- The piercing machine consists of two tapered rolls, called as piercing rolls.
- During the process, a round heated billet or steel is passed between these rolls over a mandrel.
- Both the rolls rotate in the same direction and the billet is provided with a small drilled hole at one end and uniformly heated to about 1100°C.
- It is then pushed into the two piercing rolls which impart axial and rolling movement to the billet and force it over the mandrel.

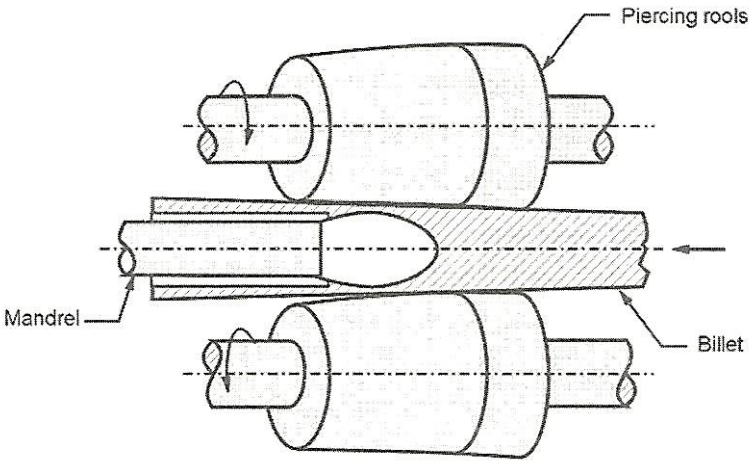


Fig. 3.38 : Tube piercing

- Hence, the combination of the revolving motion of billet and mandrel together with the axial advancement of the billet, provides a helical tubing effect on the material.
- For production of 12m length of upto 150 mm diameter rough tubing will take 10 to 30 seconds, whereas for tubing of larger diameter (upto 350 mm) second piercing operation is required.
- As above produced rough tubing is further subjected to rolling, reeling and sizing, to bring it to the correct shape and size for providing a find surface finish.
- Such tubes are produced in various metals and alloys such as steel alloys, aluminium brass, copper, etc.

3.16 Extrusion

- Extrusion is a compression process in which the work metal is forced to flow through a small opening which is called as die to produce a required cross-sectional shape.
- The Extrusion process is similar to squeezing toothpaste or cream from a tube.
- Almost any solid or hollow cross-section may be produced by extrusion process.
- As the geometry of the die remains same during the operation, extruded parts have the same cross-section.

- During the process, a heated cylindrical billet is placed in the container and it is forced out through a steel die with the help of a ram or plunger.
- The products made by extrusion process are tubes, rods, railing for sliding doors, structural and architectural shapes, door and window frames, etc.
- Extrusion process is suitable for the non-ferrous alloys, steel alloys, non-ferrous metals, stainless steel, etc.
- Extrusion process is carried out on horizontal hydraulic press machines which are rated from 250 to 5500 tones in capacity.

Extrusion process is classified as follows:

1. According to physical configuration

a) Direct (Forward) extrusion

b) Indirect (Backward) extrusion

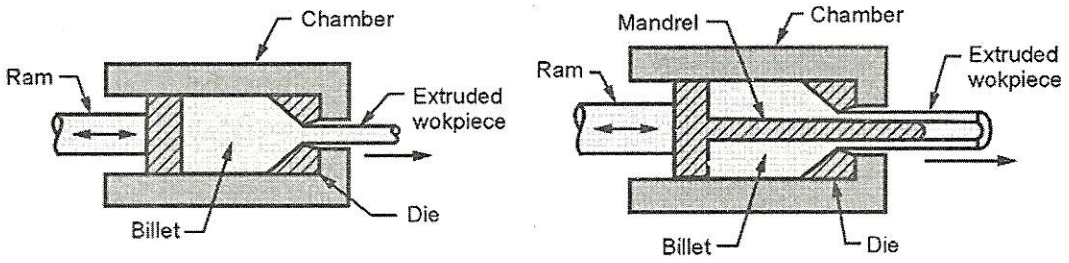
2. According to working temperature

a) Hot extrusion

b) Cold extrusion

3.16.1 Direct Extrusion

- Direct or forward hot extrusion is most widely used and the maximum numbers of extruded parts are produced by this method.
- Figure 3.39 shows the direct extrusion process in which the raw material is a billet.



a) To produce solid components b) To produce hollow components

Fig. 3.39 : Direct extrusion

- A billet is heated to its forging temperature and fed into the machine chamber.
- Pressure is applied to the billet with the help of ram or plunger which forces the material through the die.
- The length of extruded part will depend on the billet size and cross-section of the die.
- The extruded part is then cut to the required length.
- As the ram approaches the die, a small portion of billet remains which cannot be forced through the die opening. This extra portion is known as butt which is separated from the product at the end.

