28.11 COLD WORKING

The working of metal below the recrystallisation temperature is known as cold working. In this working, the deformation of metals is brought by the process of slip of planes. Force required in cold working is also more as compared to hot working. During cold working, strength and hardness of metal is increased but stresses are set up. Further working is possible only after it

is annealed to remove the hardness and the residual stresses as otherwise large amount of force would be needed to work the metal further.

Advantages

- Good surface finish is obtained.
- Close dimensional tolerance can be obtained.
- The strength and hardness of metal are increased.
- It is also used to produce residual stress into certain metals in order to have improved fatigue life *e.g.* shot penning in case leaf springs.

Limitations

- Only small sized components can be easliy cold worked as greater forces are required for large sections.
- The grain structure is not refined.
- Tooling costs are high.
- Reduction in ductility.
- Work hardening takes place, which creates problems in further working.

28.14 COLD ROLLING

- If the rolling of metal is done below recrystallisation temperature (or at room temp.) that is known as cold rolling.
- Cold rolling is done to provide smooth surfaces and close tolerances. Sometimes hot rolled products are also cold rolled to improve the surface finish and dimensional tolerances. But before cold rolling pickling of hot rolled products are done. For this hot rolled products are immersed in a weak solution of dilute sulphuric acid to remove the scale and then washed with water, and then dried.
- In cold rolling, more forces are needed because rolling is done at room temperature. Roll forces also tend to flatten the rolls elastically, producing an effect much like the flattening of automobile tyres. This flattening of rolls is undesirable because this increases the surface area hence increases the roll force.
- The rolling mills are similar to that used in hot rolling (Refer article 28.5).
- Cold rolling is carried out with water soluble oils or low viscosity lubricants such as mineral oils, emulsions, paraffins and fatty oils etc. to reduce the force needed.
- Rolls made for cold rolling should not be used for hot rolling as they may crack because of high temperature.
- Smaller diameter rolls are used for cold rolling in order to reduce the required rolling force so backed roles are used to provide the strength to these rolls as in four high rolling mill and cluster mill (sendzimir mill) which are mostly used in cold rolling.

28.15 COLD FORGING

28.15.1 Cold Heading

It is used for the manufacture of bolts, rivets, screws and similar headed items. A ductile material is fed to the machine, where it is cut in standard length as shown in Fig. 28.15. It is then transferred to a holder ejector assembly. Heading punches then strike one or more blows on the exposed end to perform the upsetting. Sometimes heading is performed in more than one stages then the piece is transferred from one station to another sequentially. When the heading is completed, the ejector advances to expel the product.

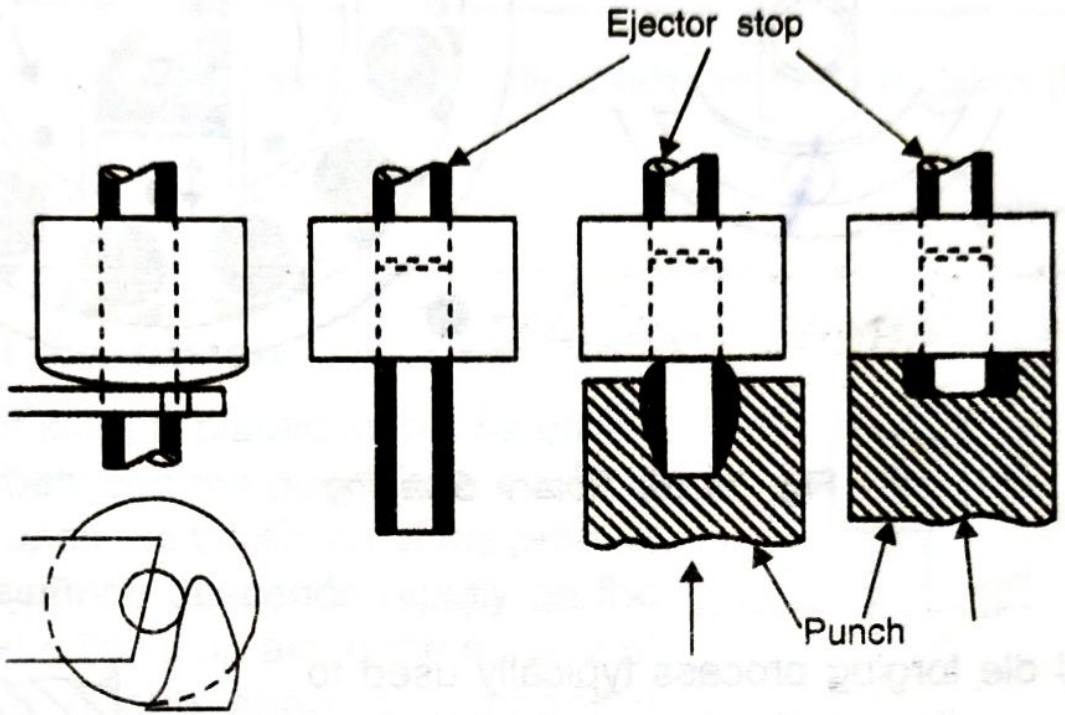


Fig. 28.15. *Cold Heading.*

28.16 COLD SPINNING

The process of cold spinning is similar to hot spinning except that the metal is worked at room temperature (Refer article 28.7). This method is used to produce kettles, cooking utensils, liquid containers and liquid reflectors etc. The parts that are produces by cold spinning have good surface finish but the force required is more as compared to hot spinning.

