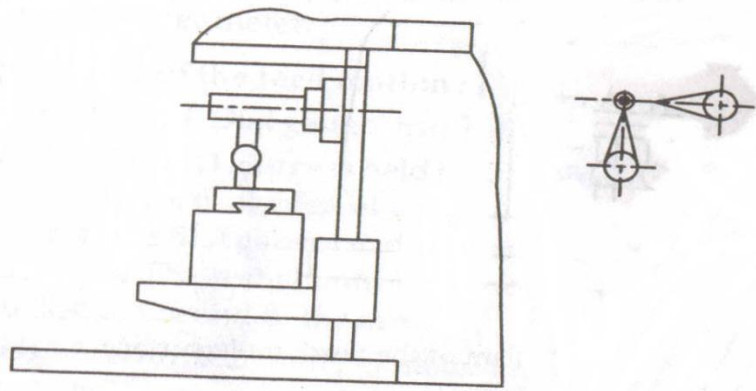
**Permissible error:-** 0.02 up to 500mm length, 0.03 up to 1000mm and 0.04 above 1000mm length.

(4) Parallelism of the cross movement of the work table to the main spindle:-

- (a) In a vertical plane
- (b) In horizontal plane

Instrument used:- Dial gauge, test mandrel with taper shank.

Procedure:- The work table is set in its mean position. The mandrel is held in the spindle. A dial gauge fixed to the table is adjusted so that its spindle touches the surface of the mandrel. The table is moved cross-wise and the error is measured in the vertical plane.



(Parallelism of the cross movement of the work table)

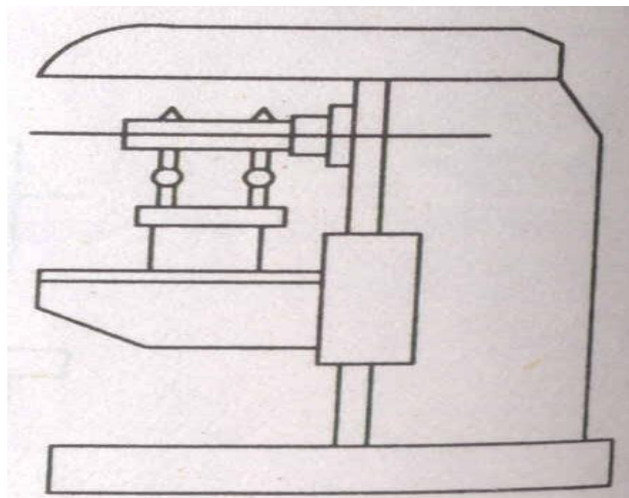
**Permissible error**:- 0.02 for the overall transverse movement of the work table.

(5) True running of internal taper of the main spindle:-

Instruments used:- 300mm long test mandrel, dial gauge

Procedure:- The test mandrel with its taper shank is held in the main spindle.

Dial gauge is kept scanning the periphery of the mandrel. Spindle is rotated and dial gauge readings are noted at different points.



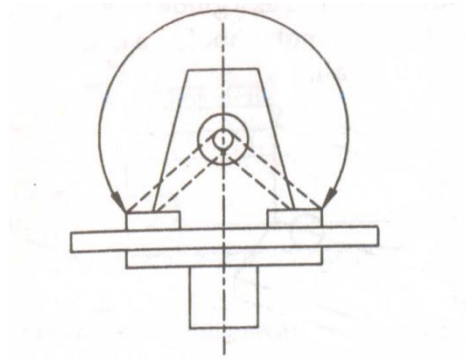
(True running of Internal taper of the main spindle.)

**Permissible error**:- 0.01 to 0.02mm .

(6) Squareness of the centre T- slot of work table with main spindle:-

Instruments used:- Dial gauge, special bracket.

Procedure:- To check the perpendicularity of the locating slot and the axis of the main spindle. The table should be arranged in the middle position of its longitudinal movement and a bracket in the locating slot. A dial gauge should be fixed in the spindle taper. Observe the readings from the dial gauge.



**Fig.** Squareness of centre T-slot.

**Permissible error**:- 0.025mm to 300mm.

(7) Parallelism between the main spindle and guiding surface of the overhanging arm:-

Instruments used:- Dial gauge, mandrel

Procedure:- The over-hanging arm is clamped in its extreme extended position. The dial gauge is fixed to the arbour support.

The feeler of the dial gauge is adjusted to touch the top or side of the test mandrel. The arbour support can then be moved along the over-hanging arm and the deviation from parallelism observed on the dial gauge.



## CHAPTER-4 SPECIAL CASTING AND POWER METALLURGY

**CASTING** – The process of pouring molten metal into the mould and allowing it to solidify is known as casting.

### Special Castings:-

- (1) Die casting
- (2) Investment casting
- (3) Centrifugal casting

#### (1) Die Casting :-

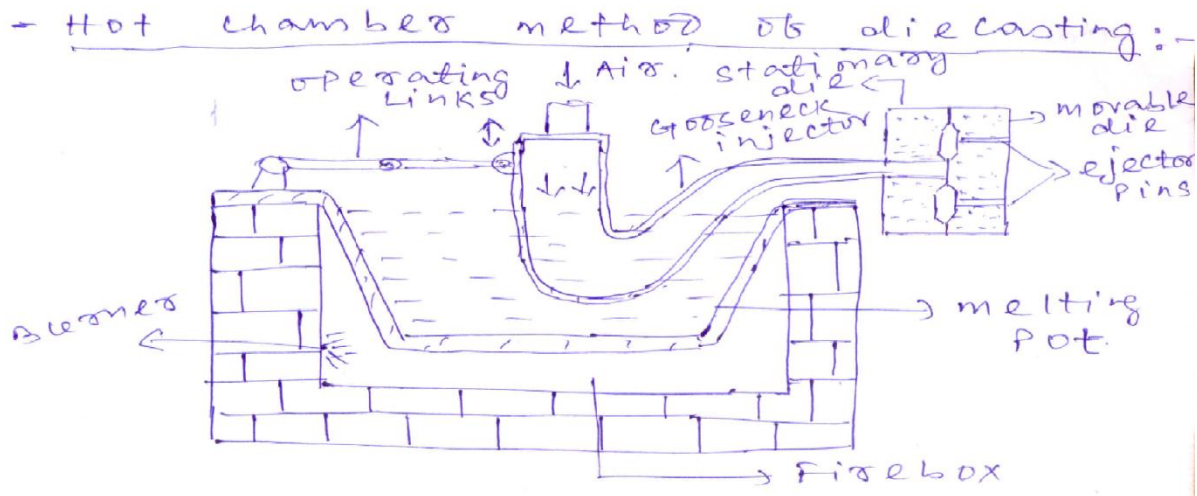
- The process of forcing the molten metal into the metallic mould (die) cavity under pressure and allowing it to solidify.
- Pressure is generally obtained by hydraulically or Pneumatically.
- The range of the pressure is (70 -5000) Kg/cm<sup>2</sup>
- The range of the pressure will be maintained during the solidification of casting.
- In this type of casting the liquid metal will be injected into the die.
- A die casting machine performs the following functions:
  - Holding two die halves firmly together.
  - Closing the die
  - Injecting the molten metal into die.
  - Opening the die
  - Ejecting the casting out of the die.

