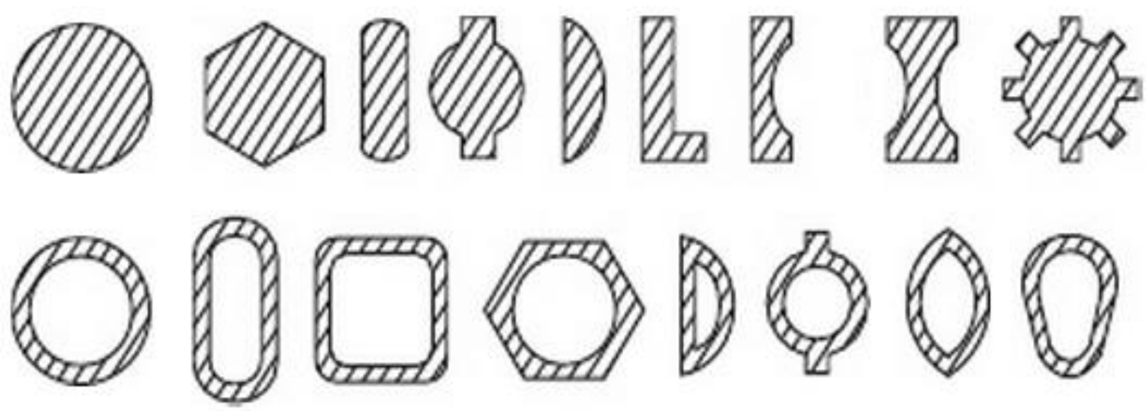
Extrusion, Wire Drawing, Tube Drawing and Making

Extrusion is a process in which the metal is subjected to plastic flow by enclosing the metal in a closed chamber in which the only opening provided is through a die. The material is usually treated so that it can undergo plastic deformation at a sufficiently rapid rate and may be squeezed out of the hole in the die. In the process the metal assumes the opening provided in the die and comes out as a long strip with the same cross-section as the die-opening. Incidentally, the metal strip produced will have a longitudinal grain flow. The process of extrusion is most commonly used for the manufacture of solid and hollow sections of nonferrous metals and alloys. e.g. aluminum, aluminum-magnesium alloys, magnesium and its alloys, copper, brass and bronze etc. However, some steel products are also made by extrusion.

The stock or the material to be extruded is in the shape of cast ingots or billets. Extrusion maybe done hot or cold. The cross-sections of extruded products vary widely. Some of these sections are shown in Fig.



Some advantages of extrusion process are described below:

(i) The complexity and range of parts which can be produced by extrusion process is very large. Dies are relative simple and easy to make.

(ii) The extrusion process is complete in one pass only. This is not so in case of rolling, amount of reduction in extrusion is very large indeed. Extrusion process can be easily automated.

(iii)Large diameter, hollow products, thin walled tubes etc. are easily produced by extrusion process.

(iv)Good surface finish and excellent dimensional and geometrical accuracy is the hall mark of extruded products. This cannot be matched by rolling.

EXTRUSION PROCESSES

Extrusion processes can be classified as followed:

(A) **Hot Extrusion**

(i) Forward or Direct extrusion.

(ii) Backward or Indirect extrusion.

(B) **Cold Extrusion**

(i) Hooker extrusion.

(ii) Hydrostatic extrusion.

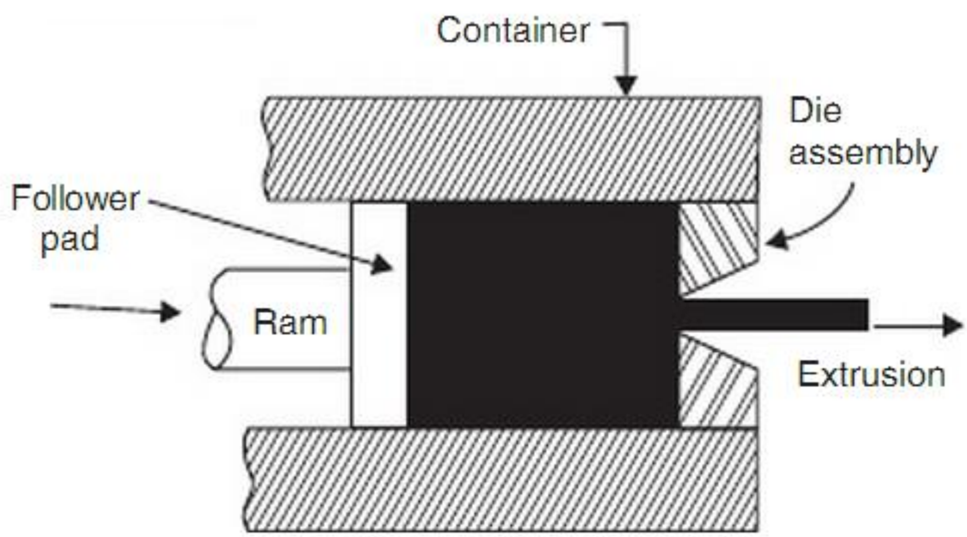
(iii) Impact extrusion.

