

# MANUFACTURING PROCESSES LAB MANUAL(20A03301P)



(For II Year B. Tech I Semester (R-20), Mechanical Engineering)  
**DEPARTMENT OF MECHANICAL ENGINEERING**

**VEMU INSTITUTE OF TECHNOLOGY**

(Affiliated To JNTUA University)



**Name of the student:** \_\_\_\_\_

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**Name of the Laboratory:** \_\_\_\_\_

**Year & Sem:** \_\_\_\_\_ **Academic Year:** \_\_\_\_\_

# MANUFACTURING PROCESSES LAB MANUAL

## (20A03301P)

### Course Objectives:

Acquire practical knowledge on Metal Casting, Welding, Press Working and unconventional machining Processes

### Course Outcomes (CO):

At the end of the lab, the student will be able to

Fabricate different types of components using various manufacturing techniques.

Adapt unconventional manufacturing methods.

## LIST OF EXPERIMENTS

### 1. METAL CASTING

- Gating Design and pouring time and solidification time calculations.
- Sand Properties Testing – Exercise for Strength and Permeability
- Molding, Melting and Casting for ferrous/ non ferrous materials.

### 2. WELDING

- TIG Welding.
- MIG Welding.
- Friction stir welding
- Any other Special Welding Processes.

### 3. MECHANICAL PRESS WORKING

- Press Tool: Blanking and Piercing operation with Simple, Compound and Combination dies.
- Closed die forging, Deep Drawing and Extrusion operations.

### 4. UN CONVENTIONAL MANUFACTUNRING PROCESSES

- Electro Discharge Machining(EDM)/ Wire cut EDM
- Plasma arc cutting / Abrasive jet machining (AJM)
- Additive manufacturing with reverse engineering

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**INSTRUCTIONS TO STUDENTS**

- ➔ Students should leave their belongings outside the lab except their observation note book, the concerned books/manuals and calculators.
- ➔ Students are requested not to place their legs on the wall or on the table.
- ➔ Students should refrain from leaning on the table and sitting on it.
- ➔ Before logging in to a particular terminal, if there is something wrong in the terminal, the student should report the same immediately to the concerned staff.
- ➔ Students should not use any disks brought from outside without prior permission from the concerned staff.
- ➔ Students can get the required manual or disks from the staff after signing in the appropriate register.
- ➔ Students should collect their printouts before leaving the lab for that particular session.
- ➔ Before leaving the Terminal, the students should properly leave their chairs in position.
- ➔ Students are not allowed to take any manual outside the lab.
- ➔ Edibles are strictly prohibited in the lab.

# 1. Gating Design and pouring time and solidification time calculations

## AIM: to design gating system and pouring time and solidification time calculations

Gating system is one of the major components for producing good quality of component. Many attempts have been made to study the effect of gating system on the flow pattern of molten metal entering to the mould. The formation of various casting defects could be directly related to fluid flow phenomena involved in the stage of mould filling. For instance, vigorous streams could cause mould erosion; highly turbulent flows could result in air and inclusions entrapments; and relatively slower filling might generate cold shuts. The manufacturing of a component consist several steps

- (i) Design of part itself
- (ii) material specification
- (iii) Design of gating system
- (iv) Design of feeder system Furthermore, porosity which is a common defect in every casting also caused from improper design of gating system. The basic element of gating system are pouring basin, sprue, runners, ingrate and, it is a series of passages in which the molten metal flows into the mould cavity to produce the castings for minimizing degradation in metal quality and for minimizing the occurrence of shrinkage porosity during the solidification. The proper feeding of the molten metal into the mould cavity has been very problematic especially when it involves castings with thin sections. In order to properly feed the molten metal into the mould cavities of these thin section castings, a proper design of gating system is required. The problem in this study is how to design a single optimize gating system that will be used to produce for aluminum alloy circular plate of different sizes and also minimize defects in the castings.
- (v) Gating Design Calculations procedure:

For designing a wooden pattern for producing casting component. Design calculations of gating system for aluminum alloy (6061T6) is calculated. Design of gating system will help to pour the charge into mold cavity before solidification. A Proper gating system always helps to avoid turbulence flow of molten metal into the mold cavity. For this study on 6061T6 aluminum alloy, we will use non-pressurized gating system with a gating ratio of:

$$A_s : A_r : A_g = 1 : 4 : 4 \quad (1)$$

Where,  $A_s$  = the cross sectional area of the Sprue Exit,

$A_r$  = the cross sectional area of the Runner,

$A_g$  = the cross sectional area of the Ingate. The choke (the smallest cross sectional area) is at the sprue base exit therefore.

$A_s = A_c$  Where,

$A_c$  = the cross sectional area of the Choke

**Pattern Allowances:**

Many types of pattern allowances like draft, machining, distortion, shrinkage allowance. Shrinkage allowance is necessary to avoid shrinkage defect in the casting. Shrinkage defect is the cavity remains inside the casting after solidification. To avoid shrinkage defect in the casting, shrinkage allowance is necessary. Shrinkage allowance for Aluminum alloys is 16mm/m

$$\text{Pattern Dimension} = \text{Actual Dimension} + \text{Shrinkage allowance} \quad (2)$$

Original dimensions of component and feeder

Length=180 mm,

Height=60mm.

$$\text{Pattern length} = 180 + 0.180 \times 16 = 182.88 \text{ mm}$$

$$\text{Pattern height} = 60 + 0.060 \times 16 = 60.96 \text{ mm}$$

**Step 1: Calculate the total weight of castings**

$$W = \rho \times V \quad (3)$$

Where: W = total weight of casting,

$\rho$  = density (2705 kg/m<sup>3</sup>)

V = total volume of casting.

$$V = 980445 \text{ mm}^3$$

$$W = 2705 \times 980445 \times 10^{-9} = 2.66 \text{ Kg}$$

**Step 2: Calculate the pouring rate and pouring time**

Pouring rate formula for non-ferrous gating:

$$R = b\sqrt{W} \quad (4)$$

Where, R = pouring rate

b = constant, depends on wall thickness;

Typical values of b are shown on table-1

Casting thickness (mm)	Below 6 mm	6 mm to 12 mm	Above 12 mm
Constant b	0.99	0.87	0.47

**Table - 1 Values of Constant (b) for Different Casting Thickness**

$$R = 0.47\sqrt{2.67} = 0.77 \text{ kg/sec}$$

$$R_a = R / (k.f) = 0.8/1 \times 0.875 = 0.88 \text{ kg/s} \quad (5)$$

Where,  $R_a$  = adjusted pouring rate,

K = metal fluidity,

C = the effect of friction with values of 0.85-0.90 for tapered sprue in the gating system.

$t = w / R_a$  Where, t = pouring time.

$$t = \frac{2.67}{0.88} = 2.92 \text{ sec.}$$

**Step 3: Calculate the effective sprue height:**

The design of the down sprue is critical in order to avoid start of turbulent flow in the system. Turbulent metal flow might cause an increased area to be exposed to air, and thus an increased oxidation of the metal.

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Those oxides may rise to the top of the casting to form a rough surface for the casting, or they may be trapped in the casting and create imperfections. Turbulent flow may also cause erosion of the sand mold. To avoid turbulence flow, oxides formed, erosion proper design of sprue is necessary

. —>Sprue height (h) = 150 mm

$$\rightarrow \text{height of casting in the cope } H_1 = 30 \text{ mm} \quad \bullet \quad H_p = h - 0.5 \times \frac{H_1^2}{H_2} \quad (7)$$

→ Total height of casting  $H_2 = 60$  mm, then using equation

Where,  $H_p$  = effective sprue height. For parting plane gating system

$$\bullet \quad H_p = 150 - 0.5 \frac{30^2}{60} = 142.5 \text{ mm}$$

**Step 4: Calculate the choke cross sectional Area:**

Choke cross sectional area is the smallest cross sectional area in the gating system which is sprue exit area used to calculate sprue height and also sprue inlet and exit radius. The flow rate equation

$$A_c = \frac{W}{\rho t C \sqrt{2gH_p}} \quad (8)$$

Where,  $A_c$  = choke area ( $\text{mm}^2$ ),

$W$  = casting weight (Kg),

$\rho$  = density of molten metal ( $\text{kg}/\text{m}^3$ )

$H_p$  = effective sprue height (mm)

$C$  = discharge coefficient (0.8)

$g$  = acceleration due to gravity ( $9.81 \text{m}/\text{s}^2$ ),

$R_a$  = adjusted pouring rate ( $\text{Kg}/\text{s}$ )

$t$  = pouring time (s)

$$A_c = \frac{2.67}{2705 \times 3 \times 0.8 \times \sqrt{2 \times 9.81 \times 142.5}} = 244 \text{ mm}^2$$

**Step 5: Calculation of the sprue inlet area, since sprue exit area**

$A_{\text{sprue exit}} = \text{choke area } A_c$

From continuity equation:

$$A_{\text{sprue-inlet}} = \frac{A_{\text{sprue-exit}} \sqrt{H_{\text{sprue-exit}}}}{\sqrt{H_{\text{sprue-inlet}}}}$$

Where,

- $A_{\text{sprue-inlet}}$  = sprue inlet cross-sectional area,
- $A_{\text{sprue-exit}}$  = sprue exit cross-sectional area,

- $H_{\text{sprue-inlet}}$  = distance between the ladle and sprue top,  
 $H_{\text{sprue-exit}}$  = distance between ladle and sprue exit.
- $A_{\text{sprue-exit}} = 244 \text{ mm}^2$

Height between ladle & sprue-inlet or height of the sprue inlet = 25 mm  
 $H_{\text{sprue-exit}} = 150 + 25 = 175 \text{ mm}$  Putting all these values in equation .... (9)

$$A_{\text{sprue-inlet}} = 112.985 \times \frac{\sqrt{175}}{\sqrt{25}} = 645.56 \text{ mm}^2$$

Diameter of the sprue inlet: 28.67 mm (cross sectional area of a circle  $= \pi/4d^2$ )

Diameter of sprue exit: 17.62 mm

### Step 6: Calculation of the Ingate and Runner cross-sectional areas using a gating ratio of 1: 4: 4

Runners are the passages that carry the molten metal from the sprue well to the gates through which metal enters the mold cavity. Gates are the passages between the runners and the part.

Runner cross-sectional area =  $4 \times 244 = 976 \text{ mm}^2$

Area of a Square =  $L \times B$

Where, L = length, B = breath.

Since for a square,

Length = Breath, Therefore, Area = (Length) <sup>2</sup>

Length of Runner = 31.24 mm and Breath of Runner = 31.24 mm.

Ingate cross-sectional area =  $4 \times 244 = 976 \text{ mm}^2$

Number of ingate used is 2 means the total area of ingate will be divided in to two equal areas. Therefore area for each ingate is  $488 \text{ mm}^2$

### Step 7: Design of Sprue well:

Sprue well is the passage of transferring molten metal from sprue exit to runner.

Sprue well cross-sectional area =  $5 \times \text{sprue exit area} = 5 \times 244 \text{ mm}^2 = 1220 \text{ mm}^2$  Sprue well depth =  $2 \times \text{runner depth} = 2 \times 31.24 = 62.68 \text{ mm}$

### Design of feeder:

Feeders are designed to compensate the solidification shrinkage of a casting, and make it free of shrinkage porosity. Feeder design parameter includes shape, and dimensions of feeder, circular section requires higher gradient than flat rectangular sections. It also depends upon the quality improvement. The temperature and gradient at any point along the feed path influence the type of feeding at that location. If both temperature and gradient are high (near the feeder). Mass feeding takes place by movement of liquid. If temperature is high, but gradient is low, inter dendrite feeding takes place finally, if temperature is low, but gradient is high solid freezing takes place. Improper feeding in the above three zones usually leads to macro porosity, micro porosity and surface sink, respectively. The feeder location must facilitate fettling and grinding off the feeder mark, this implies connecting a feeder to flat surface rather than a curved face of the casting. The ideal shape of feeder is spherical this has the lowest surface area for a given volume and therefore the longest solidification time compare to other shape. Feeders are also classified as open or blind depending upon whether the top of the feeder is open to atmosphere or not. In sand casting open feeder lose more heat than blind feeders once they are less efficient then the blind feeders. But in metal mould it is reverse open are more efficient then the blind feeders open feeders are also referred as riser since liquid metal can be seen rising in them, serving as useful indicator that mould has filled completely. The blind feeder also requires an opening to the atmosphere to enable feed metal flowing down to the hotspot. This is ensured by placing a special core

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above a blind feeder. For small casting, cylindrical, feeders are widely used. For larger casting, cylindrical feeders with spherical bottom (side location) or spherical (top position, blind type) are widely used. In this study. For the greatest efficiency, for small casting, riser should be cylindrical.