**Die casting is of two types.**

Hot chamber method

Cold chamber method

## Hot Chamber Method of die casting:-



- In hot chamber machine the melting unit constitutes an integral part of the process. The injection chamber is immersed in the molten metal at all times. At first the metal is melted in melting pot. After the metal reaches the molten state, the injection chamber is operated by air pressure which forces the metal into the die to complete the casting. The air pressure is maintained till the solidification of casting. When the solidification of the casting is completed the movable die will be opened. The die is having two halves. One half is stationary die and another half is movable die. Stationary is fixed one and movable die can be opened and closed. After opening of the movable the casting is removed by the help of ejector pins.

### Advantages –

- Simple in construction
- Operation is simple.
- It requires less space.

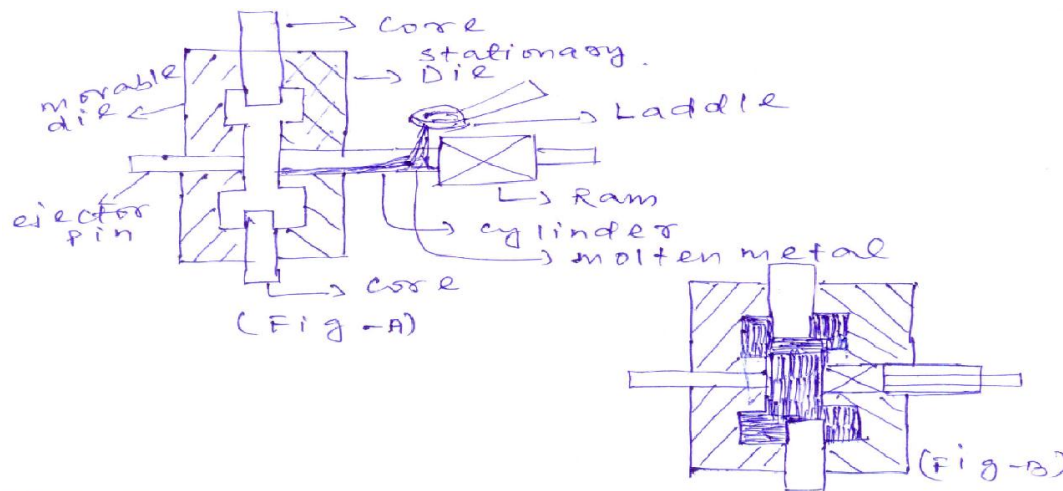
## Disadvantages-

- (1) Production rate is lower.
- (2) Compressed air does not produce pressure on molten metal.
- (3) Life and efficiencies are less.

**Applications** – Hot chamber method of die casting can produce the casting of low melting point metals such as zinc, tin and lead.

## COLD CHAMBER METHOD OF DIE CASTING –

The molten metal is poured into the cold chamber and this molten metal is forced hydraulically into the die is known as cold chamber method of die casting.



**Process:-** The metal is melted in a melting pot. In this method the melting pot is separated from cold chamber machine. After the metal reaches into molten state, the molten metal is poured into ladle. From the ladle the molten metal is poured into the cold chamber after the die is closed and all cores are locked in position. The molten metal is entered into the die by the help of hydraulic ram. The pressure required to force the metal into the die is of the order of (200-2000) kg/cm<sup>2</sup> and hence high squeezing action is exerted on the metal while it solidifies. Once the casting has solidified, the movable half of the die opens. Cores are withdrawn, ram moves to the backward and the ejector is advanced to force the casting out of the die half.

Advantages-

- Lower temperature of molten metal with higher injection pressure will produce castings of dense structure.
- Sustained dimensional accuracy and free from blow holes.
- Increases its life and efficiency due to separation of melting pot and injection unit.

#### Disadvantages-

- It requires more area.
- Working parts are costly.

#### Applications-

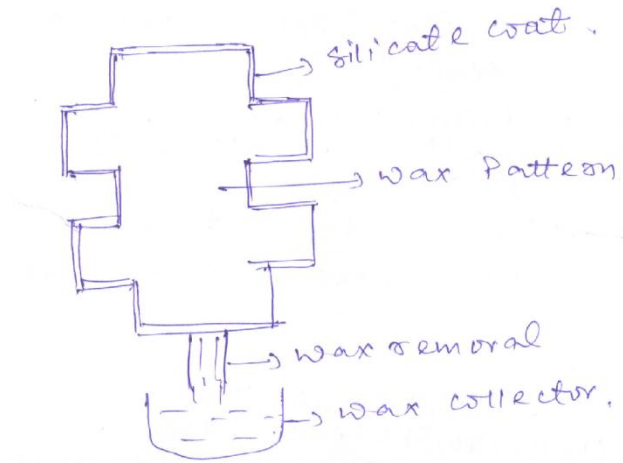
- Aluminium, magnesium, brass and low melting points material can be cast.

#### **(2) Investment Casting**:-

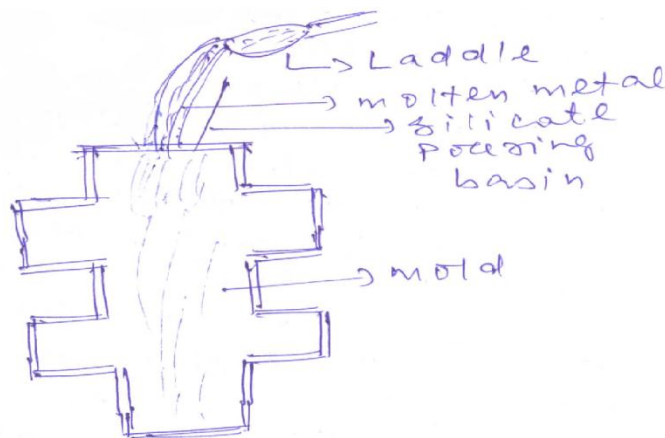
It is a lost wax method of casting.

#### Process –

- The liquid wax is injected (150 – 170)<sup>0</sup>F into the metallic die at pressure (7 – 70) kg/cm<sup>2</sup>. After cooling the wax mould is removed out of the metallic die. The silicate slurry is prepared in a pot.
- The constituents of silicate slurry are 91.2% sand, 33.8% water, 6.5% calcium phosphate 2.3% magnesium oxide and meshed silica. After the preparation of silicate slurry is over then the wax mould is dipped in the solution of silicate slurry. The wax mould can be dipped for 6 to 7 time. Now the wax mould is coated with silicate slurry.
- The silicate moulds are allowed to cool in air. Then the moulds are taken into autoclave machine. In autoclave machine the wax is removed out of the mould by the application of steam. The wax from the silicate mould is collected in wax collector.



- The silicate mould is taken into pre-heater for pre-heating. Before pouring the molten metal into the mould the pre-heating is required. Pre-heating is to remove vapours and any wax linings present on inside wall of the mould.
- The metal is melted in a melting pot. After the metal reaches into molten stage, the molten metal is poured into the ladle. From the ladle the molten metal is poured into the silicate mould. Then the casting is allowed to cool and solidify in air.



Advantages:-

- (1) Complex shapes which are difficult by any other methods are possible.
- (2) Very close tolerance and excellence surface finish can be obtained.

- (3) Little or no machining is required.
- (4) Almost any metal can be cast.
- (5) No flash on parting lines.
- (6) Stronger components
- (7) Strength is higher
- (8) Light stressed wax impression dies have a very long life.

Disadvantages:-

- (1) Expensive due to preparation of wax patterns and shell moulds.
- (2) It is a time consuming process.

Applications:-

- Textile industries
- Automobile industries
- Food industries
- Oil gas industries
- Pump and valve industries.