(iv) Cold extrusion forging.

A. **Hot Extrusion Processes**

(i) **Forward or direct extrusion process:**

In this process, the material to be extruded is in the form of a block. It is heated to requisite temperature and then it is transferred inside a chamber as shown in Fig. In the front portion of the chamber, a die with an opening in the shape of the cross-section of the extruded product, is fitted. The block of material is pressed from behind by means of a ram and a follower pad. Since the chamber is closed on all sides, the heated material is forced to squeeze through the die-opening in the form of a long strip of the required cross-section.



The process looks simple but the friction between the material and the chamber walls must be overcome by suitable lubrication.

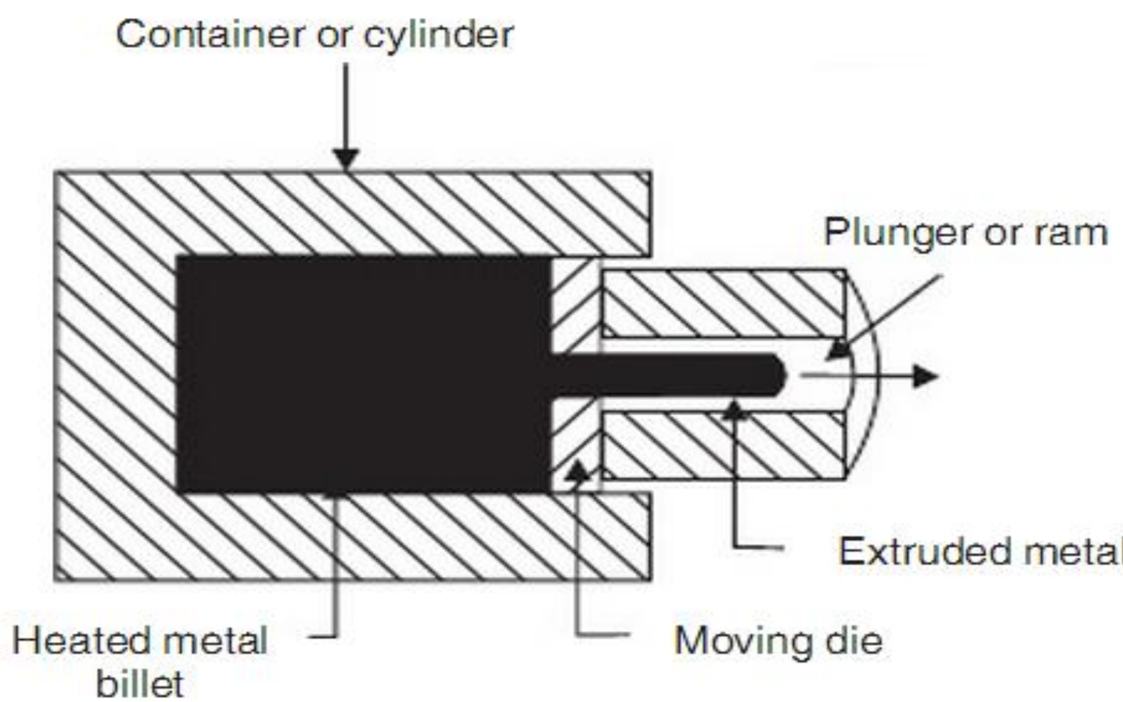
When extruding steel products, the high temperature to which the steel has to be heated makes it difficult to find a suitable lubricant. The problem is solved by using molten glass as a lubricant. When lower temperatures are used, a mixture of oil and graphite is used as a lubricant.