**According to Chvirino's rule:**

$$\frac{V}{A} \text{ Riser} > \frac{V}{A} \text{ casting}$$

Volume of riser = 0.47 × Volume of casting

Volume of riser = 0.47 × 980445 = 460809.15 mm<sup>3</sup>

$$\frac{\pi}{4} D^2 H = 460809.15$$

For top riser: H = D/2

$$\frac{\pi}{8} D^3 = 460809.15$$

$$D = 105.47 \text{ mm,}$$

$$H = D/2 = 52.73 \text{ mm}$$

Modulus of top riser: V/A = D/6 = 17.57mm

For side riser: H = D

$$\frac{\pi}{4} D^2 H = 460809.15$$

$$\frac{\pi}{4} D^3 = 460809.15$$

$$D = 83.71 \text{ mm, } H = 83.71 \text{ mm}$$

Modulus of side riser: = V/A = D/6 = 13.95mm

**Result and recommendations:**

**Table-2 Calculations of Gating System**

Element	Height	Length	Width
Sprue	150mm	Exit diameter=18mm	Inlet diameter=29
Runner	31mm	100mm	31mm
Ingate (no. of ingate-2)	22mm	25mm	22mm
Sprue well	63mm	63mm	Diameter 39mm

**Table-3**

**Parameters of Feeder**

Feeder type	Height	Diameter	Modulus
Top feeder	52.73	105.47	17.57
Side feeder	83.71	83.71	13.95

After calculating the dimensions of gating system the pattern allowances values will be obtained to make the wooden pattern. The mould cavity is produced by placing the pattern in a wood frame, filling it with the silica sand proper ramming the sand mix with the pattern in it to give the mould strength. After that the pattern is removed, now 6061 T6 Aluminium alloy is then charged into the furnace to get molten metal after melting up to required Temperature it is further heated because pouring temperature is always greater than melting temperature. After solidification and cooling casted component is taken out by breaking the mould. Design calculations of the gating system are shown in the Table-2 and design parameters of the feeder are shown in the Table-3. Proper design of gating calculations helps to avoid aspiration effect, turbulence, air entrapment, sand inclusion, oxide film and dross during pouring molten metal into the casting cavity. From the feeder design calculation it has been seen that the dimensions of height, diameter and modulus for top feeder are 52.73, 105.47 and 17.57 respectively and for side feeder 83.71, 83.71, 13.95

**Result:**

## 2. SAND PROPERTIES TESTING

**AIM:** To Determine the Grain size, Permeability and Compressive Strength of the Moulding Sand.

**APPARATUS REQUIRED:** Sieves of different numbers and cubical block

**EQUIPMENT REQUIRED:** Sieve Shaker, Permeability Apparatus and Compression Strength Testing

**MATERIAL REQUIRED:** Molding Sand.

### THEORY:

#### PROPERTIES OF MOULDING SAND:

Moulding sand must possess some properties like permeability, flowability collapsibility, adhesiveness, cohesiveness or strength and refractoriness. The properties are determined not only by the chemical composition, but by the amount of clayey matter in the sand, by its moisture content, and lastly by the shape and size of the silica sand grains.

**Porosity:** Molten metal always contains a certain amount of dissolved gases, which are evolved when the metal freezes. Also, the molten metal, coming in contact with the moist sand, generates steam or water vapour. If these gases and water vapour evolved by the moulding sand do not find opportunity to escape completely through the mould they will form gas holes and pores in the casting. The sand must, therefore, be sufficiently porous to allow the gases or moisture present or generated within the moulds to be removed freely. When the moulds are poured. This property of sand is called porosity or permeability.

**Flowability:** Flowability of moulding sand refers to its ability to behave like a fluid so that, when rammed it will flow to all portions of a mould and pack all-round the pattern and take up the required shape. The sand should respond to different moulding processes. Flowability increases as clay and water content increases.

**Collapsibility:** After the molten metal in the mould gets solidified the sand mould must be collapsible so that free contraction of the metal occurs, and this would naturally avoid the tearing or cracking of the contracting metal.

**Adhesiveness:** The sand particles must be capable of adhering to another body, i.e., they should cling to the sides of the moulding boxes. It is due to this property that the sand mass can be successfully held in a moulding box and it does not fall out of the box when it is removed.

**Cohesiveness or Strength:** This is the ability of sand particles to stick together. Insufficient strength may lead to a collapse in the mould or its partial destruction during conveying, turning over or closing. The closing may also be damaged during pouring the molten metal. The strength of moulding sand must, therefore, be sufficient to permit the mould to be formed to the desired shape and to retain this shape even after the hot metal is poured in the mould. This property of sand in its green or moist state is known as green strength. A mould having adequate green strength will retain its shape and will not distort or collapse even after the pattern is removed from moulding box. The strength of sand that has been dried or baked is called dry strength. It must have then strength to withstand erosive forces due to molten metal, and retain its shape.

**Refractoriness:** -The sand must be capable of withstanding the high temperature of the molten metal without fusing. Moulding sands with poor refractoriness may burn on to the casting. Refractoriness is measured by the sinter point of the sand rather than its melting point.

**SAND TESTING:** Grain Size: Grain size of sand is designated by a number called "Grain Fineness Number" that indicates the average size as well as proportions of smaller and larger grains in the mixture. The apparatus required for determining grain fineness consists of a number of standard sieves mounted one above the other, on a power-driven shaker. The shaker vibrates the sieves and the sand placed on the top sieve gets screened and collects on different sieves depending upon the various sizes of grains present in the moulding sand.

In this test place five standard sieves mounted one above the other on a stand and under the bottom most sieve is placed a pan. The top sieve is the coarsest and bottom most sieve is the finest of all the sieves.

1. A sample of dry sand is placed in the upper most sieve and place the sieve stand on the vibrator.
2. Then vibrate the sieve stand for a definite period of time.
3. An amount of sand may be retained on each sieve and same is weighed.
4. Calculate the AFS grain fineness number.

Sieves – Mesh	% of Sand retained	Factor	Product of col.2 & 3

**PERMEABILITY TEST:**

1. 2000 cc of water held in the inverted bell jar is allowed to pass through the sand specimen.
2. A situation comes when the liquid entering the specimen equals the air escaped through the specimen.
3. This gives a stabilized pressure reading on the manometer and the same can be read on the vertical scale.
4. Simultaneously, using a stop watch the time required for 2000cc of water to pass through the sand of specimen is also recorded.
5. Permeability number can be determined by the following relation;

$$\text{Permeability Number} = \frac{V \cdot H}{A \cdot P \cdot T}$$

Where V = volume of air passed through the specimen  
 H = height of the specimen  
 A = area of the specimen

T = time taken by the air to pass through the sand specimen  
 P = pressure recorded by manometer.

**COMPRESSION STRENGTH TEST:**

1. The specimen is held between the grips.
2. Hand wheel when rotated actuates a mechanism which builds up hydraulic pressure on the specimen.
3. Dial indicator fitted on the tester measures the deformation occurring in the specimen
4. As the applied load is continued, the specimen breaks at a particular load.
5. At this point note down the reading of dial indicator which directly gives the compression strength of the sand.

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**PRECAUTIONS:**

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1. For calculating grain size of sand, sand taken should be free from dirt particles.
2. For calculating the compression strength, load is applied gradually on the specimen.

**RESULT:**

### 3. Molding, Melting and Casting for ferrous/non-ferrous materials.

**AIM:** To Prepare a Casting for the given Solid Pattern using Green Sand Moulding Processes.

**MATERIAL REQUIRED:** Moulding sand **TOOLS REQUIRED:** Pattern, Shovel, Riddle, Rammer, Trowel, Slick, Lifter, Strike – Off bar, Draw – spike, Mallet, Moulding Boxes, Vent rod, Runner, Riser, and Swab

**THEORY: MOULDING SAND:** The principal material used in the foundry shop for moulding is the sand. This is because it possesses the properties vital for foundry purposes. Sources: All sands are formed by the breaking up of rocks due to the action of natural sources such as frost, wind, rain, heat and water currents. Rocks however are very complex in their composition and sands contain most of the elements of the rocks of which they fragment. For this reason, sands in different parts of the world vary considerably. Today, sand is obtained from places which probably once were bottoms and banks of rivers and sand dunes.

#### **PRINCIPAL INGREDIENTS:**

The principal ingredients of moulding of sands are:

1. Silica sand grains
2. Clay
3. Moisture and
4. Miscellaneous materials

Silica in the form of granular quartz, itself sand is the chief constituent of moulding sand. Silica sand contains from 80 to 90 percent silicon dioxide and is characterized by a high softening temperature and decomposition of granite, which is composed of feldspar and quartz. The feldspar, when decomposed, becomes clay (hydrous aluminium silicate). However, silica sand grains impart refractoriness, chemical resistivity, and permeability to the sand. They are specified according to their average size and shape. Clay is defined as those particles of sand (under 20 microns in diameter) that fail to settle at a rate of 25mm per minute, when suspended in water. Clay consists of two ingredients: fine silt and true clay. Fine silt is a sort of foreign matter or mineral deposit and has no bonding power. It is the true clay which imparts the necessary bonding strength to the mould sand, so that the mould does not lose its shape after ramming.

True clay is found to be made up of extremely minute aggregates of crystalline, usually flake-shaped, particles called clay minerals. Most moulding sands for different grades of work contain 5-20 percent clay. Moisture, in requisite amount furnishes the bonding action of clay; it penetrates the mixture and forms a microfilm which coats the surface of flake-shaped clay particles. The bonding quality of clay depends on the maximum thickness of water film it can maintain. The bonding action is considered best if the water added is the exact quantity to form the film.

On the other hand the bonding action is reduced and the mould gets weakened if the water is in excess. The water should be between 2-8percent. Miscellaneous materials that are found in addition to silica and clay, in moulding sand are oxide of iron, limestone, magnesia, soda, and potash .The impurities should be below 2 percent.

**Gating system:** Gating system refers to all those elements which are connected with the flow of molten metal from the ladle to the mould cavity. The various elements that are connected with a gating system are:

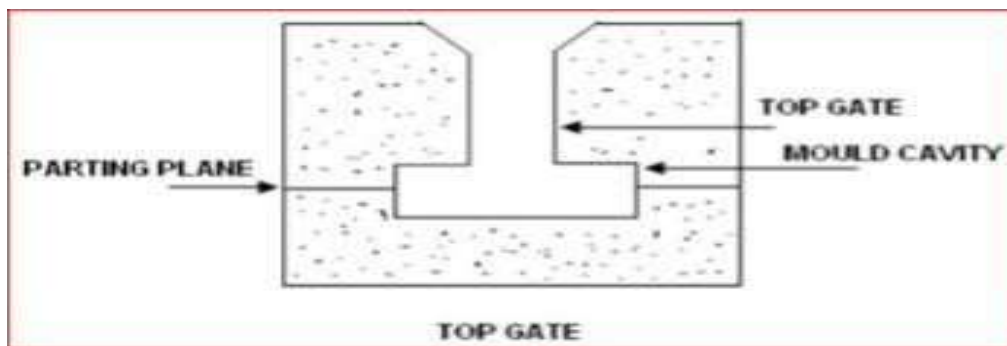
1. Pouring basin
2. Sprue
3. Sprue base well
4. Runner
5. Runner extension
6. Ingate
7. Riser

### Gates:

Also called the ingates, these are the openings through which the molten metal enters the mould cavity. Depending on the application, various types of gates are used in the casting design. They are:

1. Top Gate
2. Bottom Gate
3. Parting Gate

### Top Gate:



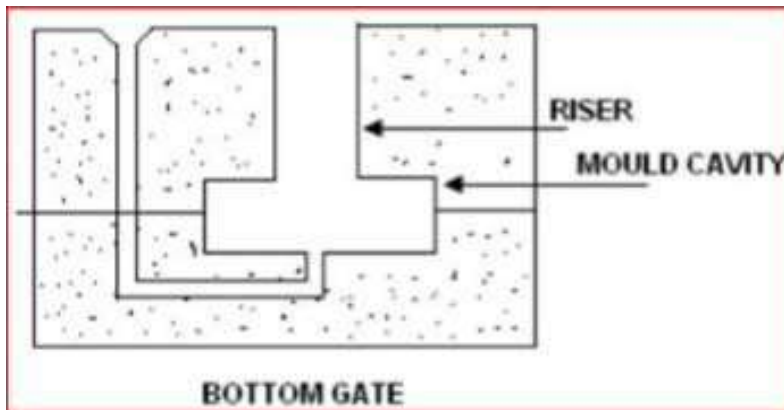
This is the type of gating through which the molten metal enters the mould cavity from the top as shown in fig. since the first metal entering the gate reaches the bottom and hotter metal is at the top, a favorable temperature gradient towards the gate is achieved. Also the mould is filled very quickly. But as the metal falls directly into the mould

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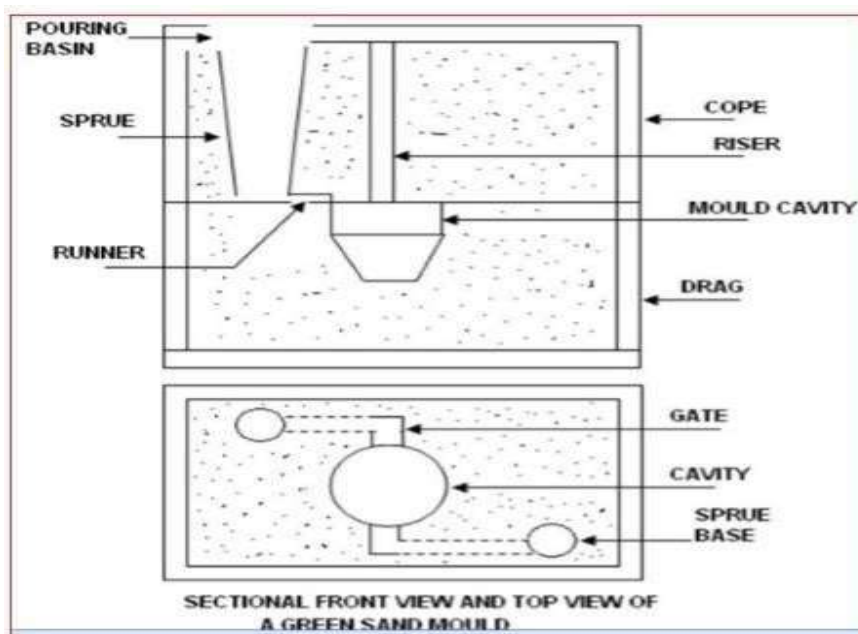
cavity through a height, it is likely to cause mould erosion. Also because it causes turbulence in the mould cavity it is prone to form dross and as such top gate is not advisable for those materials which are likely to form excessive dross. It is not suggested for non – ferrous alloys and is suggested only for ferrous alloys. It is suitable only for simple casting shapes which are essentially shallow in nature

### Bottom Gate:



When molten metal enters the mould cavity slowly as shown in fig., it would not cause any mould erosion. Bottom gate is generally used for very deep moulds. It takes higher time for filling the mould and also generates a very unfavorable temperature gradient.