### **(3) Centrifugal casting:-**

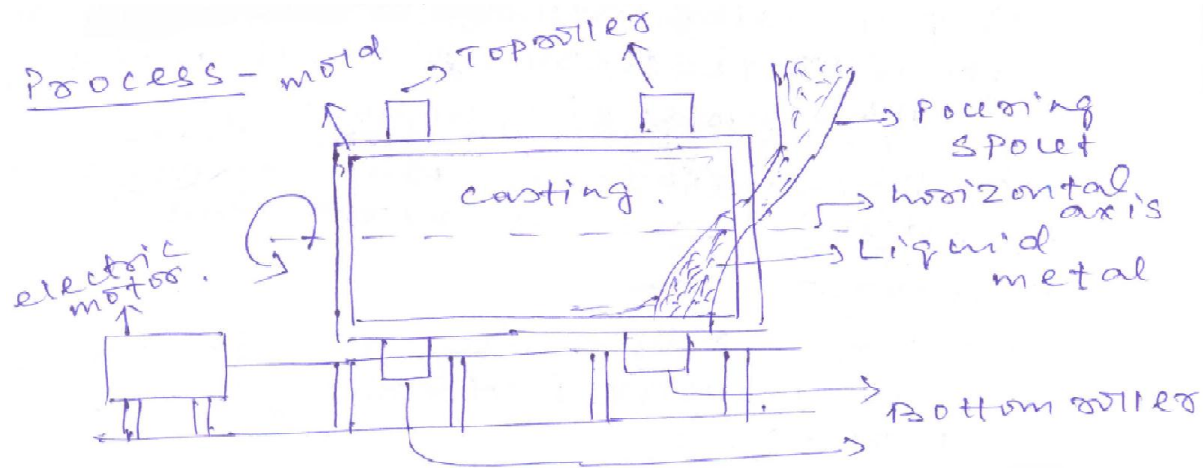
The casting which utilizes the molten metal into the rotating mould.

The centrifugal casting is classified into three types

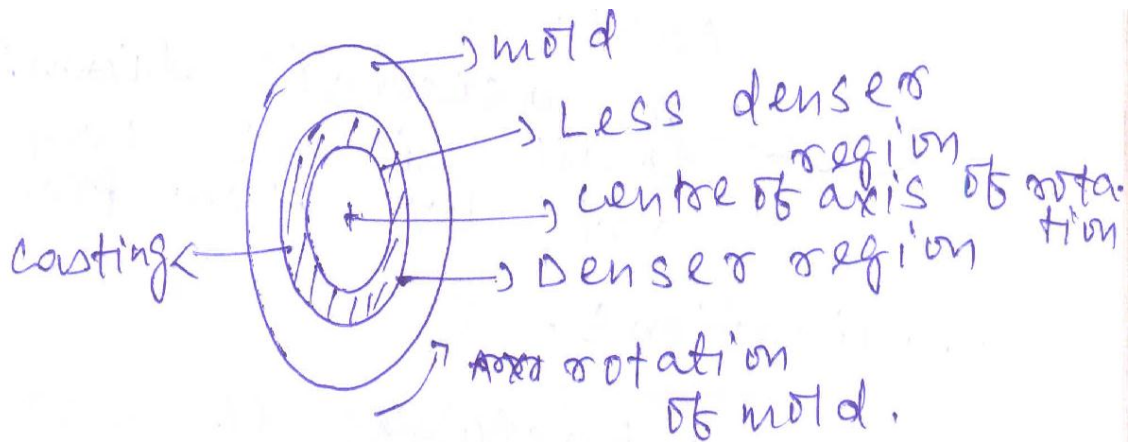
- (1) True centrifugal costing
- (2) Semi-centrifugal casting
- (3) Centrifuging casting.

#### **True centrifugal casting-**

- It utilizes the forces generated by the centrifugal action to distribute the molten metal in the rotating mould.



- Centrifugal force play a major role in shaping and feeding of the casting.
- Mould is rotated about its own axis at a predetermined speed.
- Moulds may be rotated about its horizontal axis or vertical axis.
- Moulds for longer parts may be rotated about its horizontal axis.
- Moulds for smaller parts may be rotated about its vertical axis.
- The molten metal for the cast part is introduced to the mould from an external source by the help of a pouring spout. The liquid metal flows down into the rotating mould.
- The metal casting will harden as the mould continuous to rotate.
- By the help of the pipe puller the casting can be extracted from the mould.
- The forces play a major role for the solidification of casting.
- Due to the greater force in outer region of the rim that portion will be denser.



- All the impurities will remain in less denser region of metal casting, closer to the centre of the axis of rotation.
- Impurities are solid inclusions and trapped air.
- The impurities will be removed by the machining process.

#### Advantages:-

- No use of sprues, risers or other gating systems.
- Good surface finish
- Quality castings with good dimensional accuracy can be produced.
- Material of high density and with few impurities is produced in the outer regions of cylindrical parts.
- Large metal casting 10ft in diameter, and 50ft long can be produced.
- High melting point materials iron, steel can be cast.
- Core is not required.

#### Disadvantages:-

- All alloys cannot be cast.
- Small items cannot be cast by this process.

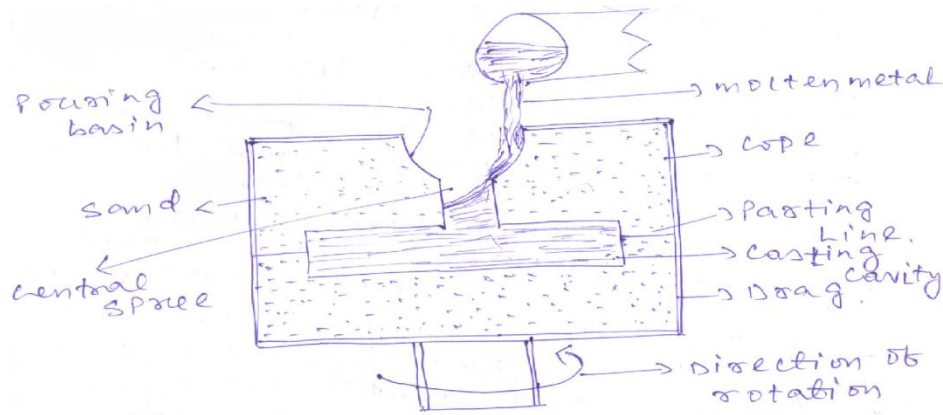
#### Applications:-



- Manufacturing of various tubes and pipes such as sewage pipes, gas pipes, water supply lines, rings, bushing, the liner for engine cylinder, brake drums, street lamp posts.

**Semi centrifugal Casting:-**

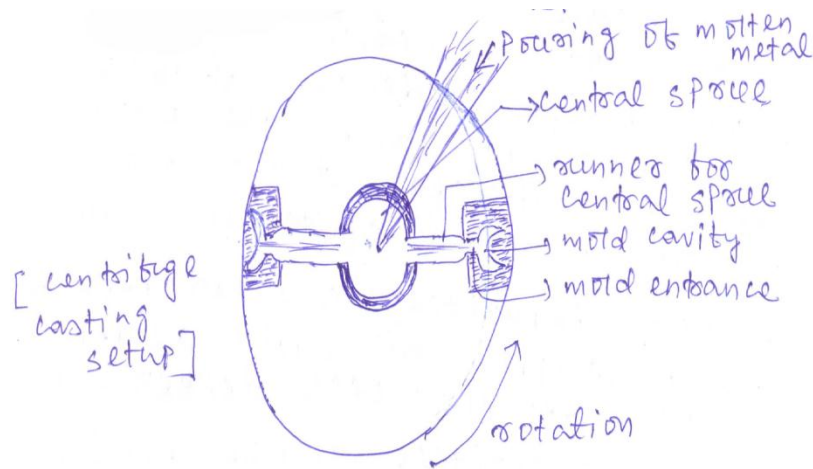
- The molten material for the metal casting is poured into a pouring basin and is distributed through a central sprue to the areas of the mould. The forces generated by the rotation of the mould ensure the distribution of molten material to all regions of the casting.