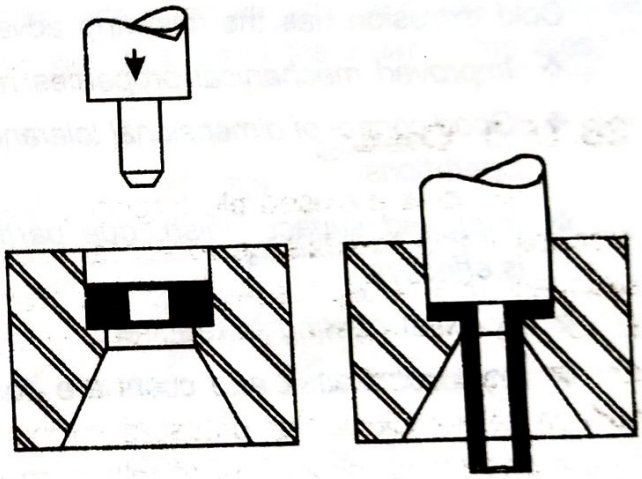
28.17 COLD EXTRUSION

The principal of cold extrusion is exactly similar to hot extrusion (Refer article 28.8). Mainly it is of two types :

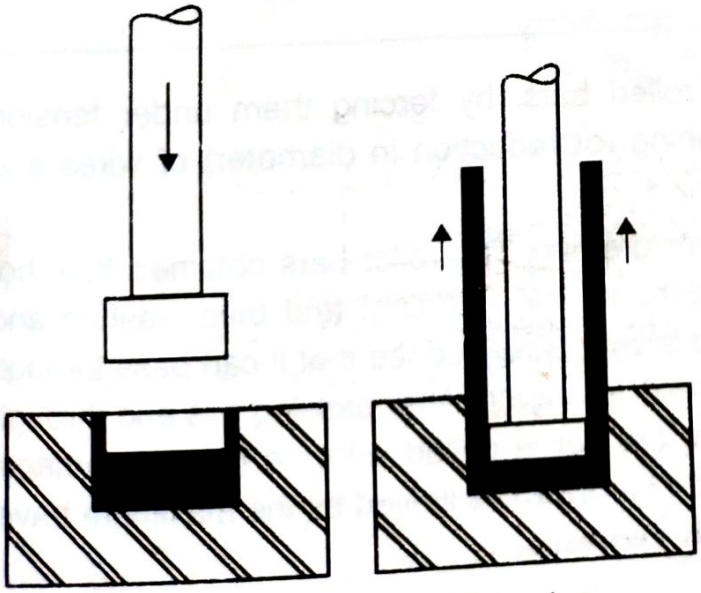
Impact Extrusion
Hydrostatic Extrusion

28.17.1 Impact Extrusion

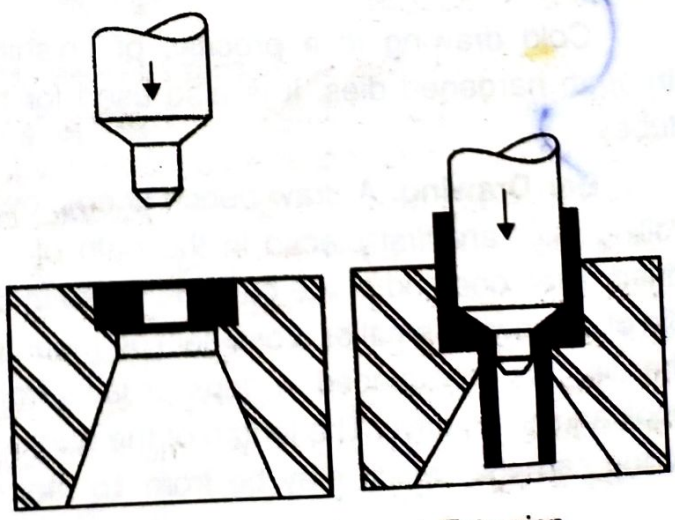
Metal (blank or slug) is placed in the die cavity. There is clearance between the punch and die. This clearance depends upon the thickness of the product required. When the punch descends rapidly on the blank (slug), the metal flows up along the surface of the punch forming a cup shaped component generally. This process is used for low strength metals such as lead, tin, zinc and aluminium to produce such items as collapsible tubes for toothpaste, various creams, medications, small cans for shielding electronic components, cans for food and beverages etc.