### PROCEDURE:



1. First the pattern is placed with its larger diameter side is on a mould board.

2. The drag section of the flask is set over the pattern on same board.
3. After powdering the pattern with lycopodium, talc or graphite, a 15 to 20 mm layer of facing sand is riddled over the pattern.
4. The drag is then filled by layers of green sand mixture from 70 to 100 mm thick, compacting each layer with rammer.
5. The top of the mould is rammed with the butt end of a rammer. The object of ramming the sand is to consolidate it, thereby preventing the cavity of the mould from being enlarged by the metal.
6. After the sand is rammed a strickle is used to scrape off the excess sand level with the top of the flask.
7. The mould is then vented by sticking it with a fine stiff wire at numerous places (The vent holes should not reach the pattern by 15 to 20 mm as otherwise they may spoil the mould. Moreover, the metal may run in to the vent holes during pouring. These vent holes permit the escape of gases generated in the mould when the molten metal comes in contact with moist sand).
8. A small amount of loose sand is sprinkled over the mould and bottom board is placed on the top. The drag is rolled over, the moulding board is removed, and the upper surface is sprinkled with parting sand (The parting sand is used to prevent the joints between the halves of a mould from adhering to one another when the two parts of the moulding box are separated).
9. The cope section of the flask is then assembled.
10. Tapered wooden pegs to serve as sprue and riser are placed in proper position as shown in figure on the pattern which is riddled over with facing sand and then cope is filled with green sand.
11. The operation of filling, ramming and venting of the cope proceed in the same manner as in the drag.
12. A funnel shaped opening is scooped out at the top of the sprue to from the pouring basin.
13. Next the cope is lifted off and placed on a board with the parting line upward.
14. An iron bar is now pushed down to the pattern and rapped sideways .So as to loosen the pattern and prevents any sand from sticking to the pattern.
15. Next pattern is drawn out using draw spike.
16. Runners are cut in the cope according to the dimensions shown in fig.
17. Cut the gates in the drag according to the dimensions shown ( Use Top Gating System).
18. If needed all the cavity edges are repaired.
19. Finally the mould is assembled, the cope being carefully placed on the drag so that the flask pins fit into the bushes.
20. The mould is then ready for pouring.

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21. Molten metal (Aluminium) is prepared in the high frequency electrical induction furnace.
22. Take the molten metal from crucible in to the ladle.
23. Pour the molten metal from the ladle into the pouring basin so that the molten metal will enter into the mould cavity through the sprue, runner and gate.
24. Allow the molten metal to solidify.
25. Then break the mould to obtain desired casting

**PRECAUTIONS:**

1. Care must be taken to have proper alignment of the pattern as well as moulding boxes
2. Sand should be rammed properly and evenly.
3. The pattern should be rapped gently and withdrawn carefully without damaging the mould cavity.
4. Care should be taken to avoid over cuts and corners.
5. Care should be taken while pouring the molten metal in to the cavity.

**RESULT:**

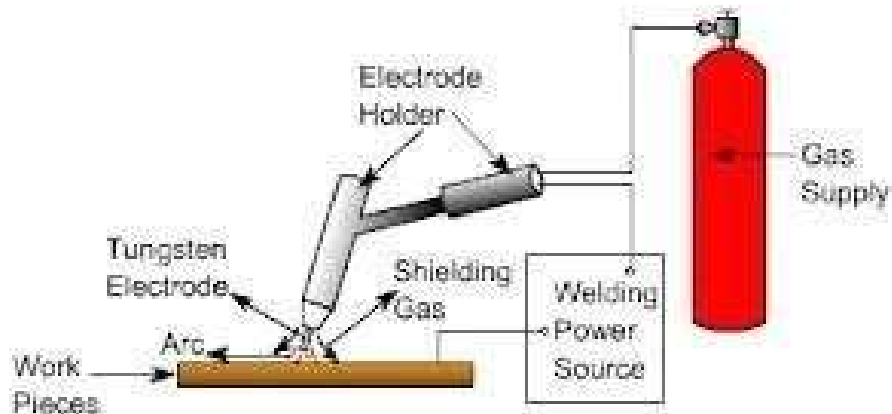
## 4. TIG WELDING

**Aim:** To make butt - Welding using TIG welding equipment.

**Equipment and Material Required:**

Inert gas(helium, argon) welding outfit, MS Sheets 150x50x5mm (2No)

**Tools Required:** Wire brush, hand gloves, and chipping hammer, spark lighter.



**Procedure:**

1. Inert gas valve on the torch is opened slightly and lightened with the help of a spark lighter.
2. The torch tip is to be positioned above the plates so that white cone is at a distance of 1.5mm to 3mm from the plates.
3. Torch is to be held at an angle of 30 to 45 degree to the horizontal plane.
4. Now filler rod is to be held at a distance of 10mm from the flame and 1.5 mm to 3 mm from the surface of the weld pool.
5. As the backward welding allows better penetration, backward welding is to be used.
6. After the completion of welding, slag is to be removed by means of chipping hammer, wire brush.

**Precautions:**

1. Never look at the arc with the naked eye. Always use a shield while welding.
2. Always wear the safety hand gloves, apron and leather shoes.
3. Ensure proper insulation of the cables and check for openings.
4. Care is taken to avoid arc blow, which will cause serious defect in the weldment.
5. Ensure that torch movement is uniform.
6. See that the joints are extremely clean.

**Sketch:**

**Result:** A butt joint is prepared using gas welding process

## 5. PREPARATION OF T- LAP JOINT USING MIG WELDING

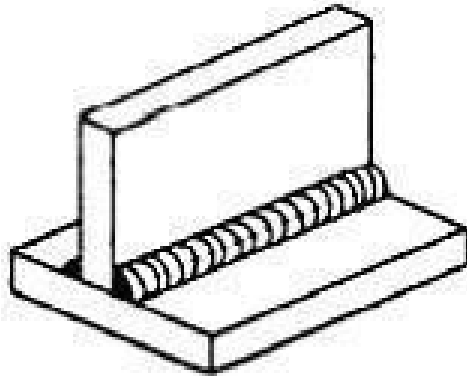
**AIM:**To prepare a butt joint with mild steel strip using MIG Welding technique.

**Material Required:** Two pieces of Mild steel

**Equipment:** Welding unit, Electrode, Wire Brush, Tongs, goggles

**Procedure:**

- i. The edges of joining surfaces of metals are prepared.
- ii. Clean the mild steel flats to be joined by wire brush.
- iii. Arrange the flat pieces properly providing the gap for full penetration for butt joint (gap  $\frac{1}{2}$  thicknesses of flats).
- iv. Practice striking of arc, speed and arc length control
- v. Set the welding current, voltage according to the type of metal to be joined.
- vi. Strike the arc and make tacks at the both ends to hold the metal pieces together during the welding process
- vii. Lay beads along the joint maintaining proper speed and arc length (Speed 100-150 mm/min).
- viii. Clean the welded zone and submit.



T - Joint

**Sketch:**

**Precautions:**

- Use goggles and gloves to protect the human being from the generated arc.
- Maintain constant arc length to get uniform weld bead.

**Result:**

## 6. FRICTION STIR WELDING

**Aim:** To perform friction stir welding (FSW) on two similar aluminum sheets of same gauge.

### Instruments required:

FSW machine, Fixture for clamping the workpiece on the machine table, Al sheets of dimensions (100 mm x 50 mm x 2.5 mm), FSW tool (having flat shoulder surface and straight circular pin), Few others necessary equipments for tightening and loosening the desired nuts and bolts.

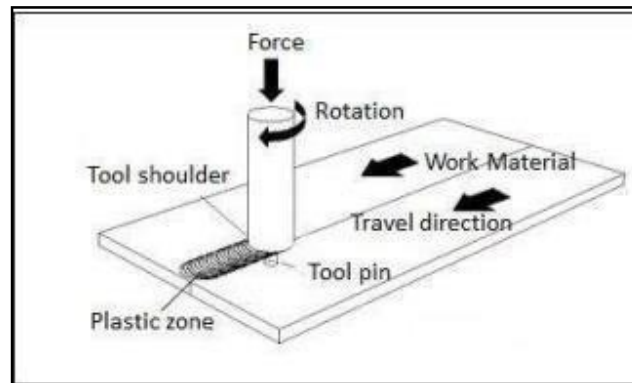


Figure. Schematic diagram of FSW process

### Experimental procedure:

1. Switch on the MCB switch (electric input to the machine), On/Off switch on the machine body at the left side and start the computer monitor attached with the machine.
2. Then, double click on the stir welding icon on the desktop in order to start the software. Once the software gets started; it will ask for pressing hydraulic knob for switching it on, and then for spindle home.
3. Fix the FSW tool into the spindle through proper dimension of collet, and then tight the adapter nut using semicircle spanner.
4. Place the work piece on the anvil of machine worktable. Make sure the sheets are being placed in such a manner that the joining line is parallel to the machine X-axis, and then clamp the workpiece using bolts.
5. Once it will be done, choose the manual mode option from the available options. Insert suitable values for worktable movement and move the worktable against fixed FSW tool for obtaining the Xstart, Xend and Zend position values. Here, X start, X end denotes start and end point of welding on the work-piece clamped, and Zend position denotes the point up to which the FSW tool will reach during plunging.
6. Come out from the manual mode and then go to the parameter for specifying the parameters for weld to be conducted. If required change the spindle tilt angle.
7. After specifying the parameters go to the auto mode and click on icon continue, to start the weld. But, before pressing cycle on switch, make sure that the coolant pump for spindle is switched on.
8. After finishing of the weld, switch off the coolant pump, and hydraulic knob.

**Precautions:**

1. Before clamping the work piece on the anvil the edges of the faying surfaces should be straight, so that there should not be any gap between faying surfaces; in order to achieve good weld.
2. The joining line should be parallel to the machine X-axis, and the anvil should be placed in such a position so that the FSW tool pin center should not be off-set from the expected joining line.
3. When coming out from the manual mode, move the spindle up in the Z-axis; otherwise, while selecting auto mode the spindle will directly move to the last Z-value the spindle had in the manual mode.
4. Before pressing the cycle on knob in the monitor panel the work-piece should be rigidly clamped on the anvil, and the Allen bolts (placed at the right bottom side of the anvil) must be tightened in order to prevent the vibration of anvil along Y-axis.