- As the metal casting solidifies in a rotating mould the forces constantly push the material out from the central sprue.

**Centrifuging casting:-**

- Centrifuging casting is the third main branch of centrifugal casting process used for industrial manufacture of cast parts.



- In centrifugal casting moulds are arranged around the central sprue.
- These moulds contain all the necessary geometry for the cast part. Runners travel from the central sprue to the mould entrances.
- The molten material is introduced into the central sprue. The entire system is rotated about its axis with the central sprue at the centre of rotation. When an object is rotated, forces are produced that act directly away from the centre of the axis of rotation.
- The molten material moves into the moulds from the centre through the runners. When the correct amount of molten metal to manufacture the casting is poured and distributed completely into the moulds, the apparatus will continue to rotate as solidification is occurring.
- During the solidification of the casting the moulds will be rotated. The forces acting on the material farther from the centre are greater than the forces, those are acting on the material closer to the centre.
- The material is denser at the outer region and the material is less denser at the area closer of the centre of rotation.
- The impurities such as inclusions and trapped air will be deposited at the less denser region.
- The impurities can be removed by the help of machining process.

Advantages:-

- Cast parts with thin walled sections can be manufactured.
- High density, high mechanical strength and fine grained structure can be produced.
- Desired shape can be manufactured.
- Great surface finish can be achieved.

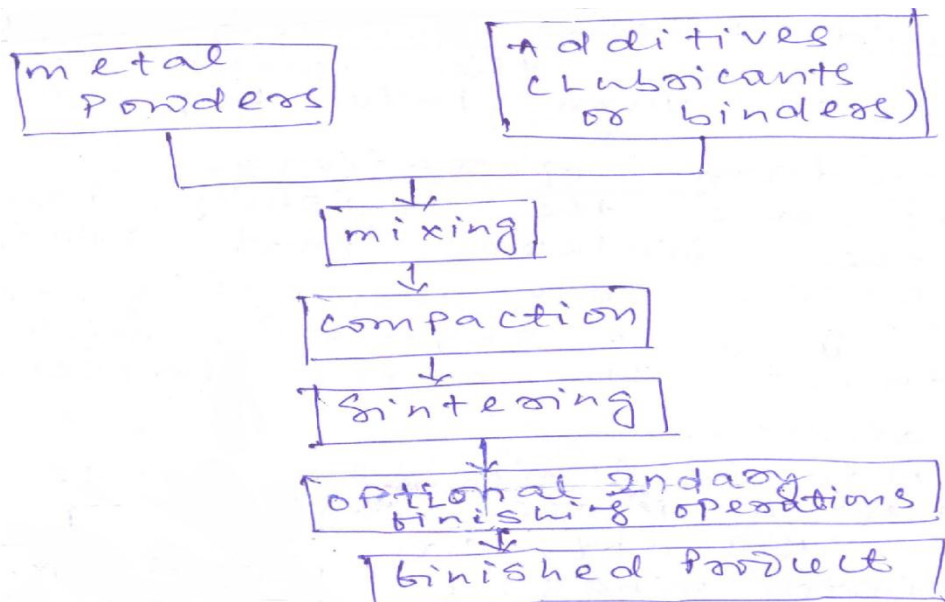
Disadvantages:-

- All alloys cannot be cast.
- Small items can be produced.

## Powder Metallurgy

**Definition-** It is a process of forming metal parts by heating compacted metal powders to just below their melting points.

Flow chart of powder metallurgy:-



1. Metal powder is prepared from the metals.
2. The metal powders are mixed with additives (binders of Lubricants)
3. Forming of the mixed powder into compact form.
4. The compact powders are introduced into the die.
5. Then sintering will be started. Sintering of the compact to enhance integrity and strength.
6. Sintering is the process of heating the powder at a temperature below the melting point of the major constituents.
7. Sintering - (a) Solid phase sintering  
(b) Liquid phase sintering

(a) Solid Phase sintering – In this the minor constituents will not turn into liquid stage.

(b) Liquid Phase Sintering – In this case the minor constituents will turn into liquid stage.

#### 8. Secondary Operations:-

These are the finishing processes to the sintered part. Finishing processes are annealing, polishing, machining if required, surface treatment to avoid corrosion.

#### Applications:-

- Manufacturing of brake linings, clutch plate, connecting rod crank shaft, cam shaft and piston rings.
- Porous material such as bearing & filters can be manufactured.
- Tungsten filaments of electric bulb, radio valves, x-ray tube, oscillator valve.
- Military defence application.
- Atomic energy application.
- Manufacturing of grinding wheels.
- Clocks & timing devices, type writers, calculators, and permanent magnet can be manufactured.
- Manufacturing of toothed components like gear.
- Material which are very difficult for machining- wire drawing dies, press tools, stone hammers & rock drilling bits can be manufactured.

- Manufacturing of nozzles for rocket & missiles.
- Jet engine parts.

Advantages:-

- Accuracy is better
- Surface is good.
- Machining Processes are eliminated.
- Longer life of the product.
- Uniformity of structure.
- Void, blow holes are absent
- No material is wasted as scrap.
- Highly gratified labour is not required.
- Porous parts can be manufactured.
- Mixed powders of copper & lead can be successfully shaped by powder metallurgy.
- Product cost is cheaper.
- Hard tool bits can be formed.

Disadvantages:-

- Complicated shapes cannot be achieved.
- Don't have good physical properties.

