

Code: 23ME3401

**II B.Tech - II Semester – Regular / Supplementary Examinations  
APRIL 2026**

**MANUFACTURING PROCESSES  
(MECHANICAL ENGINEERING)**

Duration: 3 hours

Max. Marks: 70

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 Note: 1. This question paper contains two Parts A and B.

2. Part-A contains 10 short answer questions. Each Question carries 2 Marks.

3. Part-B contains 5 essay questions with an internal choice from each unit. Each Question carries 10 marks.

4. All parts of Question paper must be answered in one place.

BL – Blooms Level

CO – Course Outcome

**PART – A**

		BL	CO
1.a)	State any two advantages of casting.	L1	CO1
1.b)	Explain the function of a riser in casting.	L2	CO1
1.c)	List different types of flames in gas welding.	L1	CO3
1.d)	Name different types of welded joints.	L1	CO1
1.e)	Explain the term strain hardening.	L2	CO1
1.f)	Explain the difference between hot working and cold working.	L2	CO1
1.g)	Explain blanking and piercing in sheet metal forming.	L2	CO4
1.h)	Explain the term explosive forming.	L2	CO4
1.i)	List the basic steps involved in Additive Manufacturing (AM).	L1	CO5
1.j)	Describe VAT photo polymerization.	L2	CO5

## PART – B

			BL	CO	Max. Marks
<b>UNIT-I</b>					
2	Explain centrifugal casting process with a neat sketch.	L2	CO2	10 M	
<b>OR</b>					
3	Explain types of gates, gating ratio and mention their functions.	L2	CO1	10 M	
<b>UNIT-II</b>					
4	Discuss welding defects, their causes and remedies.	L2	CO3	10 M	
<b>OR</b>					
5	Explain Manual Metal Arc Welding with a neat sketch.	L2	CO3	10 M	
<b>UNIT-III</b>					
6	Explain plastic deformation in metals and alloys. Describe recovery, recrystallization, and grain growth.	L2	CO1	10 M	
<b>OR</b>					
7	Explain the fundamentals of rolling. Describe different types of rolling mills and rolling products.	L2	CO1	10 M	
<b>UNIT-IV</b>					
8	Explain the types of presses and press tools used in sheet metal forming.	L2	CO4	10 M	

<b>OR</b>				
9	Discuss rubber pad forming with advantages, limitations and applications.	L2	CO4	10 M
<b>UNIT-V</b>				
10	Explain Direct Energy Deposition (DED) process and discuss the applications of Additive Manufacturing.	L2	CO5	10 M
<b>OR</b>				
11	Explain Selective Laser Sintering (SLS) process with a neat sketch.	L2	CO5	10 M

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**PART-A**

1.
  - a) **State any two advantages of casting.**  
Stating any two advantages of casting: 2M
  - b) **Explain the function of a riser in casting.**  
Explaining the function of riser: 2M
  - c) **List different types of flames in gas welding.**  
Listing the types of flames: 2M
  - d) **Name different types of welded joints.**  
Naming different types of welded joints: 2M
  - e) **Explain the term strain hardening.**  
Explaining Strain hardening: 2M
  - f) **Explain the difference between hot working and cold working.**  
Explaining any four differences between hot working and cold working: 2M
  - g) **Explain blanking and piercing in sheet metal forming.**  
Explaining Blanking operation: 1M  
Explaining Piercing (Punching) operation: 1M
  - h) **Explain the term explosive forming.**  
Explaining the principle of Explosive forming: 2M
  - i) **List the basic steps involved in Additive Manufacturing (AM).**  
Listing the basic steps involved in Additive Manufacturing: 2M
  - j) **Describe VAT photo polymerization.**  
Describing the VAT photopolymerization process: 2M

**PART-B**

**UNIT-I**

2. **Explain centrifugal casting process with a neat sketch.** 10 M  
Explaining the centrifugal casting process: 5M  
Sketch of centrifugal casting process: 5M

**OR**

3. **Explain types of gates, gating ratio and mention their functions.** 10 M  
Explaining the types of gates: 6M  
Explaining Gating ratio and mentioning their functions: 4M

**UNIT-II**

4. **Discuss welding defects, their causes and remedies.** 10 M  
Discussing any five welding defects: 5M  
Their causes and remedies: 5M

**OR**

- 5. Explain Manual Metal Arc Welding with a neat sketch. 10 M**  
Theory of Manual Metal Arc welding: 5M  
Neat Sketch: 5M

### UNIT-III

- 6. Explain plastic deformation in metals and alloys. Describe recovery, recrystallization, and grain growth. 10 M**  
Explaining Plastic deformation in metals and alloys: 4M  
Recovery: 2M  
Recrystallization: 2M  
Grain Growth: 2M

OR

- 7. Explain the fundamentals of rolling. Describe different types of rolling mills and rolling products. 10 M**  
Fundamentals of rolling: 2M  
Different types of rolling mills: 6M  
Rolling products: 2M

### UNIT-IV

- 8. Explain the types of presses and press tools used in sheet metal forming. 10 M**  
Types of Presses: 5M  
Types of Dies: 5M

OR

- 9. Discuss rubber pad forming with advantages, limitations and applications. 10M**  
Rubber pad forming Theory: 2M  
Rubber pad forming Diagram: 2M  
Advantages: 2M  
Limitations: 2M  
Applications: 2M

### UNIT-V

- 10. Explain Direct Energy Deposition (DED) process and discuss the applications of Additive Manufacturing. 10 M**  
Direct Energy Deposition (DED) process Theory: 3M  
Direct Energy Deposition (DED) process Diagram: 3M  
Applications of Additive Manufacturing: 4M

OR

- 11. Explain Selective Laser Sintering (SLS) process with a neat sketch. 10 M**  
Explaining the Selective Laser Sintering (SLS) process: 5M  
Sketch of Selective Laser Sintering (SLS) process: 5M

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**MANUFACTURING PROCESSES  
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**PART-A**

1.

**a) State any two advantages of casting. (Any two may be written)**

- It is possible to cast practically any material, be it ferrous or non-ferrous.
- The necessary tools required for making sand moulds are very simple and inexpensive. As a result, for trial production or production of a small lot, it is an ideal method.
- It is possible in casting process to place the amount of material where exactly required. As a result, weight reduction in design can be achieved.
- Castings are generally cooled uniformly from all sides and therefore they are expected to have no directional properties.
- There are certain metals and alloys which can only be processed by the casting and not by any other process like forging because of the metallurgical considerations.
- Casting of any size and weight, even up to 200 tons can be made.

**b) Explain the function of a riser in casting.**

As molten metal solidifies, it shrinks. The riser supplies additional molten metal to the casting to fill the shrinkage cavities and prevent defects. The riser is designed to solidify last, ensuring that molten metal flows from the riser to the casting during solidification. By feeding molten metal where needed, it helps avoid internal voids, porosity, and shrinkage defects.

**c) List different types of flames in gas welding.**

The different types of flames used in gas welding are:

1. **Neutral Flame** – Has a balanced mixture of oxygen and acetylene; commonly used for most welding operations.
2. **Carburizing (Reducing) Flame** – Contains excess acetylene; used for welding high-carbon steels and for applications requiring a reducing atmosphere.
3. **Oxidizing Flame** – Contains excess oxygen; used for welding materials like brass and bronze.