- When the billet is forced to flow through the die opening, there is friction between the workpiece and chamber walls. This friction is overcome by providing additional ram force. This is the major problem with this process.
- To overcome this problem oxide layer is provided on the billet or dummy block is used between the ram and billet.
- Direct extrusion process is also used to produce hollow or semi-hollow sections.
- To produce hollow sections, by direct extrusion process, a mandrel is used. Refer figure 3.39 (b).
- When the billet is compressed, the material is forced to flow through the gap between the mandrel and die opening. This result in tubular cross-section.

3.16.2 Indirect Extrusion

- Indirect extrusion is also called as backward extrusion.
- In this type, the ram or plunger used is hollow and as it presses the billet against the backwall of the closed chamber, the metal is extruded back into the plunger, Refer figure 3.40.

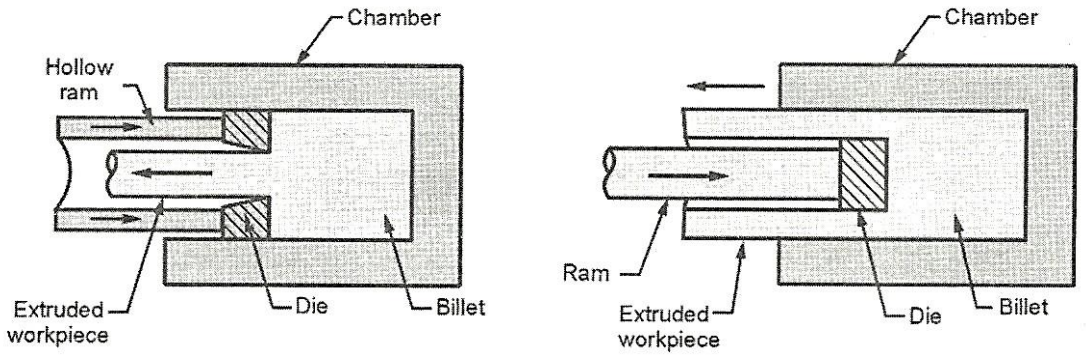


Fig. 3.40 : Indirect or backward or reverse extrusion

- It involves no friction between the metal billet and the chamber because the billet does not move inside the chamber.
- As compared to direct extrusion, less total force is required in this method.
- But the equipment used is mechanically complicated in order to support the passage of the extruded shape through the centre of the hollow ram.
- Indirect extrusion is also used to solid as well as hollow components. For producing solid parts, ram is hollow whereas for producing hollow parts ram is solid. Refer figure 3.40 (b).

3.16.3 Comparison between Direct and Indirect Extrusion

Sl. No	Direct / Forward Extrusion	Indirect / Backward Extrusion
1.	During the process a solid ram is used.	A hollow ram is used for the process.
2.	Flow of metal is in the same direction as the movement of the ram.	Flow of metal is in the opposite direction as the movement of the ram.
3.	A dummy block is used during the operation.	Dummy block may or may not be used. Die plays a part of the dummy block.
4.	Die is mounted on the cylinder or container.	Die is mounted over the bore of the ram.
5.	Because of relative motion between the heated metal billet and the cylinder walls, friction problem arises.	As the billet in the container remains stationary, there is no friction.
6.	Large amount of force is required to move the billet in the cylinder.	As the billet is stationary, process does not require large amount of force.
7.	Handling of extruded metal is very easy.	Handling of extruded metal is difficult.

COLD WORKING PROCESSES

3.17 COLD ROLLING:

Cold rolling is use for producing bars of all shapes, rods, sheets and strips. Cold rolling is generally employed for providing a smooth and bright surface finish to the previously hot rolled steel. It is used to finish the hot rolled components, to close tolerances and improve their hardness and toughness. Before cold rolling, the hot rolled articles are cleaned through pickling and other operations. The same types of rolling mills, as in hot rolling, are used for cold rolling. The part being rolled is generally annealed and pickled before the final pass is made, so as to bring it to accurate size and obtain a perfectly clean surface.

3.17.1 Comparison between Hot Rolling and Cold Rolling

Sl. No	Hot rolling	Cold rolling
1.	Metal is fed into the rolls after being heated above recrystallisation temperature.	Metal is fed into the rolls when its temperature is below recrystallisation temperature.