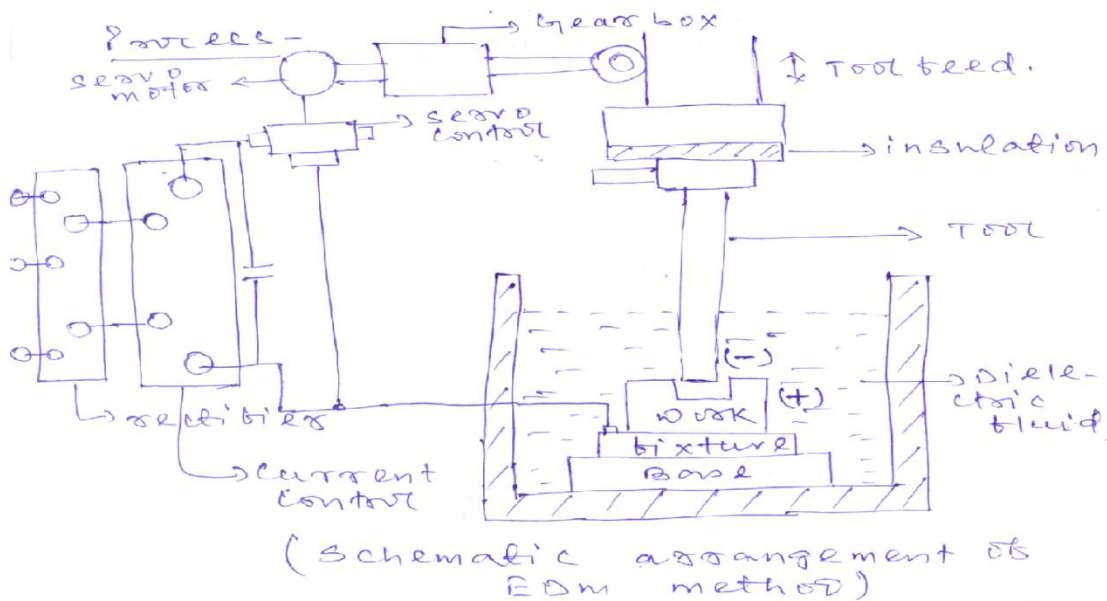
## CHAPTER-5 NON CONVENTIONAL MACHINING PROCESS

### Non conventional machining methods:

1. Electro discharge machining(EDM)
2. Electro chemical machining(ECM)
3. Abrasive jet machining(AJM)
4. Ultrasonic machining(USM)
5. Plasma arc machining(PAM)
6. Electron beam machining(EBM)
7. Laser beam machining(LBM)

### 1. Electro discharge machining:

- It has been recognized that a powerful spark, such as at the terminals of an automobile battery will cause pitting of the metal at both the anode and the cathode.
- Power is supplied from an AC service to a rectifier for generating the spark.
- DC output is then feed to the spark generation circuit.
- Tool, work and servomechanism are connected to the circuit.
- The function of the servomechanism is to maintain a very small gap between the tool and work. The gap maintained is (0.025 to 0.75) mm.



- The tool and the work are submerged in dielectric fluid having poor electrical conductivity.
- The spark is the transient electric discharge between the work and tool.
- When the potential difference (voltage) is sufficiently large across the gap the dielectric fluid becomes ionized and breaks down to form the spark.
- The condenser discharges the current in the form of a spark.
- The time interval of spark is (10 to 30) microseconds.
- The current density is (5 to 500) A/mm<sup>2</sup>.
- The thousands of spark discharge occur/second across the gap between tool and work which results a temperature 12000° C.
- At each discharge heat transfers from high temperature spark to both tool and work.
- It melts the metal in a thin surface layer.
- Work – anode

Tool – cathode

- Dielectric fluids are based such as white spirit, paraffin, petroleum base hydrocarbon fluids, transformer oil, kerosene and mineral oil.
- Dielectric fluid cools the cutting zone.
- Tool materials are based such as copper, brass, alloys of zinc and tin, hardened plain carbon steel, tungsten carbide, graphite etc.

#### Advantages of EDM

- Complex shapes can be produced which are difficult to produce in conventional methods.
- Extremely hard materials with very close tolerance can be achieved.
- There is no direct contact between work and tool. So delicate sections and weak materials can be machined without any distortion.
- A good surface finish can be obtained.
- Very fine holes can be drilled.
- The chips, burrs can be easily cleaned from the surface due to the presence of dielectric fluid.
- Cutting forces are zero.

#### Disadvantages of EDM

- Only electrically conducting materials can be machined by EDM.
- The low rate of material removal.
- Power consumption is very high.

- Excessive tool wear occurs during machining.
- Fire hazard associated with use of combustible oil based dielectrics.
- Cost is more.
- Time consuming process.
- Reproducing sharp corners on the work piece is difficult.

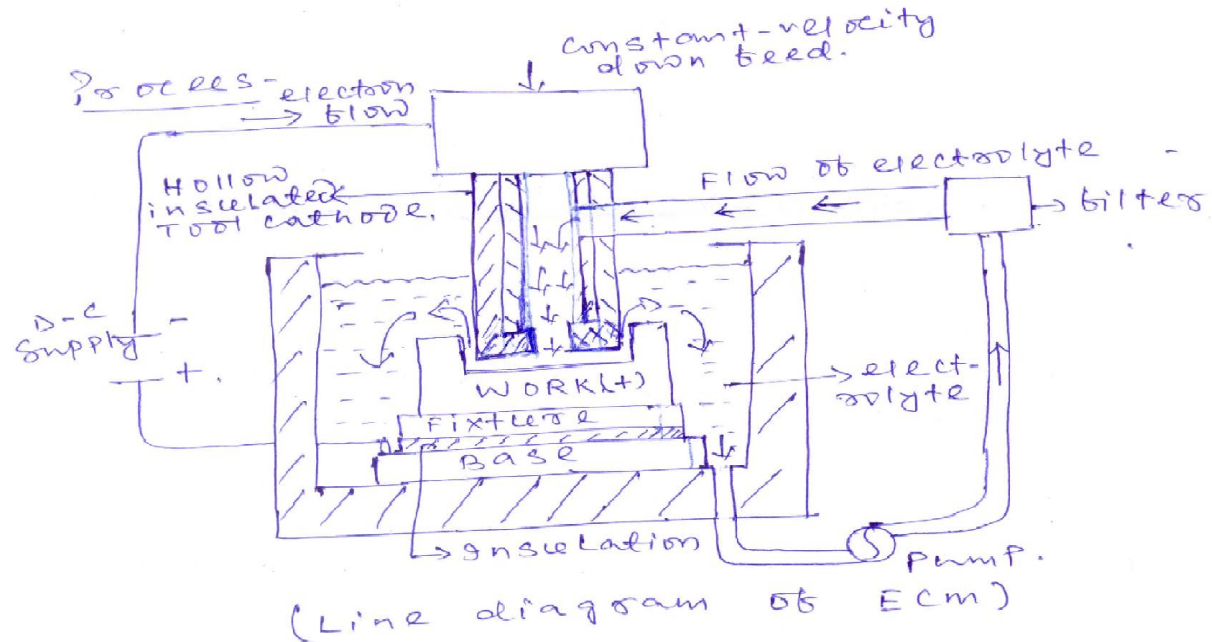
#### Application of EDM

- Manufacturing of the dies, press tools for the press machines.
- Manufacturing of moulds for the foundry shop.
- Manufacturing of the dies for the forging shop.
- Dies for the injection moulding machines.
- This process is useful for machining of small holes, orifices or slots in diesel fuel injection nozzles, in air craft engines, air brake, valve etc.
- This process is suitable for machining burr free intricate shapes, narrow slots and blind cavities etc.

#### **2. Electro chemical machining (ECM):**

- In ECM the principle of electrolysis is based for the removal of material from the metal surface. The principle of electrolysis is based on Faraday's laws of electrolysis.
- Work piece – anode , tool – cathode
- The tool is hollow tubular type to provide passage for circulation electrolyte between the tool face and the work.
- As the power supply is switched on and the current starts flowing through the circuit.
- Electrons are removed from the surface of the atoms of the work piece.





- The cat-ions tend to migrate to the hollow cutting tool.
- Before these ions can get deposited on the cutting tool face, these are swept away by rapidly flowing electrolyte.
- The anions which move towards DC supply for the neutralization.
- The tool is fed towards the work piece automatically at constant velocity to control the gap between the work and the tool.
- The sides of the tool are insulated to concentrate the metal removal action at the bottom face of the tool.
- The electrolyte with burrs from the tank is lifted by the help of pump and reused again.
- The filter is provided for the filtration of burrs and dirt particles after the pump.
- The electrolyte is used 20% common salt (NaCl) solution. It acts as coolant during metal removal.