**Sketch:****Result:**

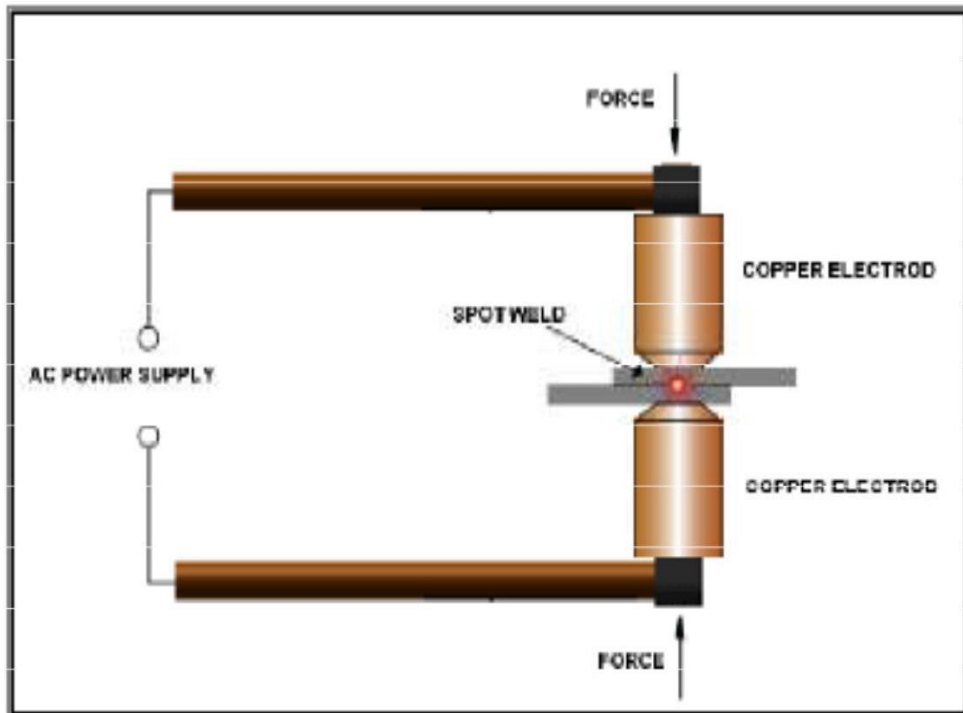
## 7. PREPARATION OF SQUARE TRAY USING SPOT WELDING

**Aim:** To prepare the square tray using spot welding technique.

**Equipment:**

Spot welding machine

**Material Required:**

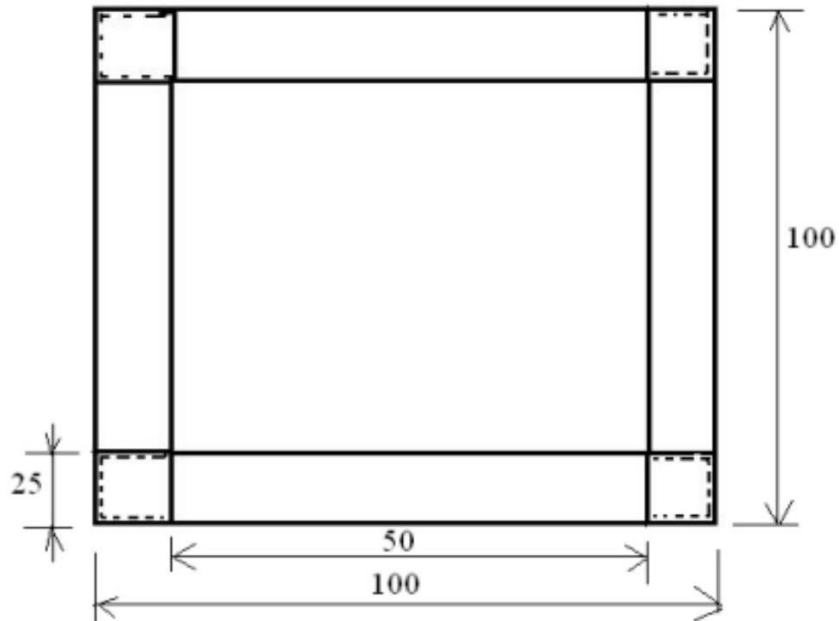


Spot welding machine

**PROCEDURE:**

- Switch on the machine and set the current in the machine to 2 Ampere
- Set the timer to two seconds
- Overlap the two metal pieces to the requires size and place them between the two electrodes.
- Apply pressure by foot on the lever such that two electrodes come into contact if the over lapped metals.
- After 2 seconds remove the pressure on the lever slowly.

- Now the joint is ready for use.
- Repeat the same procedure at various amperes
- Test the strength of the joints using universal testing



A typical square tray

**PRECAUTIONS:**

1. Ensure that the electrodes should not be touched.
2. Don't touch the welded portion by hand immediately after the welding is done.

**Result:**

## 8. STUDY OF PROGRESSIVE DIE

### (Blanking and Piercing)

**AIM:** To study a progressive tool and perform blanking and piercing

**OPERATIONS:** To determine the punching force and blanking force theoretically and compare the same with obtained readings.

**TOOLS AND MATERIAL REQUIRED:** Progressive tool, Clamps and Blank.

**EQUIPMENT REQUIRED:** Hydraulic Press

#### **SPECIFICATIONS:**

Capacity: 25 tons

Distance between columns: 865x300 mm<sup>2</sup>

Distance between ram to bed: minimum 180mm: maximum 915mm Travel of ram: 180mm Power of motor: 5 H.P.

#### **THEORY:**

#### **SHEET METAL WORKING (OR) PRESS WORKING OF SHEET METAL**

Press working may be defined as a chip less manufacturing process by which various components are made from sheet metal. This process is also termed as cold stamping. The main features of a press are: A frame which supports a ram or a slide and a bed, a source of mechanism for operating the ram in line with and normal to the bed. The ram is equipped with suitable punch and a die block is attached to the bed. A stamping is produced by the down ward stroke of the ram when the punch moves towards and into the die block. The punch and die block assembly is generally termed as a "die set" or simply as a "die". Press working operations are usually done at room temperature. In this process, the wall thickness of the parts remains almost constant and differs only slightly from the thickness of the initial sheet metal. The initial material in cold press working is: low carbon steels, ductile alloy steels, copper and its alloys, aluminium and its alloys, as well as other ductile materials from 10th of a mm to about 6 or 8 mm thick.

Elastic recovery or spring back. In metal working processes, the total deformation imparted to a work piece will be the sum of elastic deformation and plastic deformation. We also know the elastic deformation is recoverable where as plastic deformation is permanent. So, at the end of a metal working operation, when the pressure of metal is released, there is an elastic recovery by the material and the total deformation gets reduced

a little. This phenomenon is called as “Springback”. This phenomenon is of more importance in cold working operations, especially in forming operations such as bending etc. Spring back depends upon the yield point strength of a metal. The higher the yield point strength of a metal, the greater the spring back. The amount of spring back for a forming operation is difficult to predict and cut- and try methods are most satisfactory to account for it. To compensate for spring back, the cold deformation must always be carried beyond the desired limit by an amount equal to the spring back.

**Press operation:** The sheet metal operations done on a press may be grouped into two categories, cutting operations and forming operations.

In cutting operations, the work piece is stressed beyond its ultimate strength. The stresses caused in the metal by the applied forces will be shearing stresses. In forming operations, the stresses are below the ultimate strength of the metal. In this operation, there is no cutting of the metal but only the contour of the work piece is changed to get the desired product. The cutting operations include: blanking, punching, notching, perforating, trimming, shaving, slitting and lancing etc. The forming operations include: bending, drawing, redrawing and squeezing. The stresses induced in the metal during bending and drawing operations are tensile and compressive and during the squeezing operations these are compressive.

**Blanking:** Blanking is the operation of cutting a flat plate from sheet metal. The article punched out is called the Blank and is the required product of the operation. The hole and metal left behind is discarded as waste. It is usually the first step of series of operations.

**Punching:** It is a cutting operation by which various shaped holes are made in sheet metal. Punching is similar to blanking except that in punching, the hole is the desired product, the material punched out to form the hole being waste.

**Perforating:** This is a process by which multiple holes which are very small and close together are cut in flat work material.

**Trimming:** This operation consists of cutting unwanted excess material from the periphery of a previously formed component.

**Shaving:** The edges of a blanked part are generally rough, uneven and un square. Accurate dimensions of the part are obtained by removing a thin strip of metal along the edges.

**Slitting:** It refers to the operation of making incomplete holes in a work piece. Lancing: This is a cutting operation in which a hole is partially cut and then one side is bent down to form a sort of tab or louver. Since no metal is actually removed, there will be no scrap.

**Bending:** In this operation, the material in the form of flat sheet or strip is uniformly strained around a linear axis which lies in the neutral plane and perpendicular to the lengthwise direction of the sheet metal.

**Drawing:** This is a process of forming a flat work piece into a hollow shape by means of a punch which causes the blank to flow into a die cavity.

## TYPES OF DIES:

The dies may be classified according to the type of press operation and according to the method of operation.

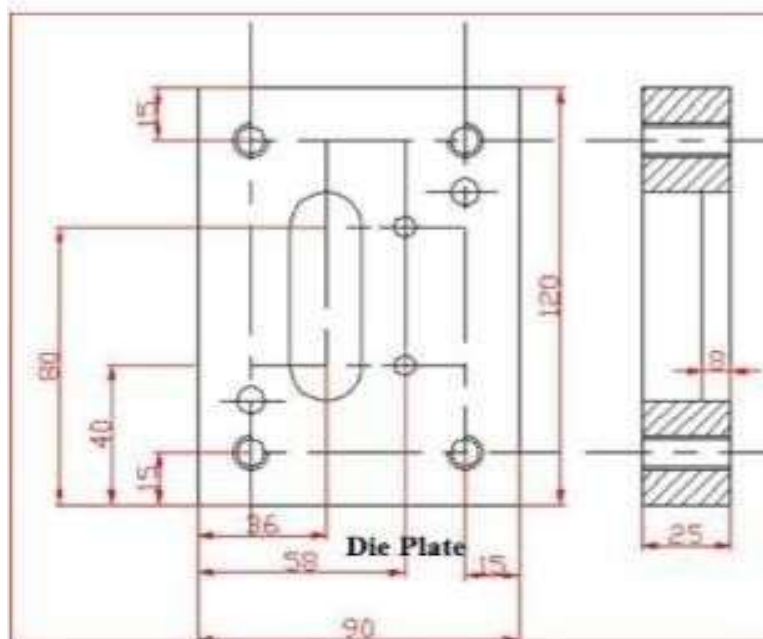
**Types of press operation:** According to this criterion, the dies may be classified as: cutting dies and forming dies.

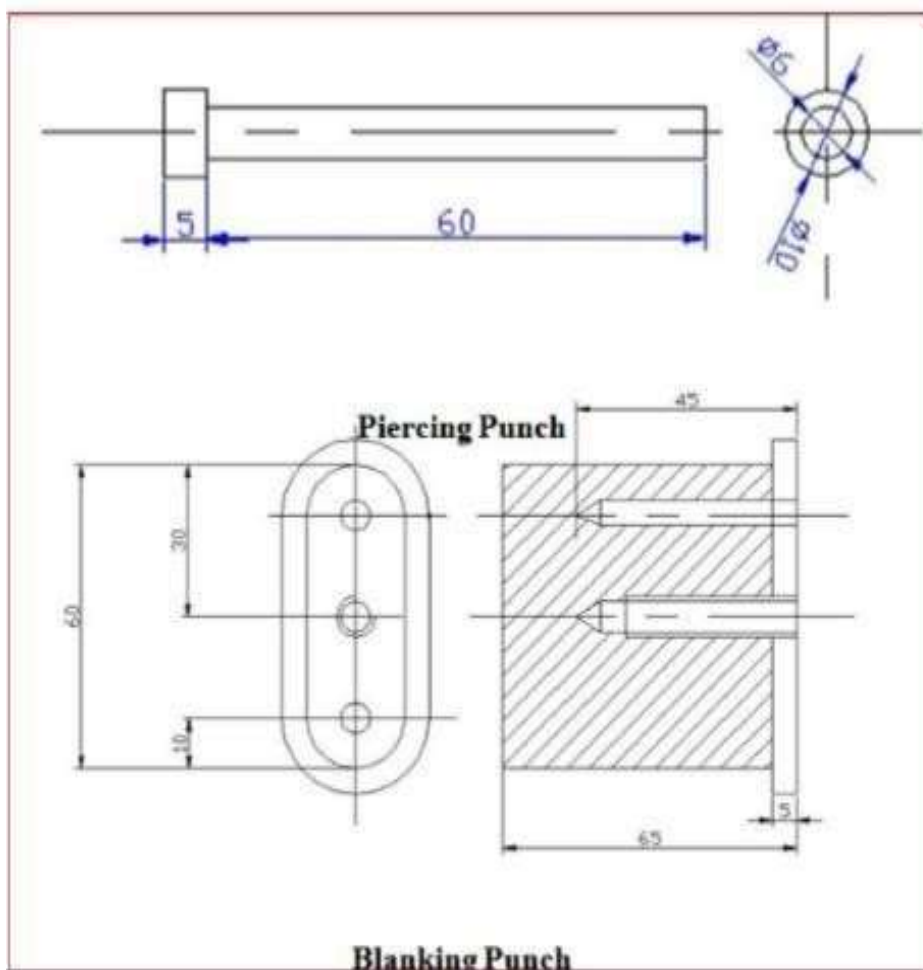
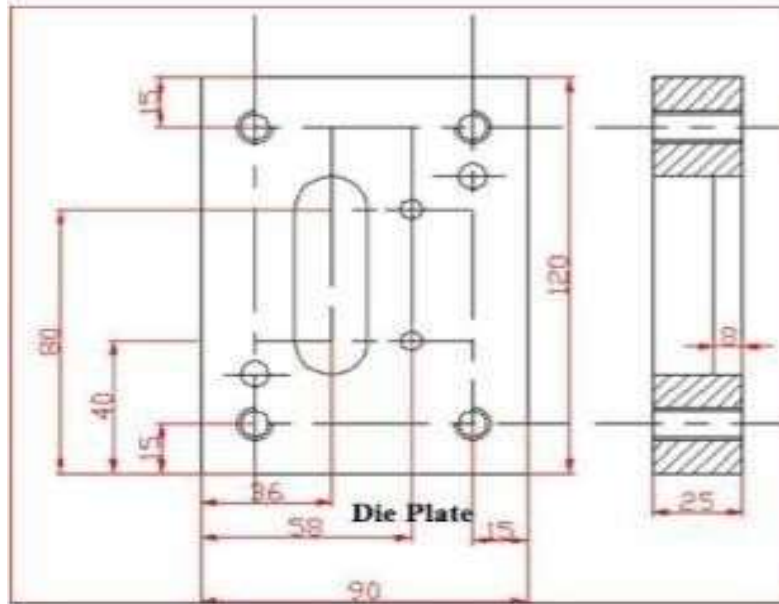
**Cutting dies:** The dies are used to cut the metal. They utilize the cutting or shearing action. The common cutting dies are: blanking dies, piercing dies, perforating dies, notching, trimming, shaving dies etc.