**d) Name different types of welded joints.**

Different types of welded joints are Butt joint, Lap joint, T-joint, Corner joint, Edge joint.

**e) Explain the term strain hardening.**

Strain hardening (also called work hardening) is the phenomenon in which a metal becomes stronger and harder when it is plastically deformed (e.g., by rolling, hammering, or drawing) below its recrystallization temperature. In simple terms, strain hardening improves strength by making the metal more resistant to further deformation.

**f) Explain the difference between hot working and cold working.**

Sl. No.	Hot Working	Cold Working
1	Done above recrystallization temperature	Done below recrystallization temperature
2	Refinement of grains takes place	Grain structure is distorted
3	Impurities and porosity are removed from metals after hot working	Impurities and porosity exist in metals after cold working
4	Residual stresses are eliminated	Residual stresses are not eliminated
5	Rapid oxidation or scaling of surfaces occurs which results in poor surface finish	No oxidation hence good surface finish is obtained
6	Close dimensional tolerances cannot be maintained	Close dimensional tolerances can be obtained
7	Tooling and handling costs are more	Tooling and handling costs are less
8	Mechanical properties such as Toughness, ductility and elongation are improved	Cold working decreases elongation, reduction in area, hardness, tensile strength, fatigue strength are improved.

**g) Explain blanking and piercing in sheet metal forming.**

Blanking and Piercing are common sheet metal cutting operations performed using a punch and die.

**Blanking:** In blanking, a piece of sheet metal is cut out (sheared) to obtain the required shape. The cut-out piece (blank) is the desired product. The remaining sheet is scrap.

**Piercing (Punching):** In piercing, a hole is produced in the sheet metal. The removed material is scrap, and the sheet with the hole is the desired product.

**h) Explain the term explosive forming.**

Explosive forming is a high-energy rate forming process in which controlled explosive energy is used to shape metal into a desired form. A sheet metal blank is placed over a die (usually inside a water-filled chamber). An explosive charge is detonated at a certain

distance from the sheet. The shock wave pressure generated (often transmitted through water) forces the metal to deform and take the shape of the die.

**i) List the basic steps involved in Additive Manufacturing (AM).**

The basic steps involved in Additive Manufacturing are:

Step 1: Prepare CAD Model

Step 2: Conversion to STL Format

Step 3: Transfer to AM machine and STL file manipulation

Step 4: Machine setup

Step 5: Build the component

Step 6: Removal of component

Step 7: Post-processing

**j) Describe VAT photo polymerization.**

VAT photopolymerization is an additive manufacturing (3D printing) process in which liquid photopolymer resin is cured (hardened) layer by layer using light, usually ultraviolet (UV) light, to create a solid object.

A vat is filled with liquid photopolymer resin. A UV light source (laser or projector) selectively exposes specific regions of the resin surface. The exposed resin polymerizes and solidifies. The build platform moves, and the process repeats layer by layer until the part is formed.

**PART-B**

**UNIT-I**

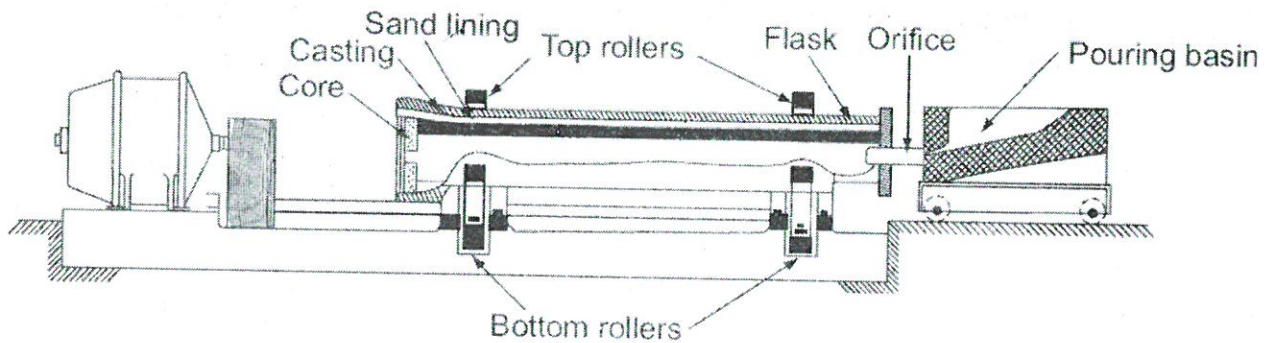
**2. Explain centrifugal casting process with a neat sketch.**

**10 M**

This is a process where the mould is rotated rapidly about its central axis as the metal is poured into it. Because of the centrifugal force, a continuous pressure will be acting on the metal as it solidifies. The slag, oxides and other inclusions being lighter, gets separated from the metal and segregates toward the centre. This is normally used for the making of hollow pipes, tubes, hollow bushes, etc., which are axi-symmetric with a concentric hole. Since the metal is always pushed outward because of the centrifugal force, no core needs to be used for making the concentric hole. The axis of rotation can be horizontal, vertical or any angle in between. Very long pipes are normally cast with horizontal axis whereas short pieces are more conveniently cast with a vertical axis.

First, the moulding flask is properly rammed with sand to conform to the outer contour of the pipe to be made. Any end details, such as spigot ends, or flanged ends are obtained with the help of dry sand cores located at the ends. Then the flask is dynamically balanced so as to reduce the occurrence of undesirable vibrations during the casting process. The finished flask is mounted in between the rollers and the mould is rotated slowly. Now the molten metal in requisite quantity is poured into the mould through the movable pouring

basin. The amount of metal poured determines the thickness of the pipe to be cast. After the pouring is completed, the mould is rotated at its operational speed till it solidifies, to form the requisite tubing. Then the mould is replaced by a new mould machine and the process continues. Metal moulds can also be used in the true centrifugal casting process for large quantity production. A water jacket is provided around the mould for cooling it. The casting machine is mounted on wheels with the pouring ladle which has a long spout extending till the other end of the pipe to be made.



OR

3. Explain types of gates, gating ratio and mention their functions.

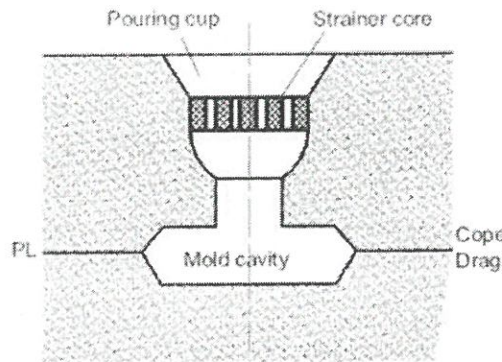
10 M

Gates are the openings through which the molten metal enters the mould cavity. The shape and the cross section of the gate should be such that it can readily be broken off after casting solidification, and also that it allows the metal to enter quietly into the mould cavity. Depending on the application, various types of gates are used in the casting design.