#### Advantage of ECM:

- Tool does not contact the work piece. So less tool, wear, less heat and less stress are produced.
- Tool can be repeatedly used.
- It is simple and versatile method.
- Surface finish can be extremely good.
- The process character does not depend upon the physical properties of the metal.

#### Disadvantages of ECM:

- High tool cost.
- 40000 Amps of current must be supplied. Power consumption is higher.
- The saline (acidic) electrolyte poses the risk of corrosion to tool, work piece and equipment.

#### Applications of ECM:

- Die sinking operation
- Drilling jet engine turbine blades.
- Multiple holes drilling.
- Machining steam turbine blades within closed limits.

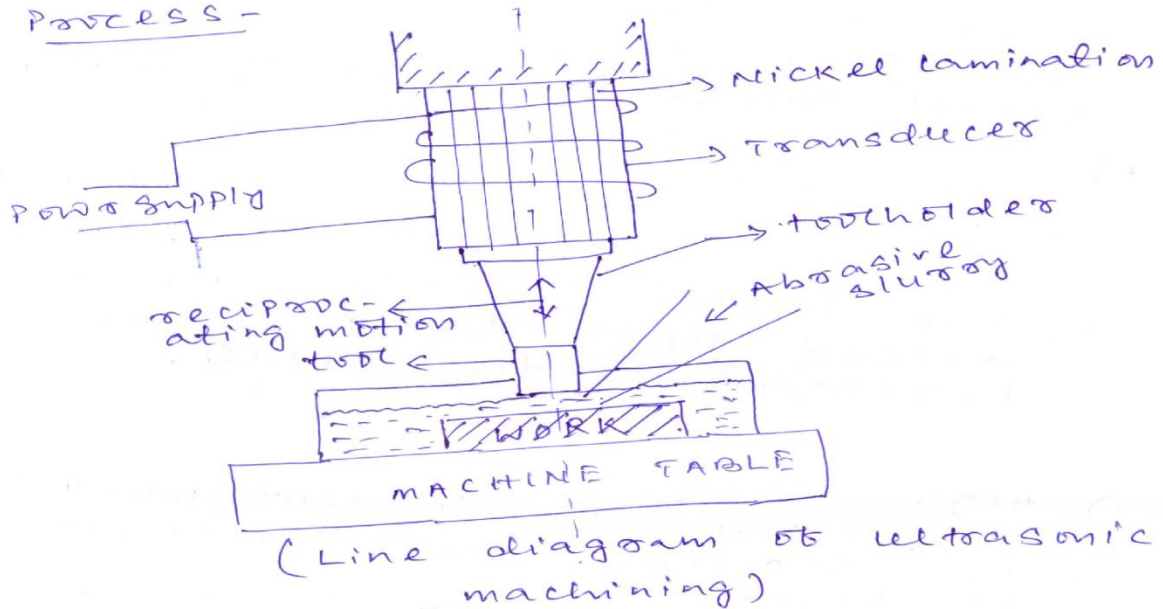
### **3. Ultrasonic machining (USM):**

- Ultrasonic machining is a kind of grinding method.
- Abrasive slurry is pumped between tool and work.
- The equipment consists of a transducer, a tool holder and a tool.
- The linear oscillatory motion of the tool is obtained by transducer which converts electric energy into mechanical energy.
- The transducer consists of a stack of nickel laminations those are wound with a coil.
- When a high frequency of current is passed through the coil changes in the electromagnetic field produce longitudinal strains in the laminations.
- These longitudinal strains are transmitted to the tool through a tool holder.

## ULtrasonic machining (USM) -

- ULtrasonic machining is a kind of grinding method.

Process -



- The tool oscillates linearly with amplitude of about 0.05 mm.
- By the help of oscillation of the tool and abrasive slurry the material is removed from the work piece.
- The tool is brazed, soldered or fastened mechanically to the transducer through a tool holder.
- The abrasive used in this process is aluminium oxide, boron carbide and silicon carbide grains.
- The abrasive slurry can be prepared by taking the mixture of boron carbide and silicon carbide and paraffin and aluminium oxide and paraffin.
- Water and paraffin acts as coolant.
- The tool used is may be copper, brass etc.

### Advantages of USM:

- Good surface finish.
- Higher structure integrity.
- Any material can be machined.
- It can be machined hard, brittle, fragile and non conducting materials.
- No heat is generated in work, no change of physical structure of material.
- Non-metal can be machined.
- It is burr less and distortion less process.

### Disadvantages of USM:

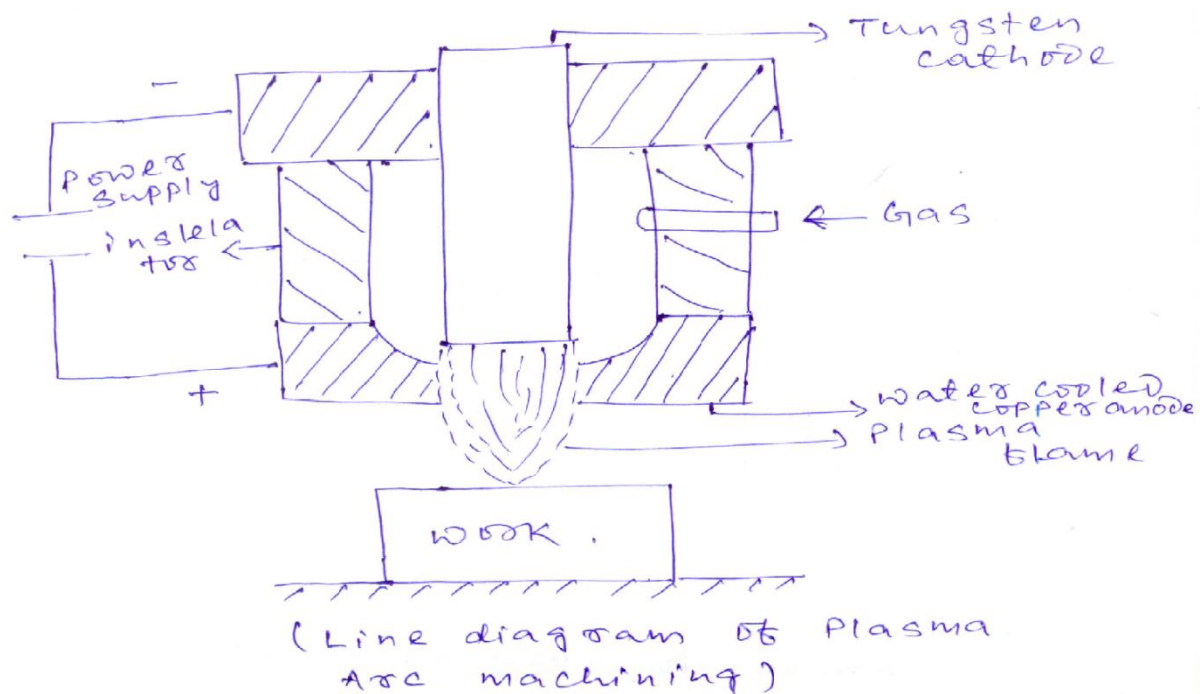
- Low metal removal rate.
- Tool wear rate is higher due to abrasive particles.
- Ultrasonic machining is used only when the hardness of work is greater than 45 HRC.