At the end of the extrusion process, a small piece of metal is left behind in the chamber which cannot be extruded. This piece is called butt—end scrap and is thrown away. To manufacture a tubular rod, a mandrel of diameter equal to that of tube—bore is attached to the ram. This mandrel passes centrally through the die when the material is extruded. The outside diameter of the tube produced will be determined by the hole in the die and the bore of tube will be equal to mandrel diameter. The extrusion process will then called “tubular extrusion”.

B. **Backward or indirect extrusion:**

This process is depicted in Fig. As shown, the block of heated metal is inserted into the container/chamber. It is confined on all sides by the container walls except in front; where a ram with the die presses upon the material. As the ram presses backwards, the material has to flow forwards through the opening in the die. The ram is made hollow so that the bar of extruded metal may pass through it unhindered.

This process is called backward extrusion process as the flow of material is in a direction opposite to the movement of the ram. In the forward extrusion process the flow of material and ram movement were both in the same direction.



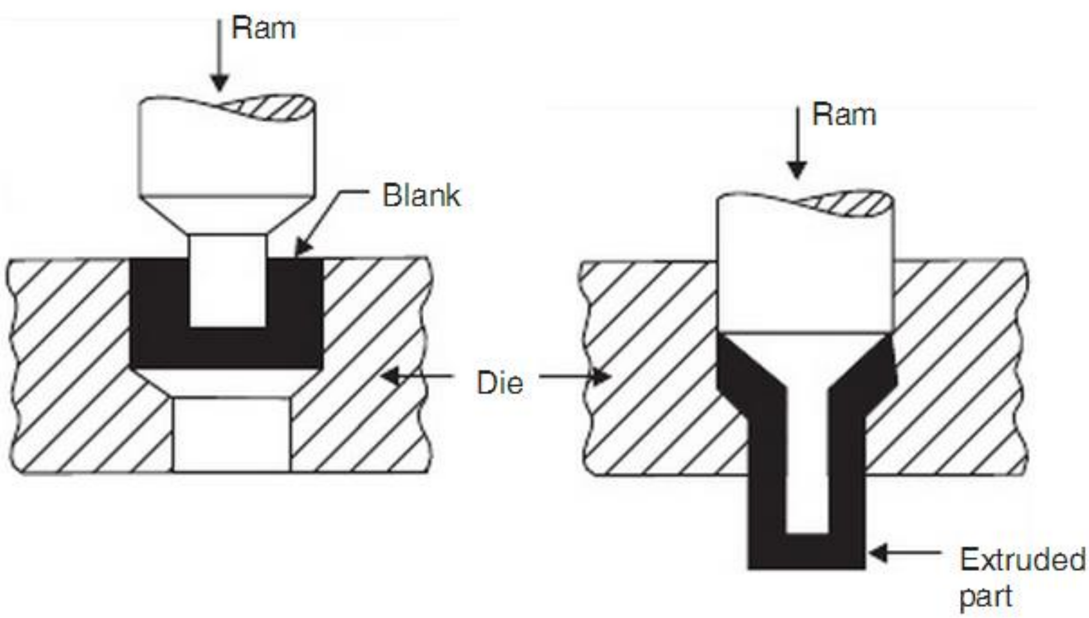
The following table compares the forwards (direct) and backwards (indirect extrusion process):

Forward or direct extrusion	*Backward or indirect extrusion*
1. Simple, but the material must slide along the chamber wall.	1. In this case, material does not move but die moves.
2. High friction forces must be overcome.	2. Low friction forces are generated as the mass of material does not move.
3. High extrusion forces required but mechanically simple and uncomplicated.	3. 25–30% less extruding force required as compared to direct extrusion. But hollow ram required limited application.
4. High scrap or material waste—18–20% on an average.	4. Low scrap or material waste only 5–6% of billet weight.