- Top Gate
- Bottom Gate
- Parting Gate
- Step Gate

**Top Gate:** This is the type of gating through which the molten metal enters the mould cavity from the top. Since the first metal entering the gate reaches the bottom and hotter metal is at the top, a favourable temperature gradient towards the gate is achieved. Also, the mould is filled very quickly. But as the metal falls directly into the mould 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 the top gate is not advisable for those materials, which are likely to form excessive dross. It is not suggested for nonferrous materials and is suggested only for ferrous alloys. It is suitable only for simple casting shapes, which are essentially shallow in nature. To reduce the mould erosion, pencil gates are provided in the pouring cup. This type of gate requires minimum of additional runners to lead the liquid metal into the cavity, and as such provides higher

casting yield. Capabilities of top-gating system are significantly extended by using direct pour-top gating system, incorporating insulating sleeve with a ceramic foam filter.



**Bottom Gate:** When molten metal enters the mould cavity slowly, it would not cause any mould erosion. The bottom gate is generally used for very deep moulds. It takes somewhat higher time for the filling of the mould. These gates may cause unfavourable temperature gradients compared to the top gating. Thus, the system may have to use additional padding of sections towards risers, and large riser sizes to compensate for the unfavourable temperature distribution.

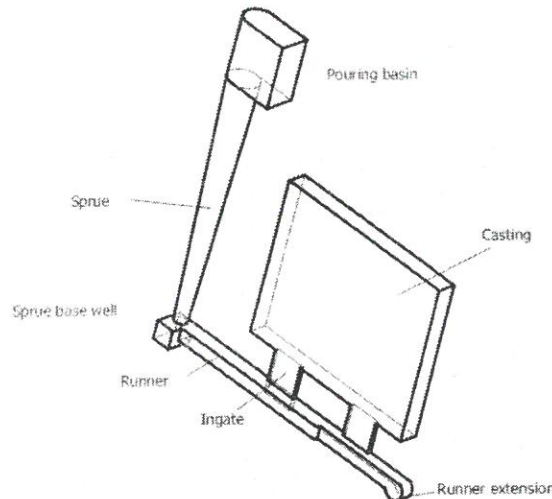
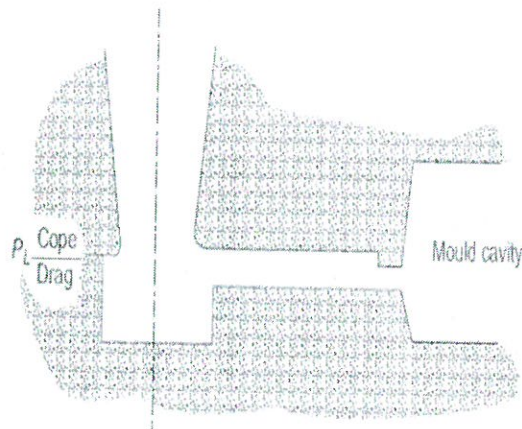


Fig. 4.10 Bottom gate

**Parting Gate:** This is the most widely used gate in sand castings. As the name implies, the metal enters the mould at the parting plane, when part of the casting is in the cope and part is in the drag. For the mould cavity in the drag, it is a top gate and for the cavity in cope, it is a bottom gate. Thus, this type of gating tries to derive the best of both the types of gates, viz. top and bottom gates. Of all the gates, this is also the easiest and most economical in preparation. However, if the drag portion of the mould cavity is deep, it is likely to cause mould erosion and aggravate dross formation and air entrapment in the case of nonferrous alloys. This can be somewhat reduced by making the gate area large such that the liquid-metal velocity is minimised and it flows slowly along the walls into the mould cavity.



**Step Gate:** Step gates are used for heavy and large castings. The molten metal enters mould cavity through a number of in-gates, which are arranged in vertical steps. The size of in-gates are normally increased from top to bottom such that metal enters the mould cavity from the bottom-most gate and then progressively moves to the higher gates. This ensures a gradual filling of the mould without any mould erosion and produces a sound casting. In designing a casting, it is essential to choose a suitable gate, considering the casting material, casting shape and size so as to produce a sound casting.

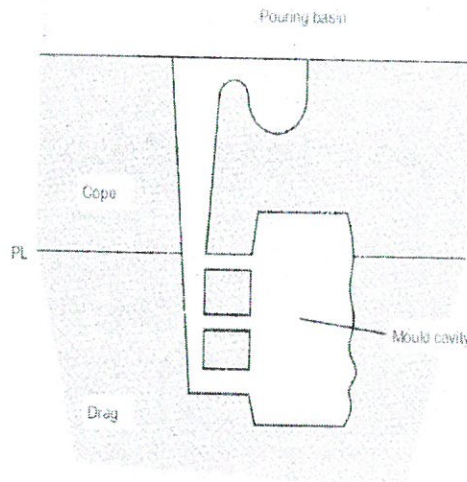


FIG. 4.12 Step gate

**Gating ratio:** It refers to the proportion of the cross-sectional areas between the sprue, runner and in-gates, and is generally denoted as sprue area, runner area, and in-gate area. Depending on the choke area there can be two types of gating systems:

**Non-pressurised gating system:** It has choke at the bottom of the sprue base, and have total runner area and in-gate areas higher than the sprue area. In this system, there is no pressure existing in the metal-flow system and thus it helps to reduce turbulence. This is particularly useful for casting drossy alloys such as aluminium and magnesium alloys. These have tapered sprues, sprue-base wells and pouring basins. When the metal enters the mould cavity through multiple in-gates, the cross section of the runner should accordingly be reduced at each runner break up, to allow equal distribution of metal through all the in-gates.

The gating ratio of a typical example is Sprue : runner : in-gate :: 1 : 4 : 4

The disadvantages of non-pressurised gating are, the gating system needs to be carefully designed to see that all parts flow full. Otherwise some elements of the gating system

may flow partially allowing the air aspiration. Tapered sprues are invariably used with non-pressurised system. Also, the runners are maintained in drag while the gates are kept in cope to ensure that the runners are full. Casting yield gets reduced because of the large metal involved in the runners and gates.

**Pressurised gating system:** normally the in-gate area is the smallest, thus maintaining a back pressure throughout the gating system. Because of this back pressure in the gating system, the metal is more turbulent and generally flows full and thereby, can minimise the air aspiration even when a straight sprue is used (after the initial stages of pouring). When multiple gates are used, this system allows all the gates to flow full. These systems generally provide a higher casting yield, since the volume of metal used up in the runners and gates is reduced. Because of the turbulence and the associated dross formation, this type of gating system is not used for light alloys but can be advantageously used for ferrous castings. Gating ratio of a typical pressurised gating system is sprue: runner : in-gate :: 1 : 2 : 1

## UNIT-II

### 4. Discuss welding defects, their causes and remedies.

10 M

Welding defects are imperfections that occur in a weld due to improper welding practices, materials, or conditions. Common defects, along with their causes and remedies, are:

<b>1. Porosity:</b> Gas pores or cavities in the weld metal.	
<b>Causes:</b> <ul style="list-style-type: none"> <li>• Moisture or contamination (oil, rust)</li> <li>• Improper shielding gas</li> <li>• Long arc length</li> </ul>	<b>Remedies:</b> <ul style="list-style-type: none"> <li>• Clean the workpiece thoroughly</li> <li>• Use proper shielding gas</li> <li>• Maintain correct arc length</li> </ul>
<b>2. Slag Inclusion:</b> Non-metallic slag trapped in the weld.	
<b>Causes:</b> <ul style="list-style-type: none"> <li>• Inadequate cleaning between passes</li> <li>• Incorrect welding angle</li> <li>• Low welding current</li> </ul>	<b>Remedies:</b> <ul style="list-style-type: none"> <li>• Remove slag between passes</li> <li>• Use proper electrode angle</li> <li>• Increase current if needed</li> </ul>
<b>3. Lack of Fusion:</b> Weld metal does not properly fuse with base metal or previous layer.	
<b>Causes:</b> <ul style="list-style-type: none"> <li>• Low heat input</li> <li>• Improper technique</li> <li>• Incorrect electrode angle</li> </ul>	<b>Remedies:</b> <ul style="list-style-type: none"> <li>• Increase heat input</li> <li>• Use correct welding technique</li> <li>• Maintain proper angle</li> </ul>
<b>4. Incomplete Penetration:</b> Weld does not extend through the joint thickness.	
<b>Causes:</b> <ul style="list-style-type: none"> <li>• Low current</li> </ul>	<b>Remedies:</b> <ul style="list-style-type: none"> <li>• Increase current</li> </ul>

<ul style="list-style-type: none"> <li>• Improper joint preparation</li> <li>Fast travel speed</li> </ul>	<ul style="list-style-type: none"> <li>• Improve joint design (root gap, bevel)</li> <li>• Reduce travel speed</li> </ul>
<b>5. Undercut:</b> Groove formed at the base of the weld along the toe.	
<b>Causes:</b> <ul style="list-style-type: none"> <li>• Excessive current</li> <li>• High welding speed</li> <li>• Improper electrode angle</li> </ul>	<b>Remedies:</b> <ul style="list-style-type: none"> <li>• Reduce current</li> <li>• Control travel speed</li> <li>• Use correct electrode positioning</li> </ul>
<b>6. Cracks:</b> Fractures in the weld metal or heat-affected zone.	
<b>Causes:</b> <ul style="list-style-type: none"> <li>• High residual stresses</li> <li>• Rapid cooling</li> <li>• Presence of impurities</li> </ul>	<b>Remedies:</b> <ul style="list-style-type: none"> <li>• Preheating and post-heating</li> <li>• Use suitable filler material</li> <li>• Control cooling rate</li> </ul>
<b>7. Spatter:</b> Small droplets of molten metal scattered around the weld.	
<b>Causes:</b> <ul style="list-style-type: none"> <li>• High current</li> <li>• Improper polarity</li> <li>• Long arc</li> </ul>	<b>Remedies:</b> <ul style="list-style-type: none"> <li>• Adjust current and polarity</li> <li>• Maintain proper arc length</li> </ul>
<b>8. Distortion:</b> Warping or change in shape of the workpiece.	
<b>Causes:</b> <ul style="list-style-type: none"> <li>• Uneven heating and cooling</li> <li>Improper welding sequence</li> </ul>	<b>Remedies:</b> <ul style="list-style-type: none"> <li>• Use proper clamping</li> <li>• Apply balanced welding sequence</li> <li>• Control heat input</li> </ul>

OR

**5. Explain Manual Metal Arc Welding with a neat sketch.**

**10 M**

The manual metal arc welding, also called the shielded metal arc welding (SMAW), is the most extensively used manual welding process which is done with stick (coated) electrodes. This process is highly versatile and can be used extensively, for both simple as well as sophisticated jobs. Further, the equipment is least expensive than most of the arc welding processes. Welds by this process can be made in any position. Job of any thickness can be welded by shielded metal arc welding. But very small thicknesses below 3 mm may give rise to difficulty in welding because of their lack of rigidity. Similarly very large thicknesses above 20 mm may take a long time for filling up the joint groove. The shielded metal arc welding can be done with either AC or DC power source. The typical range of the current usage may vary from 50 to 500 A with voltages from 20 to 40 V. The main disadvantage of the shielded metal arc welding process is the slow speed. The typical weld metal deposition rates may be in the range of 1 to 8 kg/hr in the flat position. This reduces substantially for the vertical and overhead positions. Further, a lot of electrode material is wasted in the form of unused end, slag and gas. There are more chances of slag inclusions in the bead. Also

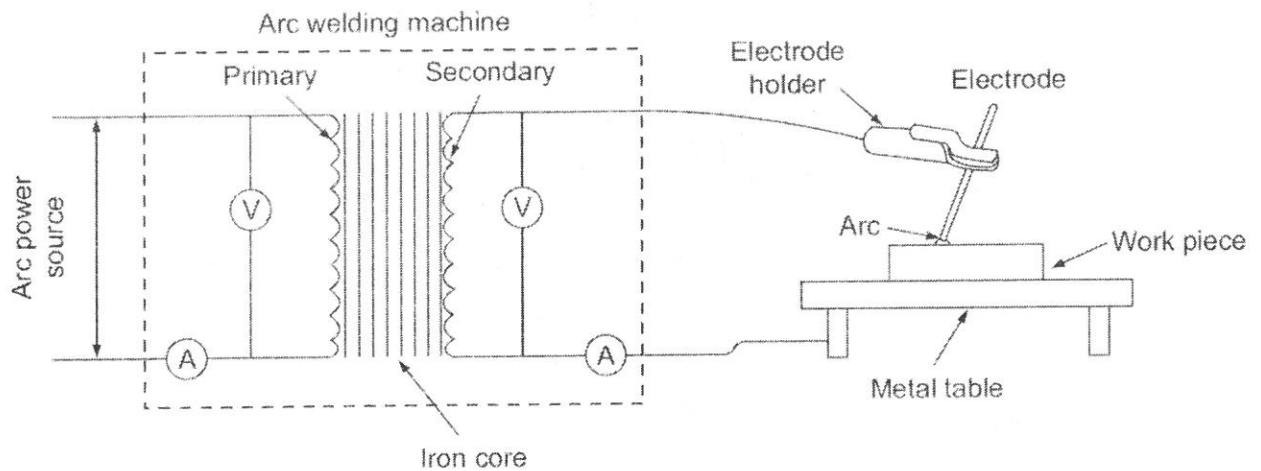
special precautions are needed to reduce moisture pick up so that it would not interfere with the welding. The electrodes for the welding operation should be selected properly depending on the requirements of the welding. The main points to be considered are

1. The composition of the base metal, which determines the electrode composition.
2. The tensile strength of the required joint.
3. The thickness of the base metal. For thinner metals the current setting should be lower.
4. The required metal deposition rate.
5. The type of arc welding equipment used. DC arc welding equipment would be preferable for overhead welding.
6. The weld position, flat, horizontal, vertical or overhead. A flat position can accommodate a larger size electrode. Also to increase metal deposition rate, coatings with iron powder can be used. In the case of vertical and overhead positions, it is necessary that the weld pool be smaller for better control. This would necessitate a small size electrode.