(*a*) Forward Impact Extrusion



(*b*) Reverse Impact Extrusion



(*c*) Combined Impact Extrusion

Fig. 28.19. *Impact Extrusion.*

28.17.2 Hydrostatic Extrusion

Hydrostatic extrusion is similar to direct extrusion and is carried out at room temperature. Here high pressure fluid (particularly castor oil, because it is a good lubricant and its viscosity is not influenced significantly by pressure) applies the force necessary to extrude the workpiece through a die. By using the fluid, the friction between the billet and chamber is eliminated and also it acts as a lubricant.

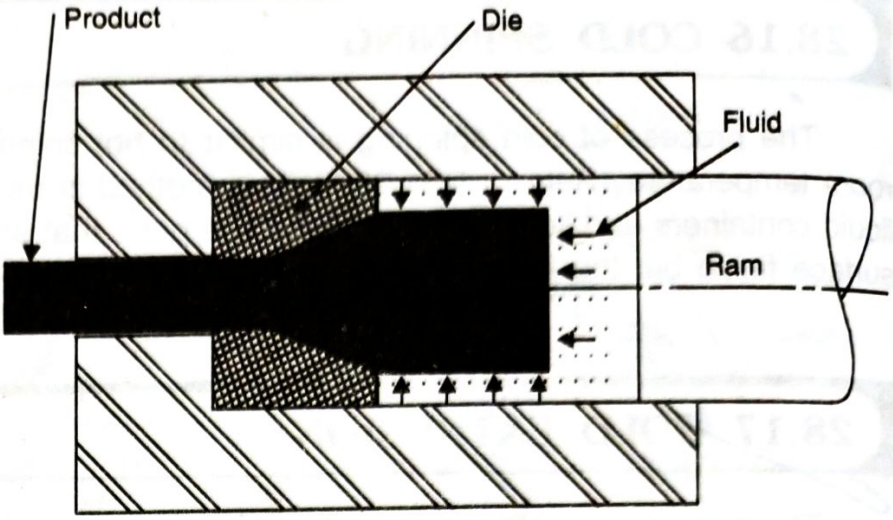


Fig. 28.20. *Hydrostatic Extrusion.*

Brittle materials can also be extruded successfully by this method because the hydrostatic pressure increases the ductility of the material. However hydrostatic extrusion has limited industrial applications because of the complex nature of tooling, experience needed with high pressures and long cycle times required.

Cold extrusion has the following advantages over hot extrusion :

- *Improved mechanical properties resulting from work-hardening.*
- *Good control of dimensional tolerances, reducing the need for further machining or finishing operations.*
- *Improved surface finish, due partly to lack of an oxide film, provided that lubrication is effective.*
- *No billet heating is required.*
- *Production rates and costs are competitive.*

28.18 COLD DRAWING

Cold drawing is a process of finishing hot rolled bars, by forcing them under tension through hardened dies. It is also used for the finishing (or reduction in diameter) of wires and tubes.

Bar Drawing. A draw bench is employed for bar drawing. The roller bars obtained from hot rolling mills are first placed in the bath of dilute sulphuric acid (pickling) and then washed and dried. Then one end of the bar is reduced in diameter or made pointed, so that it can pass through die of somewhat smaller cross-section mounted on the draw bench. After passing this end through the die, it is then placed in grips or jaws from where the bar is pulled with the help of carriage, hook and chain drive. The length of the bars, which can be drawn, is limited by the maximum travel of the carriage, which may be from 15 metres to 25 metres.