### Applications of USM:

- Machining of hard, brittle and non-conductive materials.
- It is used chiefly for drilling holes, engraving.
- It is used for broaching and slicing etc.

### 4. Plasma arc machining (PAM):

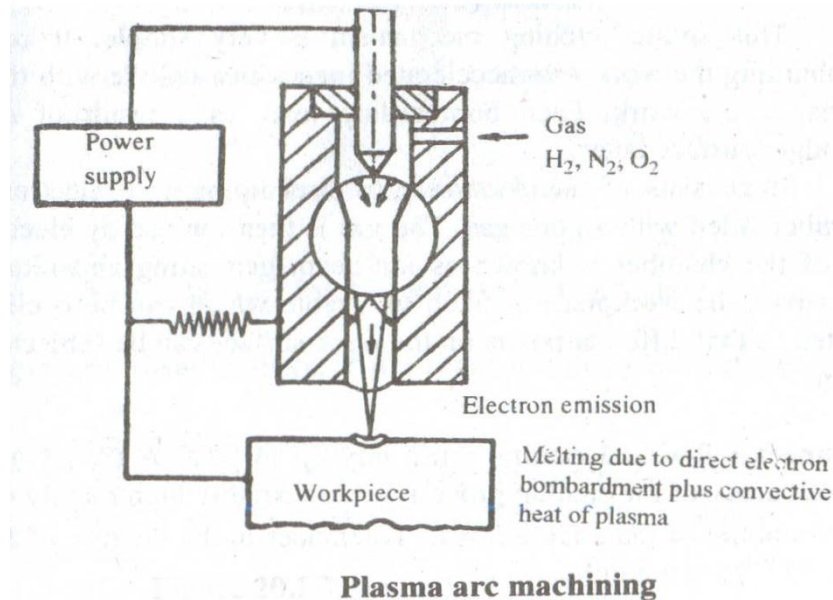
- All the gases burning at high temperatures are ionized gases.
- In plasma arc machining, the gases are ionized by placing an arc across the path of gas flow.
- The gas molecules get dissociated, causing large amounts of thermal energy to be liberated. This generates high temperature which removes the metal by melting and vaporization.



### Process:

- An arc is struck between tungsten cathode and the water cooled copper anode.

- An inert gas such as argon is passed through a small chamber in which the arc is maintained.
- As the gas flows out of the nozzle, it is heated and gets ionized the arc and forms the coving plasma flame.
- The temperature of the plasma flame is (11000 to 28000)° C.
- The temperature melts the work piece surface and cuts.
- The cathode is eroded by the high spark temperature and must be adjustable.



#### Advantages of PAM:

- Easy to operate.
- A semiskilled operator can use this machine.
- It can cut both ferrous and non-ferrous materials.
- The plasma torch is easy to operate.

#### Disadvantages of PAM:

- Cutter's electrode, nozzle sometimes requires frequent replacement which adds the cost of operation.
- Non-conductive materials cannot be cut such as wood and plastic.
- Plasma arc leaves (4-6)° bevel on the cutting edge. This angle is visible in thicker pieces.

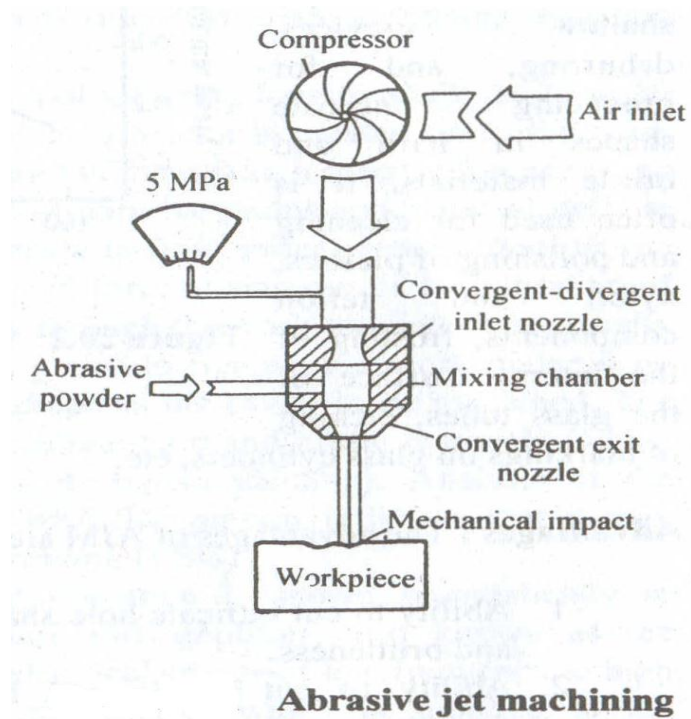
#### Applications of PAM:

- Stainless steel and aluminium alloys cannot be cut.

- Compared to ordinary flame plasma flame cuts the plain carbon steel four times faster.

#### 5. **Abrasive jet machining (AJM):**

- In this method the material is removed from the surface of the work piece by colliding a focused jet of fine abrasive particles carried by compressed gas.
- The abrasive jet with compressed gas leaves through a nozzle at a velocity of the order 300 m/sec and strikes the surface of the work piece producing impact loading on it.
- Due to impact loading the micro-cracks occur and small chips of material get loosened.
- The fresh surface is achieved.
- The abrasive material is used are aluminum oxide, silicon carbide and glass beads etc.



#### Advantages of AJM:

- Flexibility and low heat production.

- Very good surface finish.
- Hard materials can be machined.
- Complete profiles can be created.
- Easily transportable of gas and abrasive material tank so any surface of the work piece can be machined.

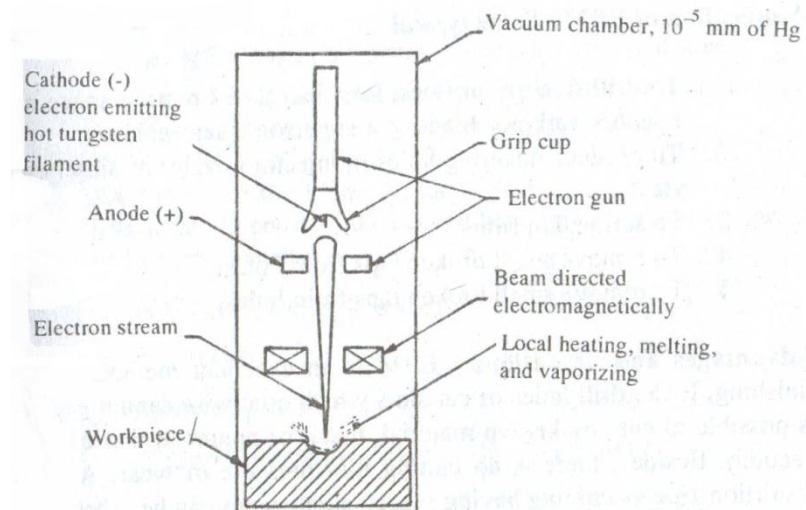
#### Disadvantages of AJM:

- Very slow rate of operation.
- Abrasive cannot be re-used.
- Slow material removal rate.
- Process produces a taper cut.
- Sometimes frequent replacement of nozzle brings an extra cost.

#### Applications of AJM:

- Ideal for cutting intricate profile out of brittle, hard, heat sensitive and thin materials.