**Forming dies:** These dies change the appearance of the blank without removing any stock. These dies include bending dies, drawing dies, squeezing dies etc..

**Method of operation:** According to this criterion, the dies may be classified as: single operation dies or simple dies, compound dies, combination dies, transfer dies, progressive dies and multiple dies.

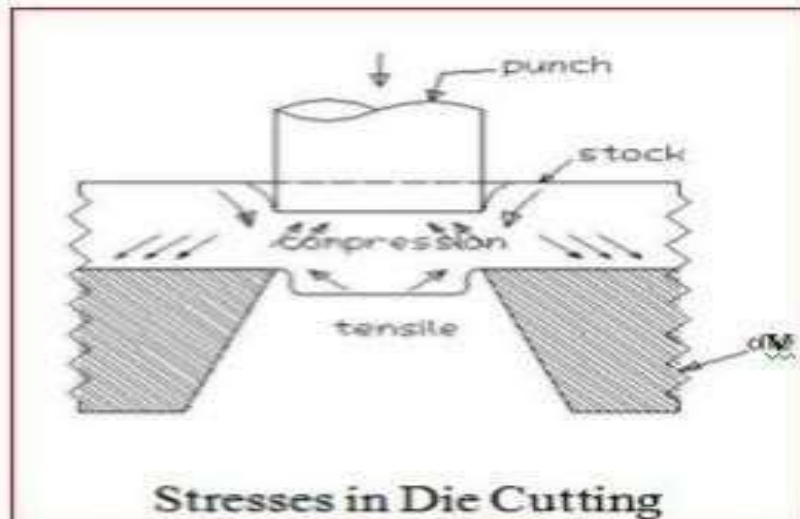
## STUDY OF PROGRESSIVE DIE:





A progressive or follow on die has a series of stations. At each station an operation is performed on the work piece during a stroke of the press. Between strokes the piece in the metal strip is transferred to the next station. A finished work piece is made at each stroke of the press. A progressive die is shown in fig. while the piercing punch blanks out a portion of the metal in which two holes had been pierced at a previous station. Thus after the stroke two holes will be punched each stroke of the press produces a required finished component.

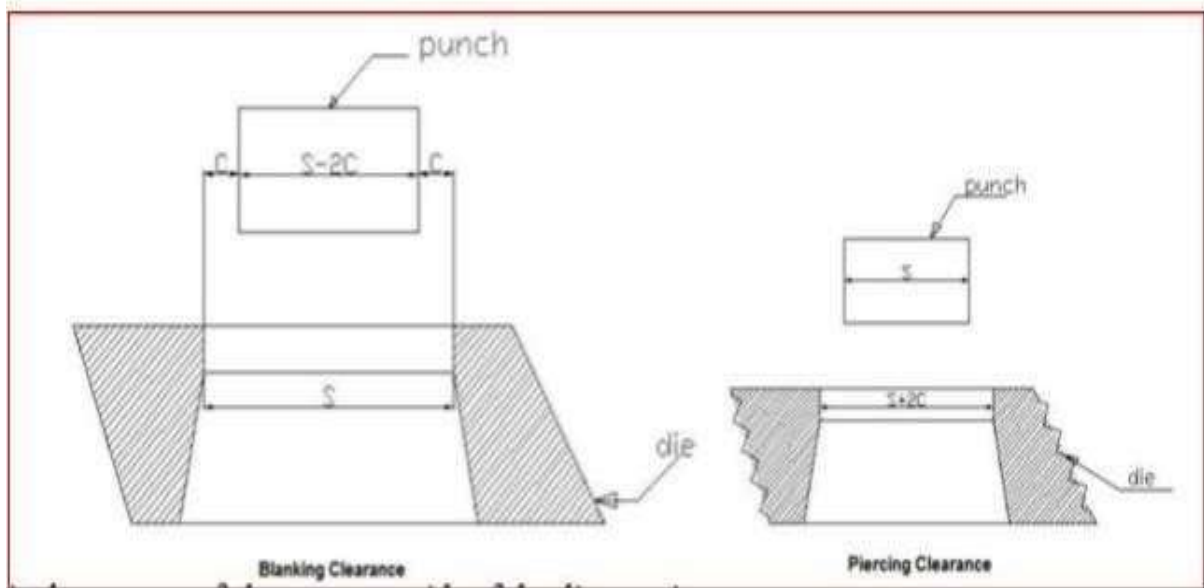
### Principle of metal cutting:



The cutting of sheet metal in the press work is a shearing process. The punch is of the same shape as of the die opening except that it is smaller on the each side by an amount known as „clearance“.

As the punch touches the material and travels downward, it pushes the material into the die opening. The material is subjected to both tensile and compressive stresses as shown in fig (a).

Stresses will be highest at the edges of punch and die and the material will start cracking there. The various steps in the rupture or fracture of material can be written as stressing the material beyond the elastic limits; plastic deformation reduction in area fracturing starts in the reduced area and becomes complete. If the clearance between punch and die is correct, the cracks starting from the punch and die edges will meet and the rupture is complete as shown in fig (b). If the clearance is too large or too small the cracks do not meet and ragged edge results due to the material being dragged and torn through the die. Clearance: The die opening must be sufficiently larger than the punch to permit a clean fracture of the metal. This difference in dimensions between the mating members of a die set is called „clearance“. This clearance is applied in the following manner: „c“ is the amount of clearance per side of the die opening.



When the hole has to be held to size, i.e. the hole in sheet metal is to be accurate, and slug is to be discarded the punch is made to the size of hole and the die opening size is obtained by adding clearance to the punch size shown in fig (a).

In blanking operation where the slug or blank is desired part and has to be held to size the die opening size equals the blank size and the punch size is obtained by subtracting the clearance from the die opening size shown in fig (b).

The clearance is a function of the kind, thickness and temper of the work material harder materials requiring clearance than soft materials, the exception being aluminium. The usual clearances per side of the die, for various materials,

are given below in terms of the stock thickness,  $t$ :

For brass & soft steel,  $c=5\%$  of  $t$  For mild steel,  $c=6\%$  of  $t$

For hard steel,  $c=7\%$  of  $t$  For Aluminium  $c=10\%$  of  $t$

The total clearance between punch and die size will be twice these figs these clearances are for blanking and Piercing operations.

The clearance may also be determined with the help of the following equation:  $c=0.0032t \times \zeta$

Where  $\zeta$  is the shear strength of the material in  $N/mm^2$ .

**Cutting forces:** In cutting operation as the punch in its downward movement enters the material it need not penetrate the thickness of the stock in order to affect complete rupture of the part. The distance which the punch enters in to the work material to cause rupture to take place is called "penetration" and is usually given as percentage of the stock thickness. The % penetration depends on the material being cut and also on the stock thickness. When a hard and strong material is being cut very little penetration of the punch is necessary to cause fracture. With softer

the penetration will be greater. The percentage penetration is also depends upon the stock thickness, being smaller for thinner sheets.

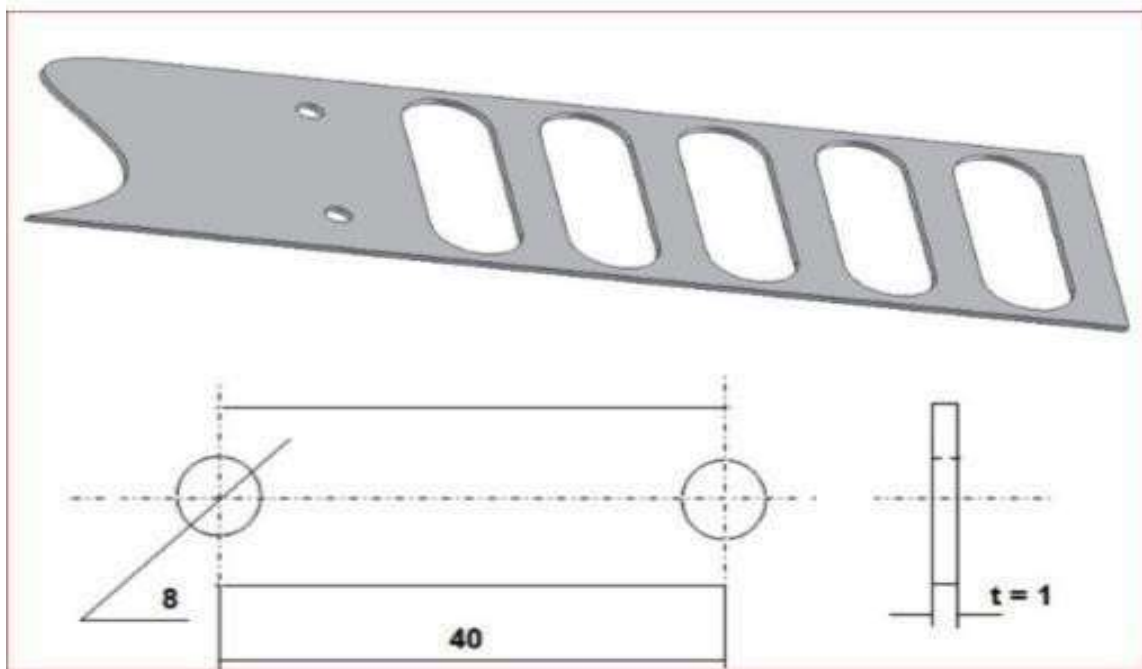
The max force  $F_{max}$  in newtons needed to cut a material is equal to :

For a circular blank of diameter  $D$  mm and of thickness  $t$  mm the maximum cutting force will be given as:  
 $F_{max} = \pi D t \zeta_s = P t \zeta_s$ .

Where  $P$  is the perimeter of the section to be blanked For rectangular blanks the length  $L$  and width  $b$  it is  
 $F_{max} = 2(L+b) t \zeta_s$ .

### PROCEDURE:

#### Component to be produced:



1. Fix the punch to the ram of the press.
2. Fix the die on the bed of the machine using clamps, bolts and nuts.
3. Place the blank of required size between the die and punch.
4. Apply pressure hydraulically on the blank through the punch so that piercing will takes place at the first station.
5. Note down the reading of the pressure gauge which directly gives the force required to perform the piercing operation.
6. Move the blank in forward direction until it touches the stopper on the die.

7. Again apply pressure hydraulically on the blank so that piercing punch blanks out a portion of the metal in which already two holes had been pierced. At the same time piercing operation takes place at the first station.
8. Note down the reading of the pressure gauge which directly gives the force required to perform the piercing and blanking operations.
9. Difference of the two readings gives the force required to perform blanking operation. 10. Compare the values with the theoretically obtained values.
11. The process may be repeated to produce the components in mass production.

**OBSERVATIONS & CALCULATIONS:**

Piercing Force ( $F_p$ ) =

Blanking & Piercing Force ( $F_{bp}$ ) =

Blanking Force ( $F_b = F_p - F_{bp}$ ) =

Maximum force needed to cut material is  $F_{max} = P \cdot t \cdot \zeta_s$  Where P is the Perimeter of the blank t is the thickness of the blank

$\zeta_s$  is the shear strength of the material.

**PRECAUTIONS:**

1. The die should be properly clamped to the bed of the machine and it is not disturbed during the process.
2. The punch is properly fixed to the ram of the machine.
3. The load should be applied uniformly on the blank.
4. The ram should be fed slowly towards the die and make sure that it is properly in line with the die.

**RESULT:**

## 9. HYDRAULIC PRESS (DEEPPDRAWING)

**AIM:** To Determine the Blank Size, Drawing Force and Blank Holding Force for Producing a symmetrical cup of circular cross section using a Draw Tool and Perform Drawing Operation.

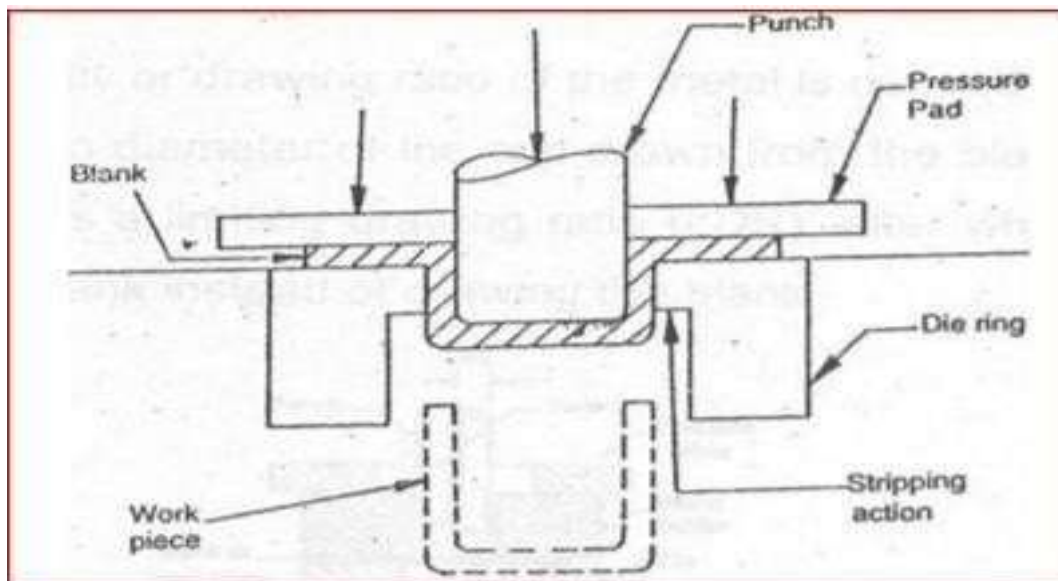
**MATERIAL REQUIRED:** Aluminum sheet of required size and MS round bar of 25mm diameter.