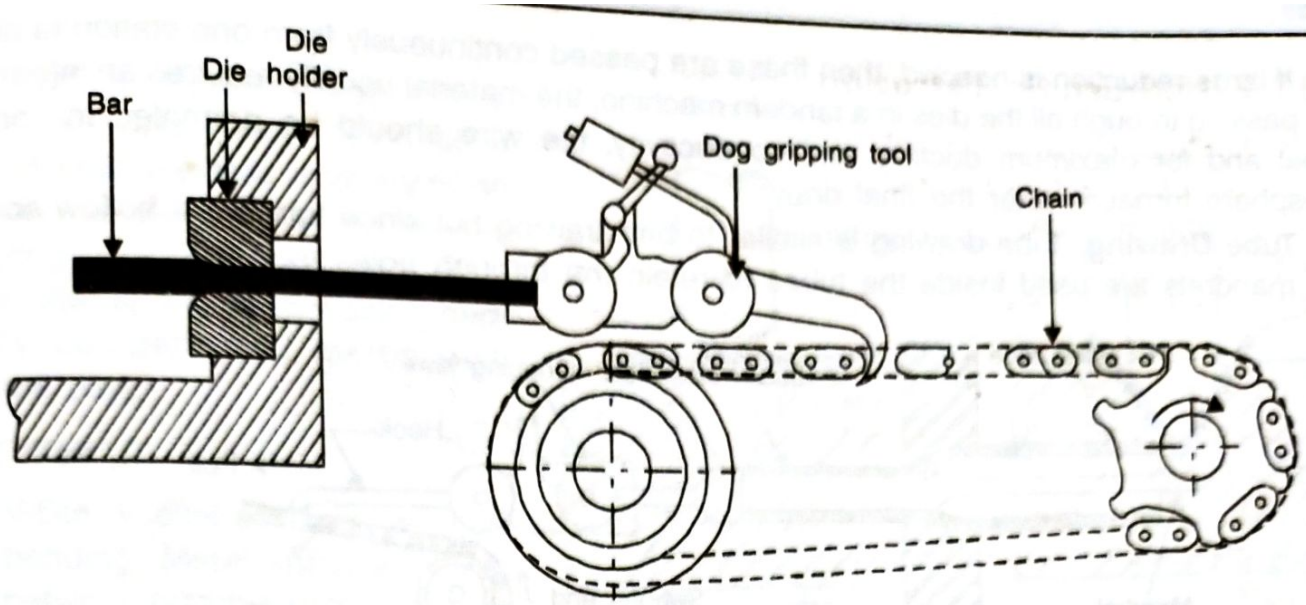


Fig. 28.21. *Bar Drawing.*

Wire Drawing. The wires obtained from the rolling mills are first pickled, washed and then dried. The end of the wire is then reduced in diameter (swaging) and passed through the die opening. Then this end is attached to the draw block, which pulls the wire. The contact region of the die is generally made up of wear resistant tungsten carbide or polycrystalline or manufactured diamond. Lubrication is also done to reduce the friction and to prevent the wear of the dies.

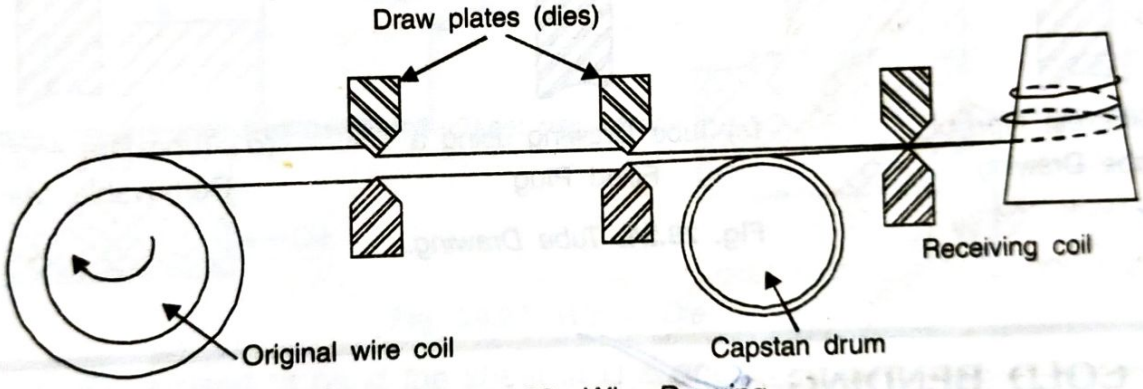


Fig. 28.22. *Wire Drawing.*

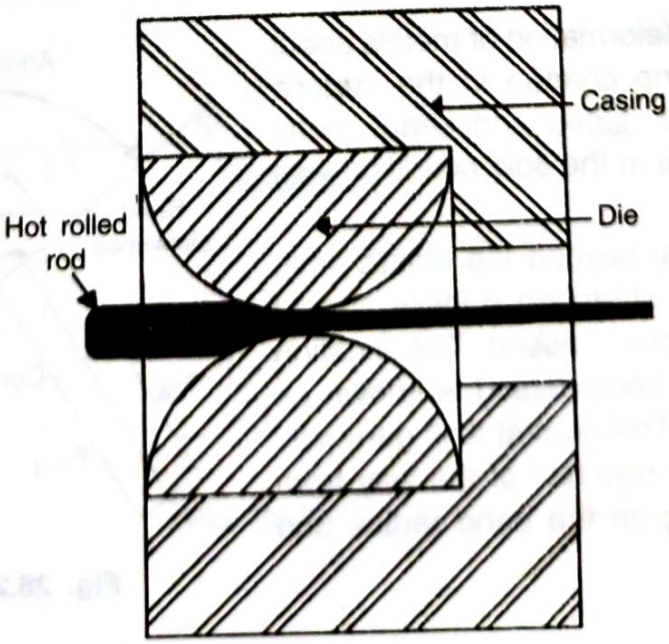


Fig. 28.23. *Wire Drawing Die.*

28.19 COLD BENDING

Bending is the plastic deformation of metals about a linear axis with little or no change in the surface area. The bars, rods, wires, tubes and sheet metal may be bent to many shapes in the cold condition with the help of dies.