#### **6. Electron beam machining (EBM):**



**Electron-beam machining**

- Electron-beam machining is a metal removal process by a high velocity focused stream of electrons which heats, melts and vaporizes the work material at the point of bombardment. The production of free electrons is obtained from thermo-electronic cathodes wherein metal are heated to the temperature at which the electrons acquire sufficient speed for escaping the space around the cathode. The acceleration of the electrons is carried by an electric field while the focusing and concentration are done by controlled magnetic fields.

The kinetic energy of a beam of free electrons is transformed into heat energy as a result of the interaction of the electrons with the workpiece material. EBM is therefore, a thermo-electric process.

- The figure shows the principle of operation of Electron-beam machining. A beam of electrons is emitted from the electron gun which is basically a triode consisting of
  - \* A cathode which is a hot tungsten filament (2500°C) emitting high negative potential electrons.
  - \* A grid cup, negatively biased with respect to the filament.
  - \* An anode which is heated at ground potential, and through which the high velocity electrons pass.
- The gun is supplied with electric current from a high voltage D.C source. The flow of electrons is controlled by the negative bias applied to the grid cup.
- The electrons passing through the anode are accelerated to two-thirds of the velocity of light by applying 50 to 150 kV at the anode, and this speed is maintained till they strike the workpiece.
- Due to the pattern of the electrostatic field produced by the grid cup, the electrons are focused and made to flow in the form of converging beam through a hole in the anode.
- A magnetic deflection coil is used to make the electron beam circular having a cross sectional diameter of 0.01 to 0.02 mm and deflect it anywhere.
- A built in microscope with a magnification of 40 on the work piece enables the operator to accurately locate the beam impact and observe the actual machining operation.
- As the beam impacts on the work piece surface the kinetic energy of high velocity electron is immediately converted into the thermal energy and it vaporized the material at the spot of its impact.
- The power density being very high (about 1.5 billion W/cm<sup>3</sup>) it takes a few microseconds to melt and vaporize the material at the spot of its impact.
- The process is carried out in repeated pulses of short duration.
- The pulse frequency may range from 1 to 16000 Hz and duration may range from 4 to 64,000 micro seconds.
- The application of the above principle is also found in electron beam drilling in which an organic or synthetic backing material is sandwiched on the other side of the component.
- The beam rapidly penetrates the work piece, vaporizing it and reaches the backing material which in turn vaporizes rapidly with an explosive release of vapour at high pressure.
- The high vapour pressure of the backing material expels the original metal vapour generated at the initial stage, making a clean hole.
-



**Accuracy:**

- Typical tolerances are about 10 % of slot width or hole diameter.
- Taper of about 4° included angle is present in slots and holes and this limits the depth-to-width ratio.
- The depth-to diameter ratio can reach 20:1 with multiple pulses.
- Heat affected zones of up to 0.03 mm deep have been observed.
- The stock removal rate is generally in the region of 1.5 mm<sup>3</sup>/s with a penetration rate of about 0.25 mm/s faster.

**Application of EBM:**

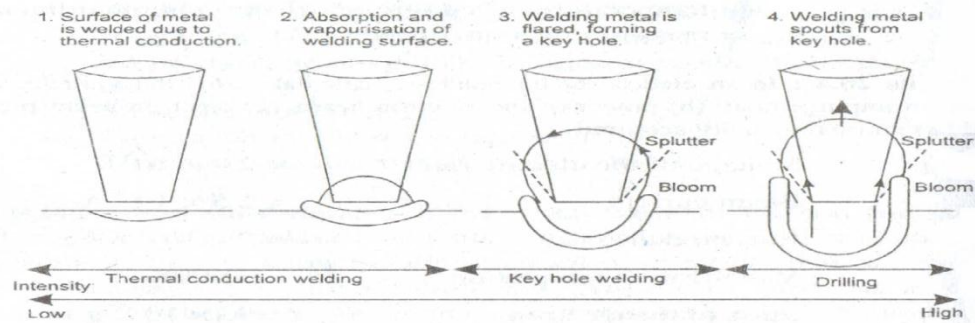
- To drill fine gas orifices, less than 0.002 mm, in space nuclear reactors, turbine blades for supersonic aero engines.
- To produce metering holes in injector nozzles in diesel engines, etc.
- To scribe thin films.
- To remove small broken taps from holes.

**Advantages and limitations:**

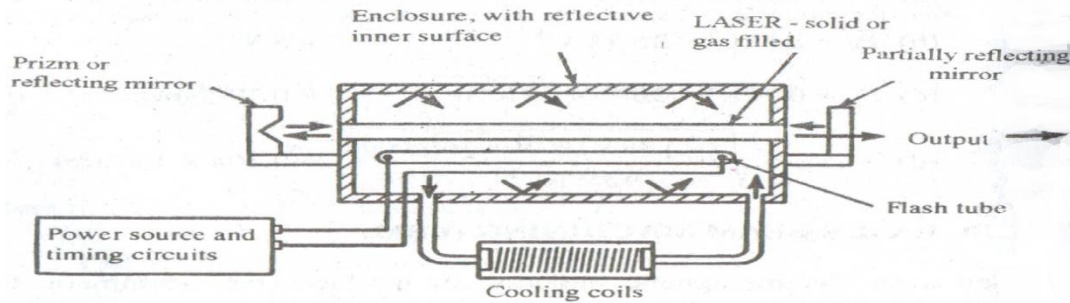
- EBM is an excellent method for micro finishing.
- It can drill holes of cut slots which otherwise cannot be made.
- It is possible to cut any known material, metal or non-metal that can exist in vacuum.
- Besides, there is no cutting tool pressure or wear.
- As a result, distortion-free machining having precise dimensions can be achieved.
- The biggest disadvantage is the high equipment cost and employment of high skill operator.
- Besides, only small cuts are possible.
- Further, requirement of vacuum restricts the size of specimens that can be machined.

**7. Laser beam machining (LBM):**

- A laser is a device which produces a beam of light.
- The laser light is the powerful source of power.
- The laser is pumped by a flash of high intensity light from a flash lamp.
- The lamp is fired by discharging a large capacitor through electric power (250-1000) watts.



**Laser beam absorption and welding mechanism on metal**



**A basic LASER circuit**

- The intense radiation from the lamp excites fluorescent impurity atoms to a higher energy level.
- When the atoms fall back to the original energy level through the series of energy levels, an intense beam of visible light is emitted.
- When the light is reflected back from the coated rod ends, more atoms are excited and stimulated to return to their ground level.
- When this light is focused with ordinary lenses at a spot on the work piece, high energy density is obtained which will melt and vaporize the metal.

Advantages of LBM:

- Flexibility
- Fully automated
- No solvent chemical is used.
- Holding the work in right position is easier.
- Do not require a lot of time for cutting.
- Use less energy as compared to plasma arc machining.
- Rubber, ceramic, wood and plastic can be machined.
- Elimination the risk of material contamination.
- Laser cutting is done by computer programming saving manpower.
- The chance of accidents and injuries are less due to less human involvement.
- Efficiency of the machine is very high.

- Reduced the chance of warping the material.

#### Disadvantages of LBM:

- High power consumption.
- Cutting plastic with laser, plastic emits fumes which subjected to heat. The fumes released can be toxic.
- Carelessness in adjusting the laser distance and temperature may lead to burning of some materials.

#### Applications of LBM:

- It can be used for drilling, scribing, cutting and shaping.
- Drilling holes in rubber baby bottle nipples, holes in nylon buttons, holes in surgical needles, flow holes in oil or gas orifices etc.
- To drill holes in diamond dies.
- Aerospace application
- For cutting of non-metals.