3.22 Cold Extrusion (Impact Extrusion)

- The most common cold extrusion process is impact extrusion.
- Various daily use products such as tubes for shaving creams, tooth paste and paints, condenser cans and such other thin walled products are impact extruded.
- The raw material is in slug form which have been turned from a bar or punched from a strip.
- By using punch and dies, the operation is performed.
- The slug is placed in the die and struck from top by the punch operating at high pressure and speed. Refer figure 3.49.

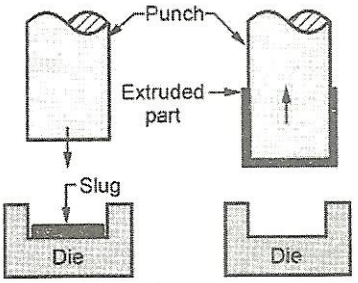


Fig. 3.49 : Principle of impact extrusion

- The metal flows up along the surface of the punch, forming a cup shaped component.
- When the punch moves up, to separate the component from the punch compressed air is used.
- At the same time, a fresh slug is fed into the die.
- The rate of production is fairly high i.e.60 components per minute.
- This process is used only for soft and ductile materials such as lead, tin, aluminium, zinc and some of their alloys.
- The main advantages of this process are its speed, product uniformity and no wastage.

3.22.1 Hydrostatic Extrusion

- In this type of extrusion process, the billet is surrounded by a working fluid which is pressurised by the ram to apply the extrusion force.
- In this process, hydraulic fluid remains between the billet and the chamber walls hence eliminating the contact between them. Also, it avoids the friction between the metal billet and the walls of the chamber.
- Figure 3.50 shows the working principle of hydrostatic extrusion.
- Due to absence of wall friction, extrusion of very long billets or even wires and large reduction can be taken.

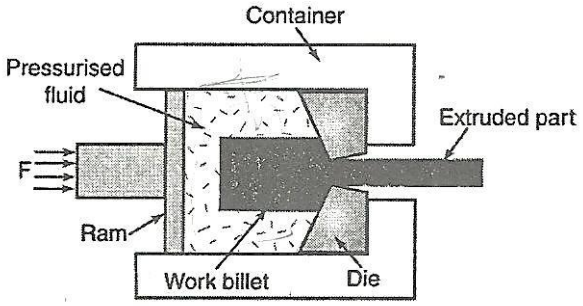


Figure 3.50 Hydrostatic Extrusion

- During the process, the ram does not directly act on the billet, instead of that, it acts on the hydraulic fluid which forces the billet through the die and produces the extrusion.
- The materials which cannot be extruded successfully by conventional methods can be extruded by this process.

Advantages

- The force required for hydrostatic extrusion is less as there is no friction between billet and container.
- Large billets and large cross-section can be extruded.
- This type of extrusion assures an even flow of material.
- High pressure in the operation improves ductility of metal.
- It allows for faster speeds, higher reduction ratios and lower billet temperatures.

Disadvantages

The billets must be prepared before use for extrusion. The entire billet must be machined to remove surface defects. It is difficult to handle fluid under high pressure.

3.22.2 Comparison between Hot and Cold Extrusion

Sl. No	Hot extrusion	Cold extrusion
1.	It involves working a metal above its recrystallization temperature.	It involves working a metal above its recrystallization temperature.
2.	It allows large amount of shape change.	It does not allow large amount of shape change due to stain hardening.
3.	It improves physical and mechanical properties of metal being extruded.	It does not improves physical and mechanical properties of metal being extruded.
4.	It is required to heat the workpiece before operation.	It is not required to heat the workpiece.

5.	Lower production rate than cold extrusion.	Higher production rate.
6.	Oxidation may takes place on the surface of workpeice.	There is no oxidation or scale formation on the surface of workpeice.
7.	Poor surface finish and accuracy of the part due to friction, wear and oxidation.	Higher accuracy and better surface finish.
8.	Hot extrusion is suitable for larger parts with more complex geometry.	Cold extrusion is suitable for smaller parts, less complex shapes and more workable metals.

3.23 Metal Forming Processes and Applications

Following table gives different metal forming processes along with their applications:

Sl. No	Metal forming process	Applications
1.	Rolling	It is used to produce articles like structural sections, sheets, rails, plates and bars.
2.	Extrusion	It is used to manufacture rods, tubes, various circular, square, rectangular, hexagonal rods and tubes both in solid and hollow form. Also for producing I,Z,T and sections.
3.	Drawing	It is used to produce bright drawn bards, solid drawn tubes and for the production of wires. Also for producing thicker walled seamless tubes and cylinders.
4.	Forging	Forged components are used in small tools, rail-road equipments and automobile and aviation industries. Also for production of rivets, screws, nuts, axles, leaf springs, gear blanks, engine housings, valve bodies, missile components, etc.