When the metal is bent beyond the elastic limit, the metal on the outside is stretched (tensile stress) while that on the inside is compressed. The location that is neither stretched nor compressed is known as the neutral axis of the bend. The neutral axis generally locates between one third or one half of the way from the inner surface, depending on the bend radius and the material being bent.

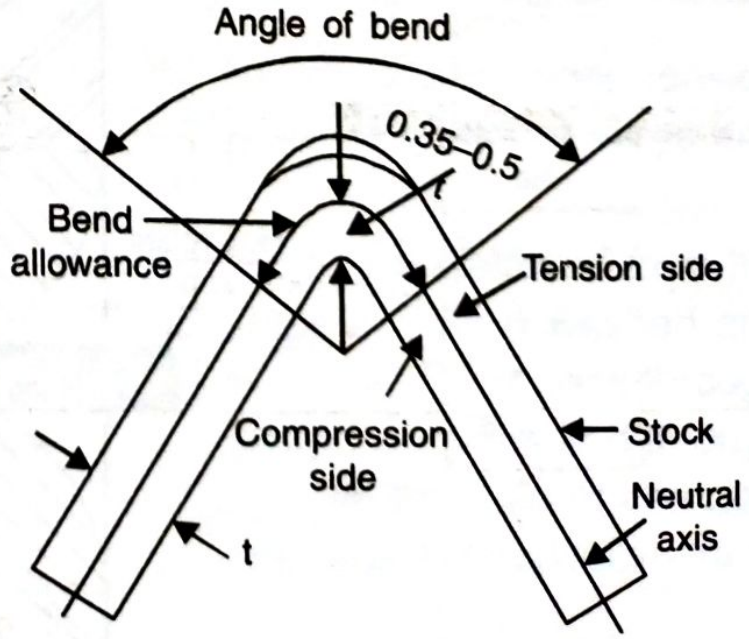


Fig. 28.25. *Cold Bending.*

Spring Back

Because all materials have a finite modulus of elasticity. Plastic deformation is followed by some elastic recovery when the load is removed. This recovery is called spring back. The final bend angle is smaller after spring back. Spring back is usually compensated for by over bending the part.

Bending dies

1. **V-Die.** V dies are used in angle bending. Metal sheet is placed between punch and die and then punch is pressed against the die and transferring the angle to the sheet.

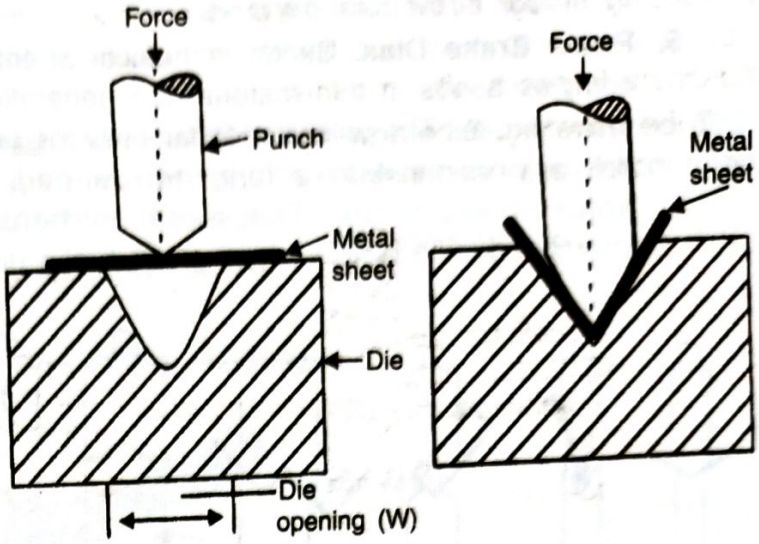


Fig. 28.26. *V Die.*

2. **Wiping Die.** Wiping dies are used for simple 90° bends.