**EQUIPMENT AND TOOLS REQUIRED:** Hydraulic Press, Draw tool and Inclinator.

**THEORY:**

**DRAWING:**

Drawing operation is the process of forming a flat piece of material into a hollow shape by means of a punch which causes the blank to flow into the die cavity. The depth of draw may be shallow, moderate or deep. If the depth of the formed cup is up to half of its diameter, the process is called "Shallow drawing". If the depth of the formed cup exceeds the diameter it is termed as "Deep drawing". Parts of various geometries and sizes are made by drawing operation, two extreme examples being bottle caps and automobile panels.



**Deep drawing operation**

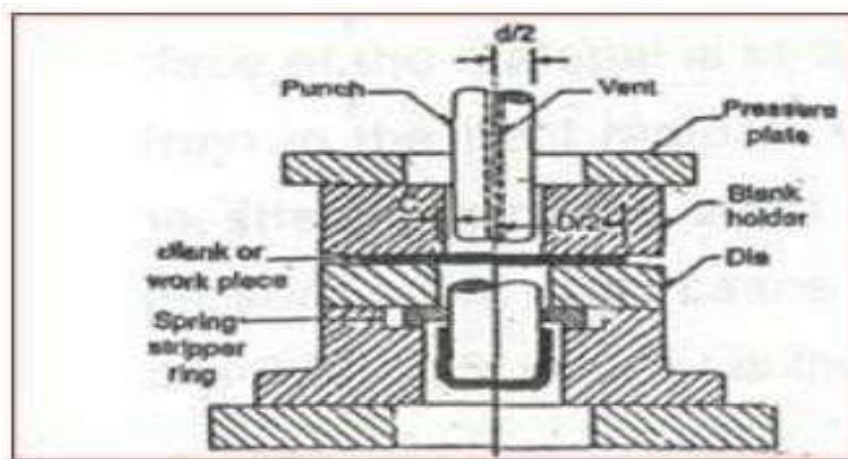
As the drawing progress i.e. as the punch forces the blank into die cavity, the blank diameter decreases and causes the blank to become thicker at its outer portions. This is due to the circumferential compressive stress to which the material element in the outer portions is subjected. If this stress becomes excessive the outer portions of the blank will have the tendency to buckle or wrinkle. To avoid this, a pressure pad or blank holder

is provided. The holding down of pressure is obtained by means of springs, rubber pad, compressed air cylinder or the auxiliary ram on a double action press.

The portion of the blank between the die wall and punch is subjected to nearly purely tension and tends to stretch and becomes thinner. The portion of the formed cup which wraps around the punch radius is under tension in the presence of bending. This part becomes the thinnest portion of the cup. This action is termed as 'necking' and in the presence of unsatisfactory drawing operation, is usually the first place to fracture. The outer portions of the blank and hole become thicker during the operation. When these portions are drawn into the cavity, 'ironing' of this section will occur if the clearance between the punch and die is not enough to accommodate increased thickness of the work piece. This ironing is useful if uniform thickness of the product is desired after the drawing operation.

#### DEEP DRAWABILITY:

Deep drawability or drawing ratio of the metal is defined as the ratio of the max blank diameter to diameter of the cup drawn from the blank, i.e.  $D/d$ . For a given material there is a limiting drawing ratio (LDR), after which the punch will pierce a hole in the blank instead of drawing the blank.



This ratio depends upon many factors, such as material, amount of friction present etc. The usual range of the max drawing ratio is 1.6 to 2.3. A simple push through drawing die is shown. The drawing punch should be properly vented with drilled passages. Venting serves double purpose it eliminates suction which would hold the cup on the punch and damage the cup when it is stripped from the punch. Secondly, venting provides passages for lubricants. Many presses used for the deep drawing operations are hydraulically operated and these presses have an additional hydraulic cylinder and piston for the additional slide.

Product applications of deep drawing process are: cups, shells, automotive bodies, gas tanks, house hold hardware etc.

### Redrawing:

In deep drawing the percentage reduction in one draw is defined as: % reduction =  $[D-d]/D \times 100$  Now  $D/d = 6$  to  $2.3$ ,  $d/D = 0.435$  to  $0.625 = 0.5$  (average) The average reduction in deep drawing =  $[1-d/D] \times 100 = 50\%$  To make tall cups of smaller diameter it is necessary to use successive drawing operations. Reducing the drawn cup to the smaller diameter and increased height is known as "redrawing".

### Blank Size:

One of the first jobs of the draw die designer is to find the size of the blank to be used for making a given cup. It is often difficult to find a blank of exact size required for making a given shell, because of thinning and thickening of sheet during drawing. The calculation should be based on volume, surface area or by layout. The following gives the useful relations in calculating the blank diameter for cylindrical shells for relatively thin materials.

$D \approx \sqrt{d^2 + 4dh}$	When $d \geq 20r$
$D \approx \sqrt{d^2 + \frac{4dh}{r}}$	When $15r \leq d \leq 20r$
$D \approx \sqrt{d^2 + 4dh} + r$	When $10r \leq d \leq 15r$
$D \approx \sqrt{(d - 2r)^2 + 4d(h - r)} + 2(d - 0.7r)$	When $d < 10r$

Where  $r$  = corner radius on the punch, mm  
 $h$  = height of the shell, mm  
 $d$  = outer diameter of the shell, mm  
 $D$  = blank diameter, mm

### Drawing Force

The drawing force depends on the cup material, its dimensions and the configuration. The drawing force can empirically be calculated using the following equation for

$$P = \frac{4}{3} \pi s t \left( \frac{D}{d} - C \right)$$

Where  $P$  = drawing force, N  
 $t$  = thickness of the blank material, mm

cylindrical shells.

$s$  = yield strength of the metal, Mpa  $C$  = constant to cover friction and bending. Its value is between 0.6 and 0.7

### Drawing Operation:

1. Fix the punch to the ram of the press.
2. Fix the die on the bed of the machine using clamps, bolts and nuts.
3. Calculate the required blank size and place the same between the punch and die block.
4. Apply the hydraulic pressure on the punch through ram so that the punch slowly descends on the blank and forces it take the cup shape formed by the end of the punch, by the it reaches the bottom of the die.
5. When the cup reaches the counter bored portion of the die, the top edge of the cup formed around the punch expands slightly due to spring back.
6. Observe the reading of the pressure gauge which directly gives the force required to perform the operation.
7. Calculate the drawing force required, to perform the operation using above relations.
8. Compare the two readings
9. Then move the punch in the return direction so that the cup will be stripped by counter bored portion.

### Precautions:

1. The die should be properly clamped to the bed of the machine and it is not disturbed during the process.
2. The punch is properly fixed to the ram of the machine.
3. The load should be applied uniformly on the bar.
4. The bar should be held properly on the die block.

### Result:

## 10. STUDY OF Electrical Discharge Machining (EDM)

AIM: Study Of Abrasive Jet Machining

Electrical discharge machining (EDM) is one of the most widely used non-traditional machining processes. The main attraction of EDM over traditional machining processes such as metal cutting using different tools and grinding is this technique utilizes thermoelectric process to erode undesired materials from the work piece by a series of discrete electrical sparks between the work piece and the electrode. A picture of EDM machine in operation

The traditional machining processes rely on harder tool or abrasive material to remove the softer material whereas non-traditional machining processes such as EDM uses electrical spark or thermal energy to erode unwanted material in order to create desired shape. So, the hardness of the material is no longer a dominating factor for EDM process. A schematic of an EDM process is shown in Figure 2, where the tool and the workpiece are Immersed in a dielectric fluid.

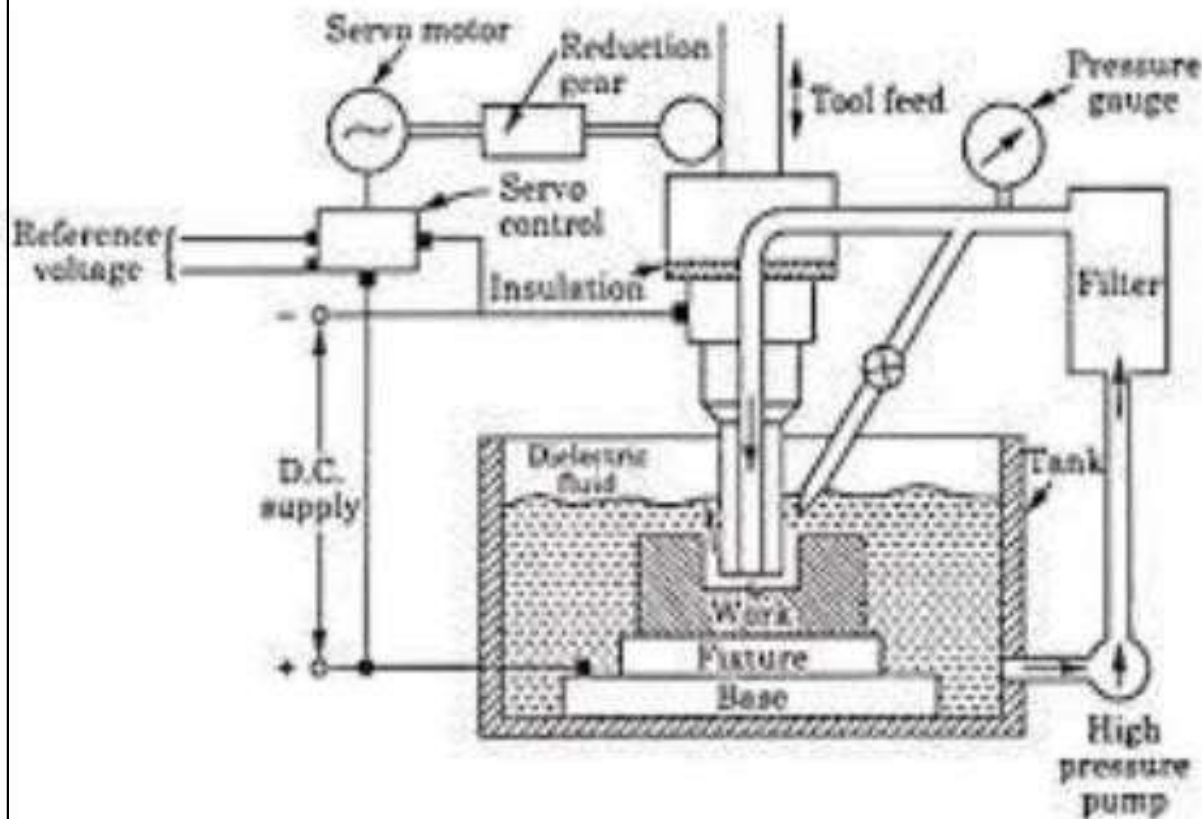


Fig. 10.1

EDM removes material by discharging an electrical current, normally stored in a capacitor bank, across a small gap between the tool (cathode) and the workpiece (anode) typically in order 3.1.1. Application of EDM The EDM process has the ability to machine hard, difficult-to-machine materials. Parts with complex, precise and irregular shapes for forging, press tools, extrusion dies, difficult internal shapes for aerospace and medical applications can be made by EDM process. Some of the shapes made by EDM process are shown in Figure.



Figure: Difficult internal parts made by EDM process

Working principle of EDM As shown in Figure 1, at the beginning of EDM operation, a high voltage is applied across the narrow gap between the electrode and the work piece. This high voltage induces an electric field in the insulating dielectric that is present in narrow gap between electrode and work piece. This cause conducting particles suspended in the dielectric to concentrate at the points of strongest electrical field. When the potential difference Between the electrode and the work piece is sufficiently high, the dielectric breaks down and a transient spark discharges through the dielectric fluid, removing small amount of material from the work piece surface. The volume of the material removed per spark discharge is typically in the range of  $10^{-6}$  to  $10^{-6}$  mm<sup>3</sup>.

The material removal rate, MRR, in EDM is calculated by the following formula:  $MRR = 40 I/T_m 1.23$  (cm<sup>3</sup>/min) Where, I is the current amp, T<sub>m</sub> is the melting temperature of work piece in °C

Dielectric fluids Dielectric fluids used in EDM process are hydrocarbon oils, kerosene and deionised water. The functions of the dielectric fluid are to:

→ Act as an insulator between the tool and the work piece.