It is generally preferable to use the largest size electrode that is permitted for a given welding situation. The covered electrodes to be used for manual metal arc welding are standardised for various base materials. The high cellulose type of electrode coating gives rise to a voluminous gas shield but also burns off quickly. Thus, the deep penetration can be achieved but the weld finish is somewhat coarser. When the content of titania (as rutile, titanium-white or ilmenite) is high, smooth arc is produced giving rise to voluminous slag and as such should normally be used for the flat position only. But the weld finish is smooth. Iron oxide when present in the coatings gives rise to higher metal deposition rates. The other materials that may be present as fluxes in coatings are manganese oxide, calcium carbonate and fluoride. The slag becomes fairly fluid when appreciable amounts of calcium carbonate and fluoride are present. These are used for high tensile structural steels. When the electrode size varies, the voltage also changes accordingly. The size of the electrode to be chosen is based on the thickness of the plate to be welded and the weld position. The root electrode size is to be used for the root pass in the case of a multipass welding. Having chosen the electrode, the welding machine is set and the edge is made ready for welding. To start the arc, first the welder has to make a contact between the electrode and the work piece so that current flow is established. Then the electrode should be moved away from the work piece by a very small amount so that the arc is established. To accomplish this generally two different methods are employed, In the first method the electrode is moved in an arc so that it will scratch the work metal and thus establish the current flow. The normal distance by which the electrode is separated from the work metal is same as that of the diameter of the electrode wire. The scratching method is an easier method and is generally preferred by the beginners. However, the electrode should be brought back immediately to the point of start where the welding should take place, otherwise the base metal will unnecessarily get defaced by the weld metal deposit. The other method which is generally preferred by experienced welders, is called the tapping start. In this the electrode is held vertically above the point where the welding is to start and in a swift motion it is moved down to contact the metal and then lifted as much as the arc gap which is same as the electrode wire diameter. Unless the motion is swift, there

are chances that the electrode itself would get welded to the base metal plate. After establishing the correct arc length, the welder should move the electrode along the length of the joint maintaining the arc. The intense heat generated under the arc starts melting the metal, with the metal at the centre of the arc being at the highest temperature. When the electrode is moved in the forward direction, the bead is formed. The electrode should be moved downwards continuously to maintain the arc length, and at the same time it should be moved sideways in a weaving motion to maintain the bead width. After completing a sideward weaving motion, the electrode is moved forward to form a new puddle which is separated from the previous puddle by a small distance of the order of 1.5 mm. This is what is seen as ripples on the welded joint. This would be continued till the joint is completely filled. At the end of the welding, if the arc is abruptly extinguished, the arc crater would not be filled and hence, a depression would be left in the joint. Therefore, the arc has to be slowly extinguished by the gradual decrease of the welding current, which ensures a complete filling of the arc crater. In multipass welding, the brittle slag coating present on the bead after the root pass is made is chipped off and then the area is cleaned with a wire brush, before the second pass is commenced. Same procedure is followed for all the subsequent passes. Welding in flat (down hand) position is relatively easy, but in horizontal position, the welding becomes somewhat difficult because the molten metal cannot be held in position against gravity. Generally, short arc length is maintained so that filler metal will be properly deposited in the groove. Also, the electrode is maintained at about 20 degrees from the horizontal. The electrode is also positioned at about 20 degrees in the direction of the electrode travel. This slant helps in pushing the molten metal into shape and reducing the sagging of the metal. The major problems in the horizontal welding are the undercutting and sagging of the weld bead. Gravity acting on the molten metal during solidification causes this sagging. This can be corrected by following the precautions specified earlier, viz., the short arc length and angular positioning of the electrode. There are two positions in the vertical, the vertically upward and vertically downward directions. Out of these, the vertically upward direction is most preferred because of the strong weld obtained. In the downward welding, the slag is likely to move down due to the gravity and mix with the weld metal. Therefore, generally only vertically upward welding is preferred. Here also to fight the gravity, the electrode is held at an angle of about 20 degrees from the vertical plane, with a short arc length so that the filler metal will be easily moved into the groove. Further, the electrode is moved in and out of the puddle so that a proper bead is formed. In the vertical position, it is necessary to provide the welder with the necessary protective clothing because of the possibility of the spill over of the liquid metal and sparks. The overhead welding is very similar to the flat position. Because of the greater possibility of the weld metal falling, the electrode sizes used are small with a very short arc length. Though welding in any position is feasible, the flat position is the best since higher weld metal deposition rates as well as good bead quality can be achieved. Because of this in many a situation, special fixtures are used to rotate the jobs in such a way that the weld joint comes into the flat position. It has been observed that adding iron powder to the coating of the electrodes causes an increase in the metal deposition rates. Along with the increase in the deposition rate, the optimum current setting to be used for the good welding quality is also increased. The increase in optimum current would be higher for higher iron powder content. The

overall effect with higher current and higher iron powder content in the electrodes is a higher efficiency.



### UNIT-III

6. Explain plastic deformation in metals and alloys. Describe recovery, recrystallization, and grain growth.

10 M

**Plastic deformation in metals and alloys** is the permanent change in shape or size that occurs when a material is subjected to stresses beyond its elastic limit (yield point). When a metal is loaded, it first undergoes elastic deformation (temporary and reversible). Once the applied stress exceeds the yield strength, the material undergoes plastic deformation, which is irreversible. Even after removing the load, the material does not return to its original shape.

Mechanism (at atomic level): Plastic deformation occurs mainly due to the movement of dislocations within the crystal structure. Atoms slide over each other along specific planes called slip planes. This movement allows deformation without complete fracture.

Modes of Plastic Deformation:

1. Slip – Movement of atomic planes over each other (most common).
2. Twinning – A portion of the crystal forms a mirror image across a plane.

Factors Affecting Plastic Deformation are Temperature, Strain rate, Grain size, Material composition. Plastic deformation increases strength and hardness (strain hardening), Decreases ductility and development of residual stresses.

Examples for plastic deformation are Rolling, forging, extrusion, and drawing processes involve plastic deformation

**Recovery:**

- Occurs at low temperatures.
- Relieves internal stresses without significant change in microstructure.
- Dislocations rearrange and reduce in energy.
- Mechanical properties (like hardness and strength) change only slightly.
- Electrical conductivity improves.

**Recrystallization:**

- Occurs at moderate temperatures (above recrystallization temperature).

- New strain-free grains form and replace the deformed grains.
- Significant reduction in hardness and strength.
- Ductility increases.
- Grain structure becomes refined and equiaxed.

**Grain Growth:**

- Occurs at higher temperatures after recrystallization.
- Newly formed grains grow in size.
- Results in coarser grains.
- Leads to decrease in strength but may improve ductility.