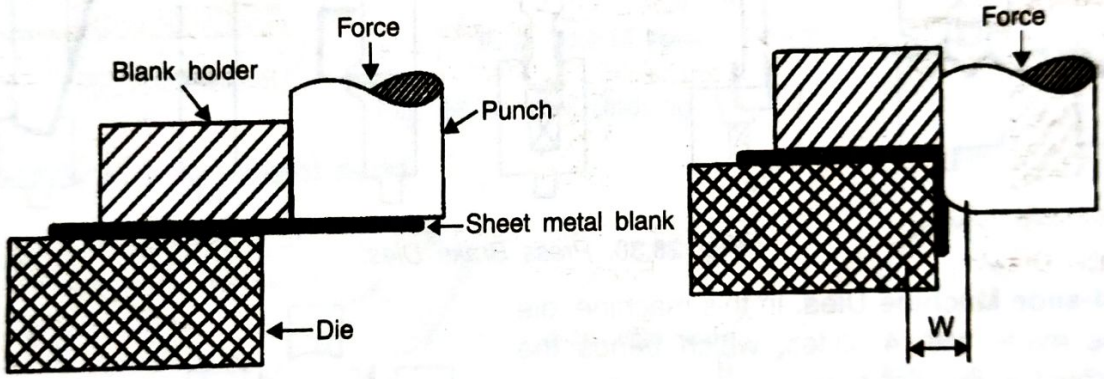


Fig. 28.27. *Wiping Die.*

3. **U-Die.** U-die is used to bend the sheet in U shape.

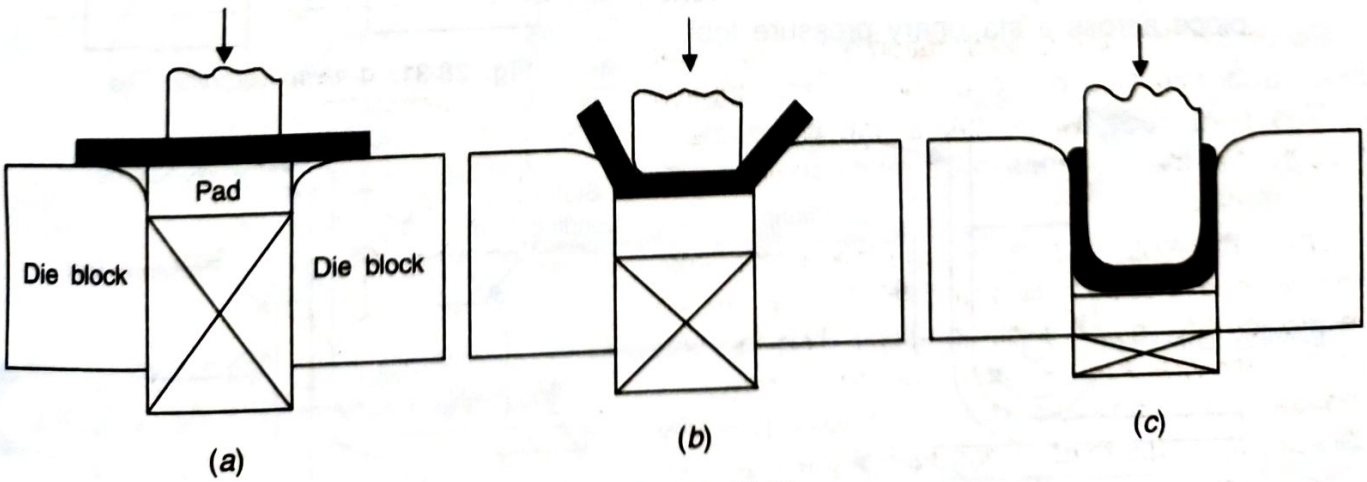


Fig. 28.28. *U Die.*

4. **Air Bending Die.** Air bending die produces the geometry by simple three point bending.
5. **Press Brake Dies.** Bends in heavier sheets or more complex bends in thin material are generally made on press brake. These are mechanically or hydraulically driven presses with a long narrow bed and short adjustable strokes. The metal is bent between interchangeable dies. Various press brake dies are :