- Act as coolant.
- Act as a flushing medium for the removal of the chips.

The electrodes for EDM process usually are made of graphite, brass, copper and copper tungsten alloys.

Design considerations for EDM process are as follows:

→ Deep slots and narrow openings should be avoided.

→ The surface smoothness value should not be specified too fine.

→ Rough cut should be done by other machining process. Only finishing operation should be done in this process as MRR for this process is low.

Advantages of EDM

→ By this process, materials of any hardness can be machined;

→ No burrs are left in machined surface;

→ One of the main advantages of this process is that thin and fragile/brittle components can be machined with out distortion

→ Complex internal shapes can be

machined Limitations of EDM

→ This process can only be employed in electrically conductive materials;

## **MFP**

## **MECHANICAL / II-ISEM**

- Material removal rate is low and the process overall is slow compared to conventional machining processes;
- Unwanted erosion and over cutting of material can occur;
- Rough surface finish when at high rates of material removal.

Result:

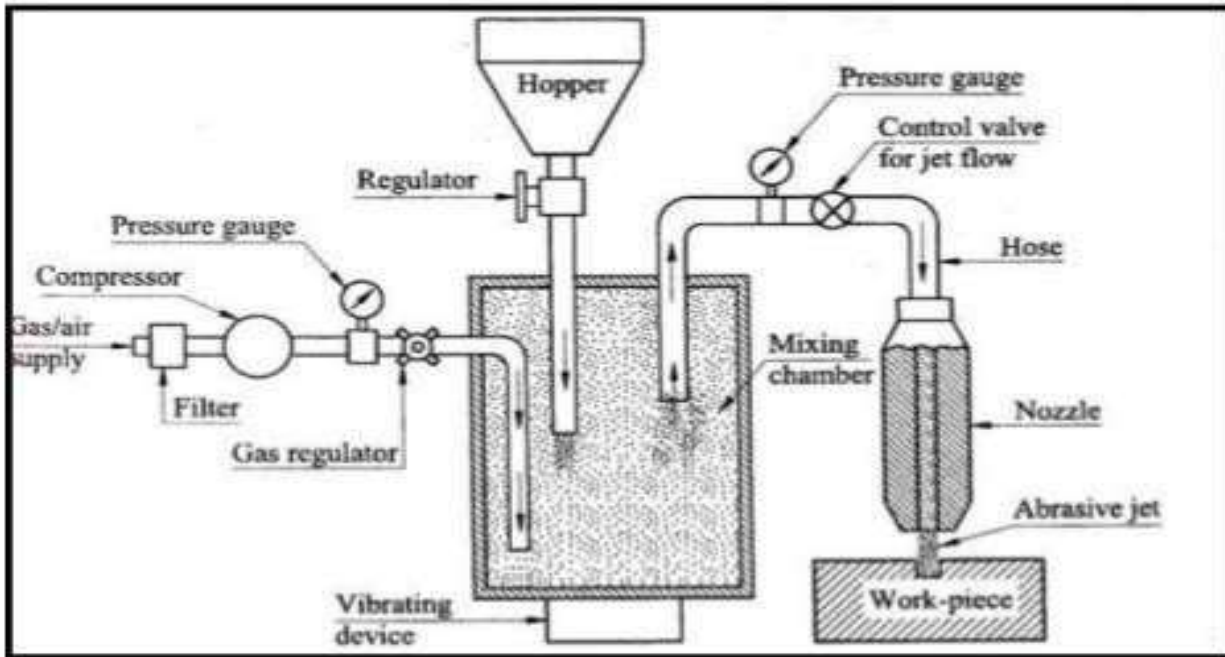
## 11. STUDY OF ABRASIVE JET MACHINING(AJM)

AIM: STUDY OF ABRASIVE JET MACHINING

In mechanical energy methods, the material is removed mechanical erosion of the work piece material.

PRINCIPLE OF AJM:

In abrasive jet machining process, a high speed stream of abrasive particles mixed with high pressure air or gas are injected through nozzle on the work piece to be machined.



### CONSTRUCTION:

The schematic arrangements of abrasive jet machine is shown in fig

It consists of mixing chamber, nozzle, pressure gauge, hopper, filter, compressor, vibrating device, regulator

- The gases generally used in this process are nitrogen, carbon dioxide or compressed air.
- The various abrasive particles used in this process are aluminum oxide, silicon carbide, glass powder, dolomite and specially prepared sodium bicarbonate.

Aluminum oxide ( $Al_2O_3$ ) is general purpose abrasive and it used in sizes of 10, 25, and 50 micron. Silicon carbide (SiC) is used for faster cutting on extremely hard materials. It is used in sizes of 25 and 50 microns. Dolomite of 200 grit size is found suitable for light cleaning and etching. Glass powder of diameter 0.30 to 0.60 mm are used for light polishing and deburring

- As the nozzle is subjected to a great degree of abrasion wear, it is made up of hard materials such as tungsten carbide, synthetic sapphire (ceramics), etc., to reduce the wear rate.
- Nozzles made of tungsten carbide have an average life of 12 to 20 hours, whereas synthetic sapphire nozzle have an average life of 300 hours. Nozzle tip clearance from work is kept at a distance of 0.25 to 0.75 mm.
- The abrasive powder feed rate is controlled by the amplitude of the vibration of mixing chamber. A pressure

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regulator controls the gas or air flow and pressure. To control the size and shape of the cut , either the work piece or the nozzle is moved by a well designed mechanism such as cam mechanism , pantograph mechanism, etc.

### **WORKING:**

- Dry air or gas (N<sub>2</sub> or CO<sub>2</sub>) is entered in to the compressor through a filter where the pressure of air or gas increased.
- The pressure of the air varies from 2 kg/cm<sup>2</sup> to 8kg/cm<sup>2</sup>.
- Compressed air or high pressure gas is supplied to the mixing chamber through a pipe line. This pipe line carries a pressure gauge and a regulator to control the air or gas and its pressure.
- The fine abrasive particles are collected in the hopper and fed into the mixing chamber. A regulator is incorporated in the line to control the flow of abrasive particles.
- The mixture of pressurized air and abrasive particles from the mixing chamber flows in to the nozzle at a considerable speed.
- Nozzle is used to increase the speed of the abrasive particles and it is increased up to 300 m/s.
- This high speed stream of abrasive particles from the nozzle, impact the work piece to be machined. Due to repeated impacts , small chips of material get loosened and a fresh surface is exposed.
- a vibrator is fixed at the bottom of the mixing chamber. When it vibrates, the amplitude of the vibrations controls the flow of abrasive particles.
- This process is widely used for machining hard and brittle materials, non metallic materials (germanium, glass ,ceramics and mica) of thin sections. This process is capable of performing drilling, cutting, deburring ,etching and cleaning the surfaces.

### ➤ **METAL REMOVAL RATE PROCESS PARAMETERS**

- The metal removal rate depends upon the following parameters.
- Mass flow rate
- Abrasive grain size
- Gas pressure
- Velocity of abrasive particles
- Mixing ratio
- Nozzle tip clearance.

### ➤ **MASS FLOW RATE:**

At particular pressure, the material removal rate increases with the abrasive flow rate. But , after reaching an optimum value , the material removal rate decreases with further increase in abrasive flow rate. This is due to the fact that the mass flow rate of gas or air decreases with the increase of abrasive flow rate.

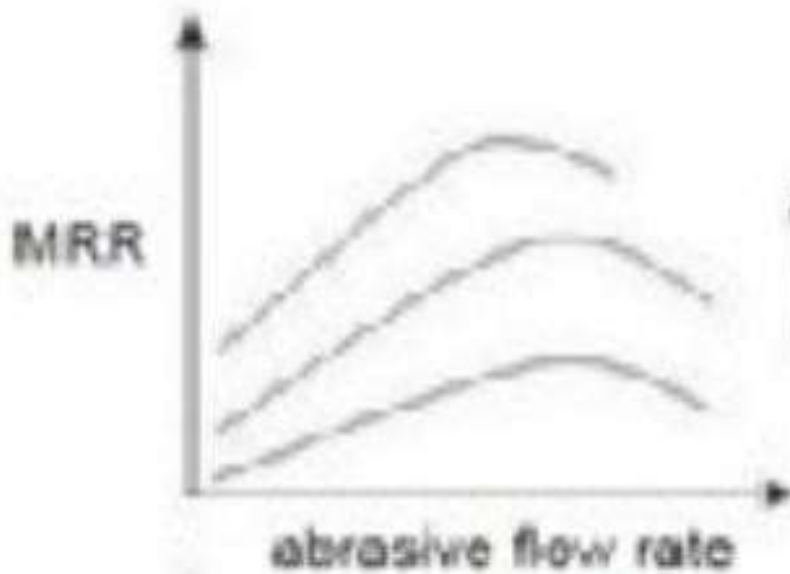


### → ABRASIVE GRAIN SIZE:

The various abrasive particles used in AJM process are aluminum oxide ( $Al_2O_3$ ), silicon carbide (sic), glass powder, dolomite and specially prepared sodium bicarbonate.

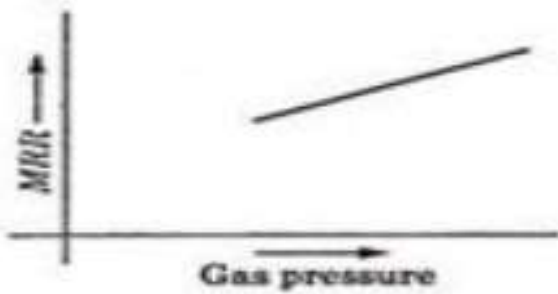
Aluminium oxide is a general purpose abrasive and is used in sizes of 10, 25 and 50 microns. Silicon carbide is used for faster cutting on extremely hard materials. It is used in sizes of 25 and 50 microns. Dolomite of 200 grit size is found suitable for light cleaning and etching. Glass powder of 0.30 to 0.60 mm are used for light polishing and deburring.

in general, larger sizes are used for rapid removal rate while smaller sizes are used for good surface finish and precision.



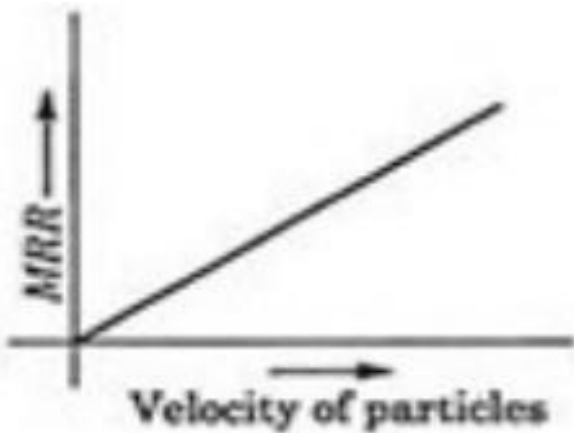
### 2. GAS PRESSURE:

The metal removal rate increases with increase in gas or air pressure as shown in fig



### 3. VELOCITY OF ABRASIVE PARTICLES:

The metal removal rate increases with the increase of velocity of abrasive particles as shown in fig.

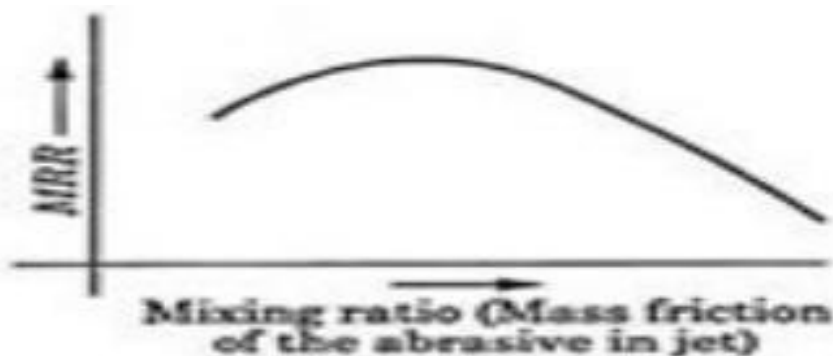


### 4. MIXING RATIO:

Mixing ratio is defined as the ratio of mass flow rate of abrasive to the mass flow rate of gas.

$$\text{mixing ratio} = \frac{\text{mass flow rate of abrasive}}{\text{mass flow rate of gas}}$$

metal removal rate first increases with the increase of mixing ratio up to certain limit after that it decreases



gradually as shown in fig.

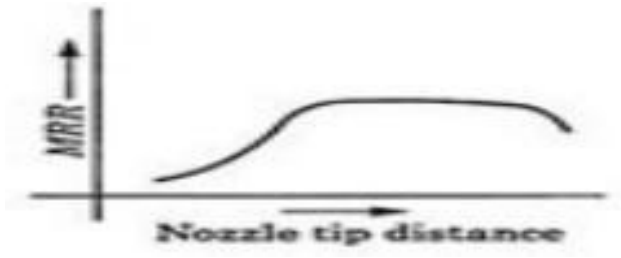
### 5. NOZZLE TIP CLEARANCE OR STAND OFF DISTANCE:

The distance between the nozzle tip and the work piece has great influence on the diameter of cut, its shape, size and also on the rate of material removal.