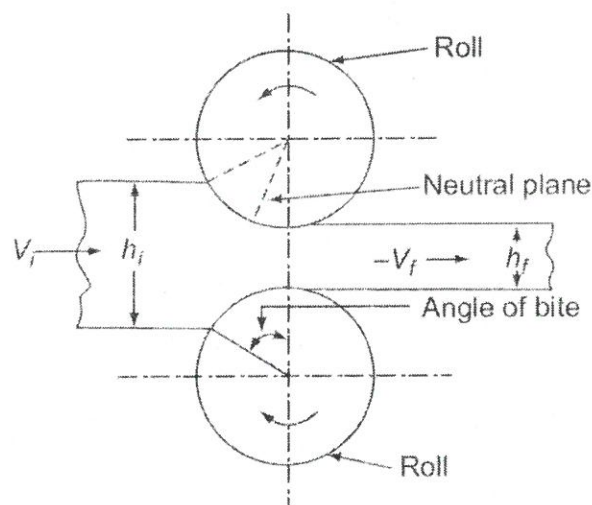
**OR**

**7. Explain the fundamentals of rolling. Describe different types of rolling mills and rolling products.**

**10 M**

Rolling is a very economical process for producing large volume of material with constant cross section. Rolling is a process where the metal is compressed between two rotating rolls for reducing its cross-sectional area. It is one of the most widely used of all the metal-working processes, because of its higher productivity and low cost. *Rolling would be able to produce components having constant cross section throughout its length. Many shapes such as I, T, L, and channel sections are possible, but not very complex shapes. It is also possible to produce special sections such as railway wagon wheels by rolling individual pieces.* Rolling is normally a hot working process unless specifically mentioned as cold rolling. The metal is taken into rolls by friction and subsequently compressed to obtain the final shape. The thickness of the metal that can be drawn into rolls depend on the roughness of the roll surface. Rougher rolls would be able to achieve greater reduction than smoother rolls. But, the roll surface gets embedded into the rolled metal thus producing rough surface. The reduction that could be achieved with a given set of rolls is designated as the 'angle of bite'. This depends on the type of rolling and the conditions of the rolls. The volume of the metal that enters the rolling stand should be same as that leaving it except in initial passes, when there might be some loss due to filling of voids and cavities in the ingots. Since the area of the cross section gets decreased, the metal leaving the rolls would be at a higher velocity than when it entered. Initially, when the metal enters the rolls, the surface speed of rolls is higher than that of the incoming metal, whereas, the metal velocity at the exit is higher than that of the surface speed of the rolls. Between the entrance and exit, the velocity of the metal is continuously changing, whereas the roll velocity remains constant. Somewhere in the contact length, the velocities of the metal and rolls are same, which is designated as 'neutral plane'. The pressure on rolls gradually builds up from the entry to the neutral point where it is highest and then decreases till it reaches the exit. The roll-separating

force which separates the two rolls apart can be obtained by multiplying the average roll pressure with the total contact area. The average roll pressure can be decreased by reducing the maximum pressure, which is a function of the contact length. Smaller contact length means less friction force acting on the roll. Thus, by reducing the contact length, it is possible to decrease the roll-separating force. This in turn, can be achieved by reducing the roll diameter, since smaller rolls would have less contact length than larger rolls for the same reduction. The smaller rolls are used for larger reductions and cold rolling where roll separating forces are large. The smaller rolls would not have enough rigidity to support a large roll-separating force. Hence backup rolls are attached to the small rolls to provide the necessary rigidity. Though higher friction between rolls and the metal is required for increasing the reduction achieved, it also increases the roll-separating force.



### Types of rolling mills:

The arrangement of rolls in a rolling mill, also called rolling stand, varies depending on the application. The names of the rolling-stand arrangements are generally given by the number of rolls employed.

**The 2-high non-reversing rolling-stand:** It is the most common arrangement. In this, the rolls always move in only one direction.

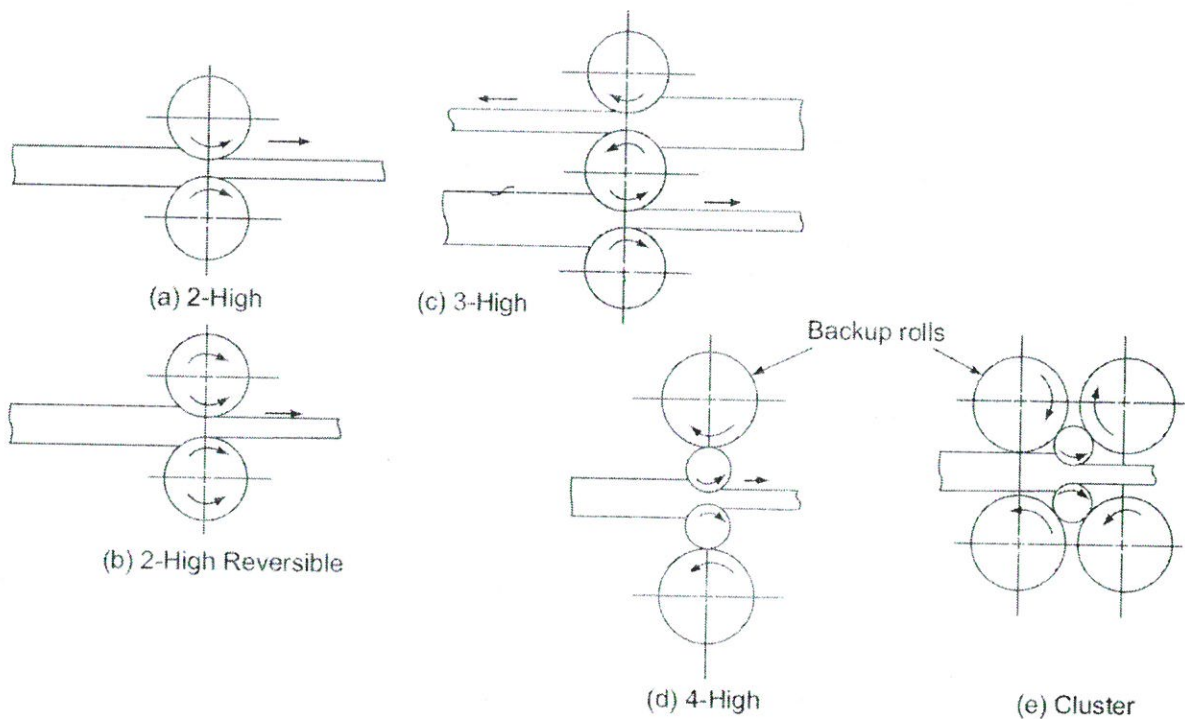
**The 2-high reversing rolling stand:** In this type the direction of roll rotation can be reversed. This type of stand is particularly useful in reducing the handling of the hot metal in between the rolling passes. When all the metal has reached the right side the direction of the rolls is reversed and the metal is allowed to enter into the next pass. These stands are more expensive compared to the nonreversible type because of the reversible drive needed.

**The 3-high rolling-stand:** This arrangement, is used for rolling of two continuous passes in a rolling sequence without reversing the drives. After all the metal has passed through the bottom roll set, the end of the metal is entered into the other set of the rolls

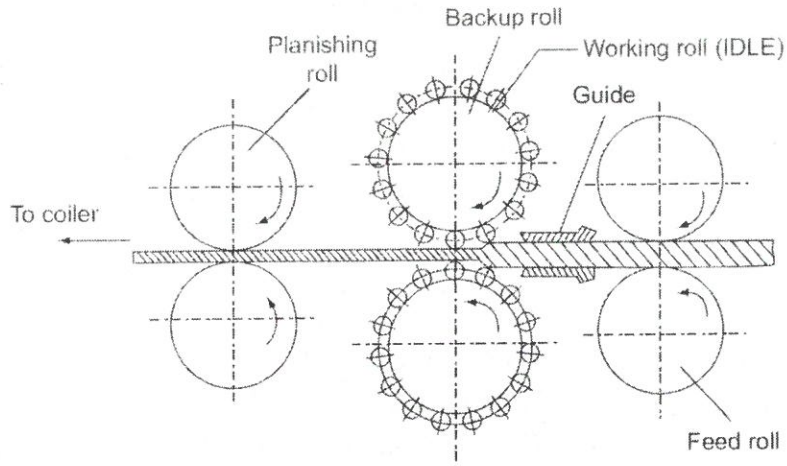
for the next pass. For this purpose a table-tilting arrangement is required to bring the metal to the level with the rolls.