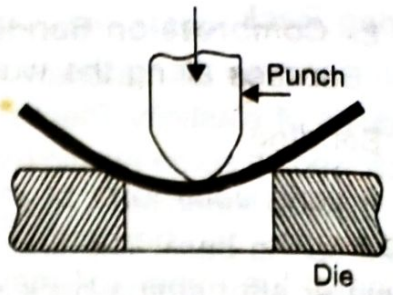


Fig. 28.29. *Air Bending Die.*

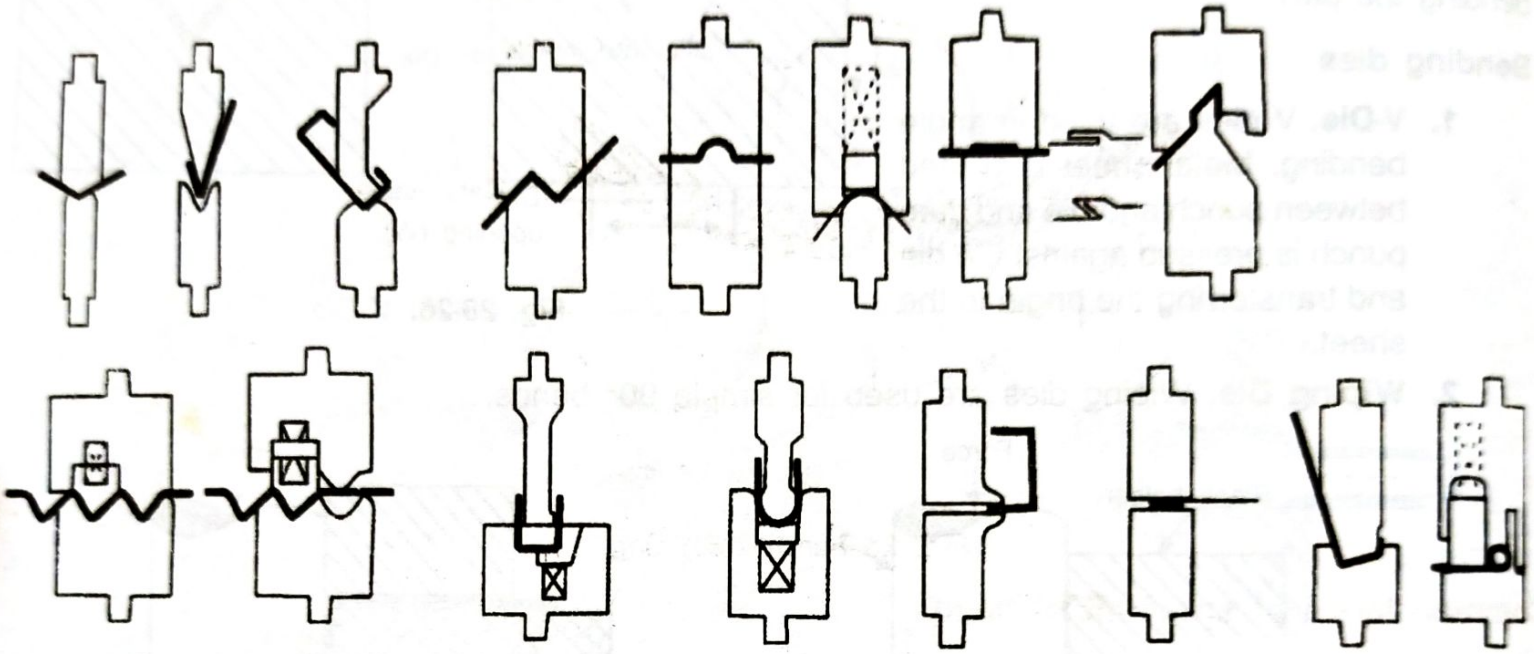


Fig. 28.30. *Press Brake Dies.*

6. **4-slide Machine Dies.** In this machine, die is made with 4 slides, which bends the sheet in circular form.
7. **Draw Bending Die.** The workpiece is clamped against a bending form and the entire assembly rotates to draw the work-piece across a stationary pressure tool.