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The material removal rate first increases with the increase of tip clearance from work piece up to a certain limit afterthat it remains unchanged for a certain tip clearance and then decreases gradually as shown in fig.



## 12.STUDY OF 3D PRINTING

### AIM: STUDY OF 3D PRINTING

3D printing allows for rapid prototyping and onsite manufacturing of products. Initially done with plastic, 3D printing now uses new techniques with new materials, such as aluminum, bronze, and glass. Bio-materials are also being incorporated, such as 3D printing ear cartilage and liver tissue. As the 3D printing industry grows, 3D printing will become a big part of many engineering fields

Introduction:- 3D printing allows for rapid prototyping and onsite manufacturing of products. Initially done with plastic, 3D printing now uses new techniques with new materials, such as aluminum, bronze, and glass. Biomaterials are also being incorporated, such as 3D printing ear cartilage and liver tissue. As the 3D printing industry grows, 3D printing will become a big part of many engineering fields

**1.Axes:** Fixed Rods The three axes that the 3D printer utilizes are on the Cartesian coordinate system. The linear fixed rods are maintained at right angles to each other, and each represents a coordinate axis. Movement The timing belts and pulleys allow the movement of the hot end (or the print bed, depending on the type of 3D printer) along each axes according to the g-code (generated by slicing software). The stepper motors power this movement.

**2. Extruder:** Extrusion is the feeding of filament into the hot end of the 3D printer. This movement is also powered by a stepper motor. Retraction This mechanism is the pulling of the melted filament from the hot end. This movement is primarily programmed through the g-code to prevent the formation of unwanted filament creating a bridge between two areas. The bridging of unwanted filament is referred to as stringing or the formation of cobwebs. Dual Extrusion Some models of 3D printers are equipped with dual extrusion capabilities. This allows for mixed material objects to be printed. Dual extrusion can used to print out complex objects with a different colour material as the support, making it easy to differentiate between the object and the support.

**3.Hot End:** The hot end is heated to temperatures ranging from 160 C to 250 C, depending on the type of filament to be used. The hot end melts the filament and pushes the melted filament through the nozzle. The hot end needs to be thermally insulated from the other components of the 3D printer to prevent any damage.

**4. Print Bed:** Heated Print beds that are heated improve print quality of 3D printed objects. The heated bed is heated to the glass transition temperature of the filament being used. This allows the model layers to slightly melt and stick to the heated bed. Non-Heated Print beds that are not heated require adhesion in the form of glue, tape, hairspray, etc. In the innovation lab, painters tape is frequently used for adhesion.

**5. Filament:** Filament is a consumable used by the 3D printer to print layers. Filament comes in a variety of materials and colors. Filament can be composed of metal, wood, clay, biomaterials, carbon fiber, etc.

i) **ABS:** - ABS is a thermoplastic that needs to be heated to temperatures from 210C to 250C. ABS can only be printed on a 3D printer with a heated bed, which prevents the cracking of the object. When ABS is heated, it emits a strong unpleasant odor. ABS requires a complete enclosure while Printing.

ii) **PLA:** - PLA is a thermoplastic that needs to be heated to temperatures from 160C to 220C. PLA is also biodegradable and emits slight odors. PLA is most frequently used in the all 3D printers. PVA PVA is a water soluble plastic that is frequently used for support in dual extrusion 3D printers. The printed object is left in water where the PVA support is dissolved and the finished object printed in the other filament remains.

**Preparing your 3D Model in CAD Software:** CAD software is used to create 3D models and designs. This software is available on our computers and the level of difficulty varies. With the exception of Sketch up Pro and the industry standard software mentioned, all of these programs are available on the innovation lab computer, Solid works main idea is user to create drawing directly in 3D or solid form. From this solid user can assemble it directly on their workstation checking clashes and functionality of it. Creating drawing is pretty easy just drag and drop the solid to drawing block.

The sequence for creation of an object via additive manufacturing comprises of a few steps – Figure 1.

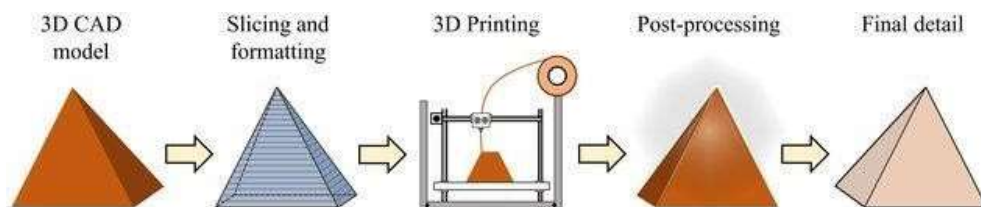


Figure 1. Production sequence for a 3D printed object

#### Preparing your 3D Model for print in Idea maker software:-

These are following step for 3D printing of model

1. Install the 3D print software idea maker
2. Check repair option in this software
3. Set the nozzle parameter and build tack temperature according to the printer guide

**Step:-1** Prepare the design Model using Designing Software(Solids Work,Autocad etc.)

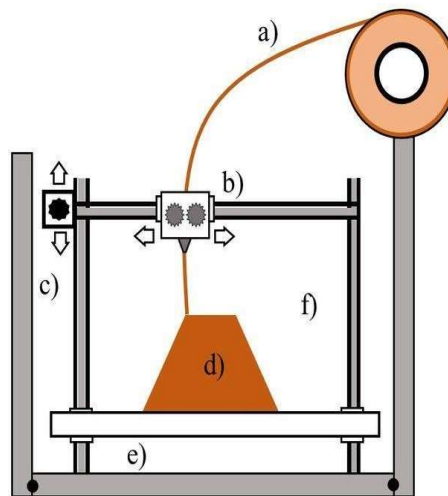
**Step:-2** Convert the designed Model file in Stl ,obj format.

**Step:-3** Prepare the design model for printing

Using Software Idea Maker and Ultimaker. Then set all parameter (nozzle temp., build task temp and support) and also repair your design using software option. Then after generating the file in G-code format.

**Step:-4** ON the 3D Printer and load the filament in nozzle and give the command print by using 3D Printing Machine.

Extrusion-based 3D printing is the most common technique for 3D printing. A typical extrusion-based FDM printing machine is shown in Figure 2



**Figure 2. Simple schematic of a 3D printer utilizing an extrusion-based technique**

- a) Material is fed in the form of cord through an extruder
- b) A heater and a nozzle – Deposition head
- c) Deposition head fixed on an axis profile with controlled movement by a motor
- d) Desired object
- e) Desired object is printed on the print bed
- f) Object printed in the print area - layer by layer due to the cooling of the material and the adhesion

**Precaution of 3D Printer machine:** These are some following precaution when you print the design in 3D Printer

1. Mechanical: Do not place limbs inside the build area while the nozzle is in motion. The printer nozzle moves in order to create the object.
2. High Temperature: Do not touch the printer nozzle -it is heated to a high temperature in order to melt the build material.
3. Always buy replacement parts from the manufacturer for safety related equipment
4. Choose an area that has adequate ventilation and exhaust capability

**Safety Equipment:**

Safety Glasses Gloves  
(recommended for post processing )

**Applications of 3D Printer:** Automotive, Medical, Engineering, Customize parts,  
Less transport, Freedom for design

Result:

### 13. PATTERN DESIGN AND MAKING

**AIM:** To Design and Manufacture a Wooden Pattern for a given Casting.

**MATERIAL REQUIRED:** Teak wood of 50 x 50 x 130 mm<sup>3</sup>

**EQUIPMENT AND TOOLS REQUIRED:** Wood Turning Lathe, Vernier Calipers, Spanner, chuck spanner, and Single Point Cutting tool, Emery Paper

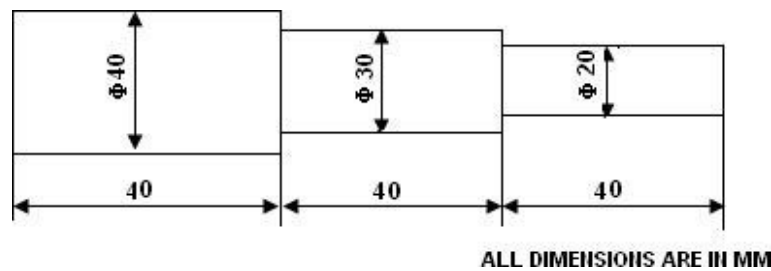
**Functions of a Pattern:**

- A pattern prepares a mold cavity for the purpose of making a casting.
- A pattern may contain projections known as core prints if the casting requires a core and need to be hollow.
- Runner, gates and risers (used for introducing and feeding molten metal to the mold cavity) may form the part of the pattern.
- A pattern may help in establishing locating points on the mold and therefore on the casting with a purpose to check the casting dimensions.
- Pattern establishes the parting line and parting surfaces in the mold.

**Problem:**

Design a Pattern for the casting shown in fig. which is to be made of steel by considering

**shrinkage and machining allowance.**



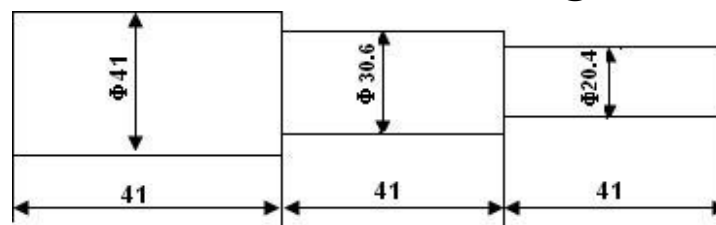
**Solution:**

For Steel Shrinkage Allowance is 21mm/m.

For dimension 40, allowance is  $40 \times 21/1000$   
 $= 0.84 \sim 1.0$  For dimension 30, allowance is  
 $30 \times 21/1000 = 0.63$

For dimension 20, allowance is  $20 \times 21/1000 = 0.42$

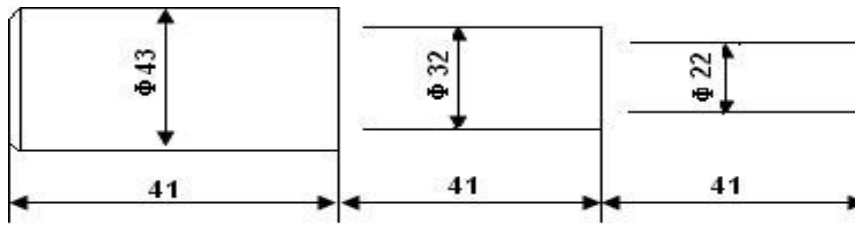
**The pattern drawing with required dimensions taking shrinkage into account is shown in fig.**



**Machining Allowance:**

Assume 2mm allowance on larger diameter size, 1.4mm on 30mm diameter size and 1.6mm on smaller diameter size.

The pattern drawing with required dimensions taking shrinkage into account is shown in fig.



ALL DIMENSIONS ARE IN MM

### PROCEDURE

- The work piece is fixed between live centre and dead center of wood working lathe.
- Adjust the machine to run the job to a required cutting speed.
- Fix the cutting tool in the tool post and make sure that the axis of the job coincides with the tip of the cutting tool.
- Give the depth of cut and feed to the cutting tool.
- Plain turning operation is performed until the diameter of the work piece reduces to 43 mm.
- Step turning operation is performed according to the given dimensions.
- Perform shoulder turning operation according to the dimensions shown in fig.
- Frequently check the dimensions by using vernier calipers.
- Finish the work piece using emery paper.

### PRECAUTIONS:

- The work piece should be held rigidly between the two centers before operating the machine.
- Tool should be properly ground, fixed at correct height and properly secured, and work also be firmly secured. Optimum machining conditions should be maintained.

### RESULT:

## 14. INJECTION MOULDING

**AIM:** To Prepare a Plastic product using Injection Molding machine

**Equipment:**

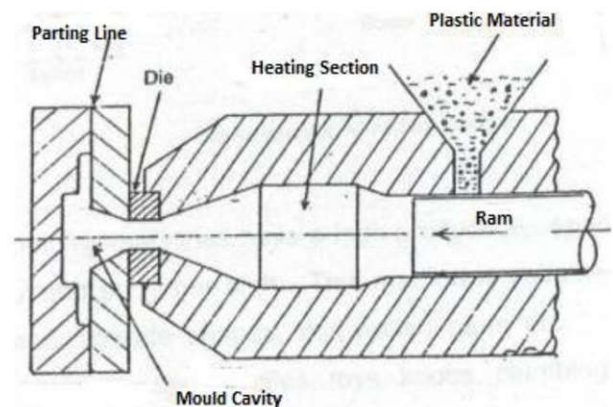
Injection molding machine Setup.

**Material Required:**

High grade poly ethylene

**Procedure:**

- Pour the raw material in the hopper.
- Place the die in such a way that its hole coincides with the central axis of the cylinder.
- Heat the cylinder by pouring plastic pellets in it.
- When the metal is heated at  $80^{\circ}\text{C}$  to  $100^{\circ}\text{C}$  it is converted into molten metal.
- Press the lever so that the softened plastic will enter into the die and gets the desired shape of the mould.
- Allow it to cool for some time.



Injection Moulding Setup

**Sketch:**

**Precautions:**

1. Align the opening of the die and an orifice of the cylinder carefully.
2. Use gloves while holding die.

**Result:**