**4-high rolling stand:** This is essentially a 2-high rolling mill, but with the small-sized rolls. The other two rolls are the backup rolls for providing the necessary rigidity to the small rolls.

A better backup can be provided to the small rolls with a **cluster arrangement** of rolls. For the rolling arrangements requiring large reduction, a number of free rotating wheels instead of a single small roll, are fixed to a large backup roll in the **planetary rolling-mill arrangement**. Since the final shape required cannot be obtained in a single pass, the rolling mills are generally arranged with rolls which have more than one pass machined into them so that, the material coming out of one pass is then to be fed back to the other pass by reversing the roll direction or by arranging the rolling mills in tandem. It is general practice to maintain tension in the strip between the stands in the interest of keeping it flat and also to control the thickness closely. This also helps in reducing the roll-separating force.



**FIG. 7.7** Rolling-stand arrangements



**FIG. 7.8** Planetary rolling mill

**Rolling Products:**

S.No.	Type of Product	Examples
1	<b>Flat Products</b>	<ul style="list-style-type: none"> <li>• <b>Plates</b> – Thick flat pieces used in shipbuilding, boilers, bridges</li> <li>• <b>Sheets</b> – Thin flat products used in automobile bodies, appliances</li> <li>• <b>Strips</b> – Narrow sheets used in packaging and electrical applications</li> <li>• <b>Foils</b> – Very thin sheets (e.g., aluminum foil)</li> </ul>
2	<b>Long Products</b>	<ul style="list-style-type: none"> <li>• <b>Bars</b> – Round, square, or hexagonal cross-sections</li> <li>• <b>Rods</b> – Used for wires and fasteners</li> </ul>
3	<b>Structural Sections</b>	<ul style="list-style-type: none"> <li>• <b>I-beams (I-sections)</b> – Used in construction</li> <li>• <b>T-sections</b></li> <li>• <b>Channels (C-sections)</b></li> <li>• <b>Angles (L-sections)</b></li> </ul>
4	<b>Rails</b>	<ul style="list-style-type: none"> <li>• Used for railway tracks</li> </ul>
5	<b>Pipes and Tubes</b>	<ul style="list-style-type: none"> <li>• Seamless or welded pipes for fluid transport and structural use</li> </ul>
6	<b>Rings and Wheels</b>	<ul style="list-style-type: none"> <li>• Produced by ring rolling processes</li> </ul>

## UNIT-IV

### 8. Explain the types of presses and press tools used in sheet metal forming. 10 M

Press machine is a metal forming machine tool. It is designed to form or cut metal by applying mechanical force or pressure. The presses are exclusively intended for mass production work.

#### Types of Presses:

- a) **Power source:** Manually Operated & Power Operated
  - **Manually Operated:** These presses are used to process thin sheet metal working operations where less pressure or force is required. These are operated by manual power. They are further classified as hand press, ball press or fly press.
  - **Power Operated:** Power presses are normally driven by mechanical mechanism or hydraulic system. Power source of these presses may be electric motor or engine.
- b) **Purpose of Use:** Shearing press, Seaming press, Straightening press, Punching press, Extruding press, Coining press, Forging press, Rolling press, Bending press
- c) **Mechanism used to transmit power to Ram:** Crank Press, Cam Driven Press, Eccentric Press, Knuckle Press, Toggle Press, Screw Press, Hydraulic Press, Rack and Pinion Press,
- d) **Method of transmission of power from motor to crankshaft:** Direct Drive Press, Flywheel Driven Presses, Single Geared Drive Presses, Double Geared Drive Presses
- e) **Number of crankshafts:** Single Crank, Double Crank
- f) **Number of drives:** Single Drive, Double Drive, Twine Drive, Quadruple Drive
- g) **Position of frame:** Vertical, Horizontal, Inclined, Inclined
- h) **Number of slides:** single action, double action or triple action press

**Dies:** A die is a specialized tool used in manufacturing industries to cut or shape the material mostly using a Press.

#### Classification of Dies:-

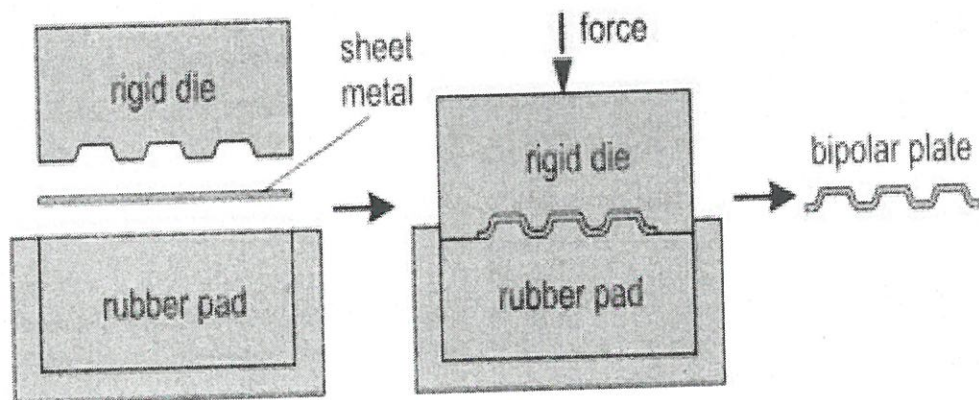
1. According to type of press operation: Cutting Dies and Forming Dies
  - a) **Cutting Dies:** These dies are used to cut the metal. They utilize the cutting or shearing action. The common cutting dies are: blanking dies, perforating dies, notching dies, trimming, shaving and nibbling dies.
  - b) **Forming Dies:** These dies change the appearance of the blank without removing any stock. These dies include bending, drawing and squeezing dies etc.
2. According to the method of operation: Simple dies, Compound dies, Combination dies, Progressive dies, Transfer dies and Multiple dies.
  - a) **Simple Die:** Only one operation is performed in one Stroke and at one Stage is called Simple Die. Single operation die is used when only blanking or piercing operation is to be done. If larger diameter blank is to be produced, this may result in a defect called dishing.
  - b) **Compound Die:** If more than one cutting stage called Compound Die. Production rate is high. The required force is high. Difficult manufacturing and design of the combination of die and punch. Not possible for more than 3 operations.