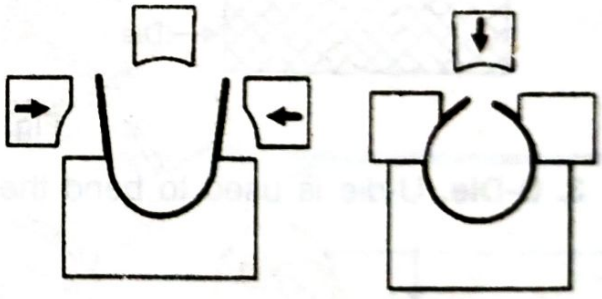


Fig. 28.31. *4-slide Machine Die.*

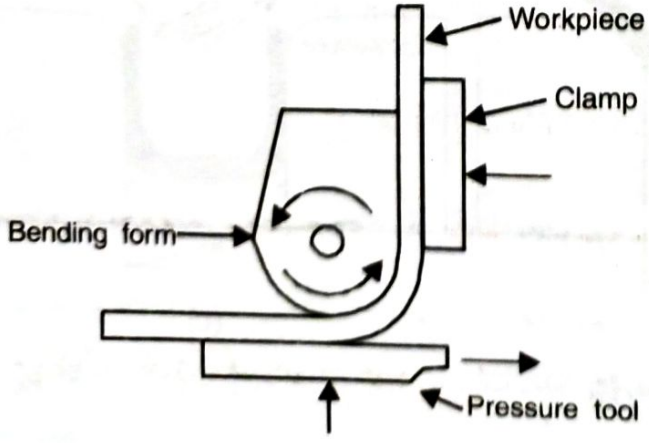


Fig. 28.32. *Draw Bending Die.*

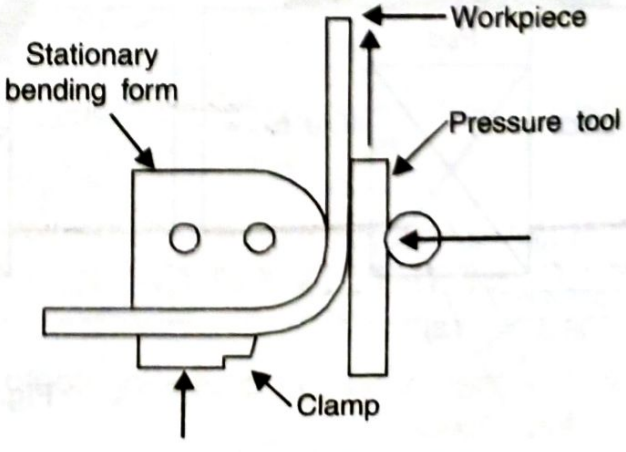


Fig. 28.33. *Compression Bending Die.*

8. **Compression Bending Die.** The bending form remains stationary and the pressure tool moves along the workpiece.

Roll Bending

A continuous form of three-point bending is called roll bending, where plates, sheets and rolled shapes can be bent to a desired curvature on forming rolls as shown in figure below. The position of the upper roll may be adjusted to control the degree of curvature.

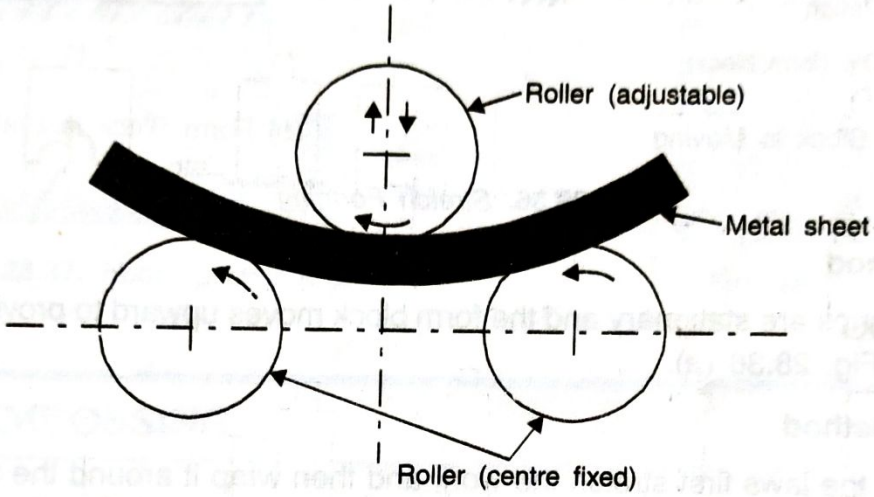


Fig. 28.34. *Roll Bending.*

Common kinds of sheet metal bend :

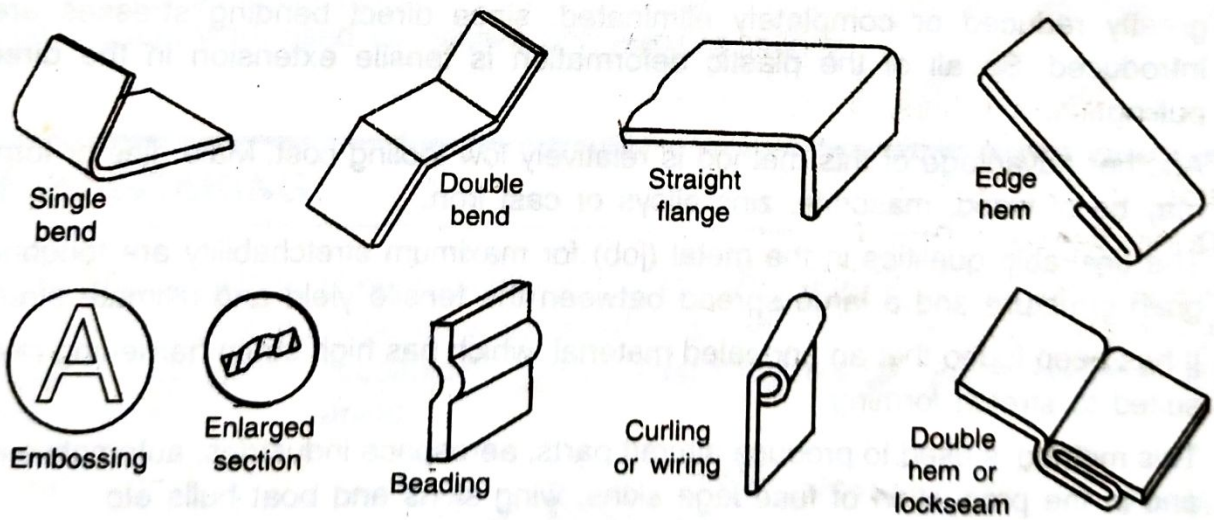


Fig. 28.35 *Common Kinds of Sheet Metal Bends.*