- c) **Combination Die:** The Combination die is that die where at one stage, multiple forming and cutting operation can be done by one stroke. Such examples of combination die are as follows: Combined deep drawing and blanking, Combined deep drawing and punching, Combined bending and blanking. Productivity is too high.
- d) **Progressive Die:** Multiple cutting operations can be performed in a stroke. Blanking will be the last operation. Productivity is the same as compound die. Force is reduced by staggering or shear. Manufacturing and design of the combination of die and punch are easier. Force balancing is difficult. Precision alignment and setup procedure is required. Much heavier than single die.
- e) **Transfer Die:** It is the same as that of progressive die, but the blanking will be the 1<sup>st</sup> operation. The production is more economical compared to progressive die. More versatile. In each stage, has to set the blank. They are often quite costly. More die protection sensors are required.
- f) **Multiple Die:** More dies attached parallelly to produce more components are known as Multiple Die. Productivity is High. In the existence of more than one dies, more products can be produced. It consumes less time. To produce 10 washers per stroke, 10 compound dies or 10 progressive dies are kept in parallel called as multiple dies.

OR

**9. Discuss rubber pad forming with advantages, limitations and applications. 10M**

In bending and embossing of sheet metal, the female die is replaced with a rubber pad. One of the die is made up of a flexible material (ex. Rubber) Or (poly-urethane material. Pressure in the rubber pad forming is usually in the order of 10Mpa. The blank is placed under the punch called male die. Then the ram (femal part) is moved so that punch touches the top surface of the work. Then the force is applied and gradually increased on the blank through the rubber pad. The blank holder ring is used to distribute uniform pressure throughout the blank. Thus the required shape is formed on the sheet metal between male and female parts.



**Advantages:**

1. Number of shapes can be formed on one rubber pad.
2. Thinning in metal blank does not take place.
3. Setting time of the tool is less.
4. Wrinkle free, shrink flanges can be produced.

**Limitations:**

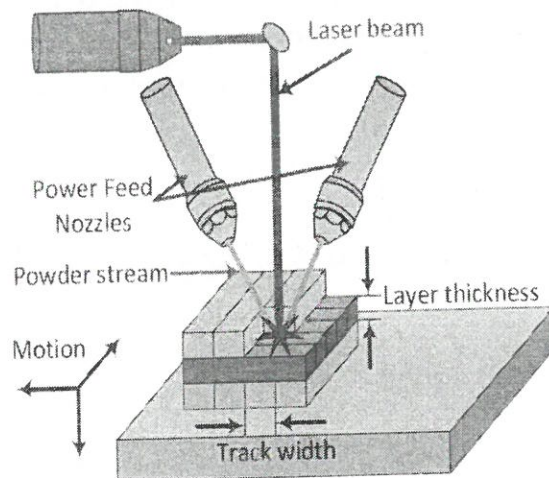
1. Rapid wearing of rubber Pads is a problem in this process.
2. Accurate sharp corners cannot be made by this process.
3. Loss of pressure between hydraulic fluid and rubber pad which is a major problem

**Applications:**

Flanged Cylinders. Rectangular cups, Spherical Domes. Unsymmetrical shaped components can be made

**UNIT-V****10. Explain Direct Energy Deposition (DED) process and discuss the applications of Additive Manufacturing.****10 M**

Directed Energy Deposition (DED) is a method for melting material as it is being deposited layer-by-layer. Material in wire or powder form is delivered along with the energy required to melt it. A number of material types can be processed this way, DED is almost exclusively applied to metals in both research and commercialized instantiations. DED presents unique advantages and disadvantages that make it particularly suited for repair and feature addition to an existing part. DED is gaining industrial interest because of its ability to create near-net-shape, large freeform structures more quickly and inexpensively than traditionally made near-net-shape castings and forgings. Directed Energy Deposition processes enable the creation of parts by melting material as it is being deposited. Although this basic approach can work for polymers, ceramics, and metal matrix composites, it is predominantly used for metal powders. Thus, this technology is often referred to as "metal deposition" technology. DED processes direct energy into a narrow, focused region to heat a substrate, melting the substrate and simultaneously melting material that is being deposited into the substrate's melt pool. Unlike Powder Bed Fusion (PBF) techniques, DED processes are *not* used to melt a material that is pre-laid in a powder bed but are used to *melt materials as they are being deposited*. DED processes use a focused heat source (typically a laser or electron beam) to melt the feedstock material and build up three-dimensional objects in a manner similar to the Material Extrusion (MEX) processes. Each pass of the DED head creates a track of solidified material, and adjacent lines of material make up layers. Complex three-dimensional geometry requires either support material or a multi-axis deposition head.



S.No.	Industry	Applications
1	Aerospace	<ul style="list-style-type: none"> <li>Fuel nozzles for jet engines (complex internal channels for efficient combustion)</li> <li>Lightweight brackets and lattice structures</li> <li>Rocket engine components</li> </ul>
2	Medical Field	<ul style="list-style-type: none"> <li>Patient-specific orthopedic implants (hip, knee replacements)</li> <li>Customized prosthetic limbs</li> <li>Dental aligners, crowns, and bridges</li> <li>Surgical guides for precise operations</li> </ul>
3	Automotive	<ul style="list-style-type: none"> <li>Topology-optimized engine parts</li> <li>Custom racing car components</li> <li>Rapid prototyping of car body parts</li> <li>3D printed tooling and molds</li> </ul>
4	Tooling and Manufacturing	<ul style="list-style-type: none"> <li>Injection mold inserts with conformal cooling channels</li> <li>Jigs and fixtures for assembly lines</li> <li>Spare parts produced on demand</li> </ul>
5	Electronics	<ul style="list-style-type: none"> <li>Custom enclosures for electronic devices</li> <li>Printed circuit structures (emerging)</li> <li>Cooling components with complex geometries</li> </ul>
6	Construction	<ul style="list-style-type: none"> <li>3D printed houses and walls</li> <li>Concrete structural elements</li> <li>Bridge components</li> </ul>
7	Consumer Products	<ul style="list-style-type: none"> <li>Customized footwear (shoe soles tailored to user)</li> <li>Jewelry with intricate designs</li> <li>Eyewear frames fitted to individuals</li> </ul>
8	Defense and Space	<ul style="list-style-type: none"> <li>On-site manufacturing of spare parts</li> <li>Drone components</li> </ul>

		<ul style="list-style-type: none"> <li>• Satellite parts with reduced weight</li> <li>• Printing of tissues and scaffolds</li> <li>• Research on organ fabrication</li> </ul>
9	Bio-printing	

OR

**11. Explain Selective Laser Sintering (SLS) process with a neat sketch. 10 M**

The process involves the spreading of the powder material over previous layers. There are different mechanisms to enable this, including a roller or a blade. A hopper or a reservoir below or beside the bed provides fresh material supply. Direct metal laser sintering (DMLS) is the same as SLS, but with the use of metals and not plastics. The process sinters the powder, layer by layer. Selective Heat Sintering differs from other processes by way of using a heated thermal print head to fuse powder material together. As before, layers are added with a roller in between fusion of layers. A platform lowers the model accordingly. A layer, typically 0.1mm thick of material is spread over the build platform. A laser fuses the first layer or first cross section of the model. A new layer of powder is spread across the previous layer using a roller. Further layers or cross sections are fused and added. The process repeats until the entire model is created. Loose, unfused powder remains in position but is removed during post processing.