C. **Cold Extrusion Processes**

(i) Hooker extrusion process:

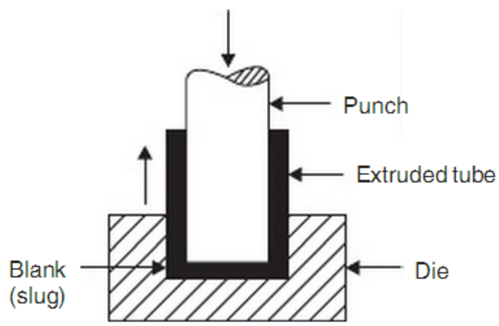
This process is also known as extrusion down method. It is used for producing small thin walled seamless tubes of aluminum and copper. This is done in two stages. In the first stage the blank is converted into a cup shaped piece. In the second stage, the walls of the cup one thinned and it is elongated. The process can be understood by referring to Fig. 4.4. This process is a direct extrusion process.



(ii) Hydrostatic extrusion:

This is a direct extrusion process. But the pressure is applied to the metal blank on all sides through a fluid medium. The fluids commonly used are glycerin, ethyl glycol, mineral oils, castor oil mixed with alcohol etc. Very high pressures are used – 1000 to 3000 MPa. Relatively brittle materials can also be successfully extruded by this method.

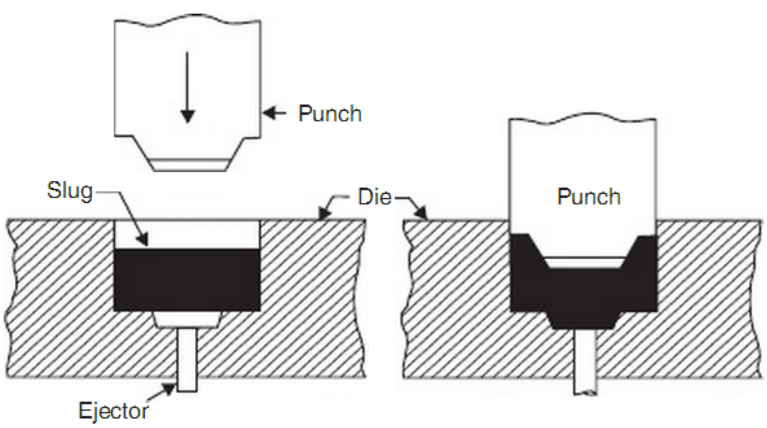
(*iii*) **Impact extrusion:** In this process, which is shown in Fig. 4.5 the punch descends with high velocity and strikes in the centre of the blank which is placed in a die. The material deforms and fills up the annular space between the die and the punch flowing upwards. Before the use of laminated plastic for manufacturing tooth paste, shaving cream tubes etc., these collapsible tubes containing paste were and are still made by this process. This process is actually a backward extrusion process.



(*iv*) **Cold extrusion forging:** This process is depicted in Fig. 4.6. This is generally similar to the impact extrusion process; but there are two differences:

1. In this process the punch descends slowly, and

2. The height of extruded product is short and the side walls are much thicker than the thin walled products produced by the impact extrusion process. In essence, this process is one of backward extrusion.



Comparison between Hot and Cold Extrusion

This is given in the following table:

Table 4.2

Cold extrusion	*Hot extrusion*
1. Better surface finish and lack of oxide layers.	1. Surface is coated with oxide layers. Surface finish not comparable with cold extrusion.
2. Good control of dimensional tolerance—no machining or very little machining required.	2. Dimensional control not comparable with cold extrusion products.
3. High production rates at low cost. Fit for individual component production.	3. High production rates but process fit for bulk material, not individual components.
4. Improved mechanical properties due to strain hardening.	4. Since processing is done hot, recrystallisation takes place.
5. Tooling subjected to high stresses.	5. Tooling subjected to high stresses as well as to high temperature. Tooling stresses are however lower than for cold extrusion.
6. Lubrication is crucial.	6. Lubrication is crucial.

MACHINES FOR EXTRUSION

Both hydraulic and mechanical presses of horizontal and vertical configuration are used for extrusion. They should be capable of exerting high forces and their rams should have long strokes. To reduce friction between metal and extrusion chamber walls, lubricants are used. The dies and punches are made from good quality alloy steels which are known as hot and cold die steels.

Extrusion speed is of the order of 0.5 m/sec for light alloys and 4.5 m/sec for copper alloys.

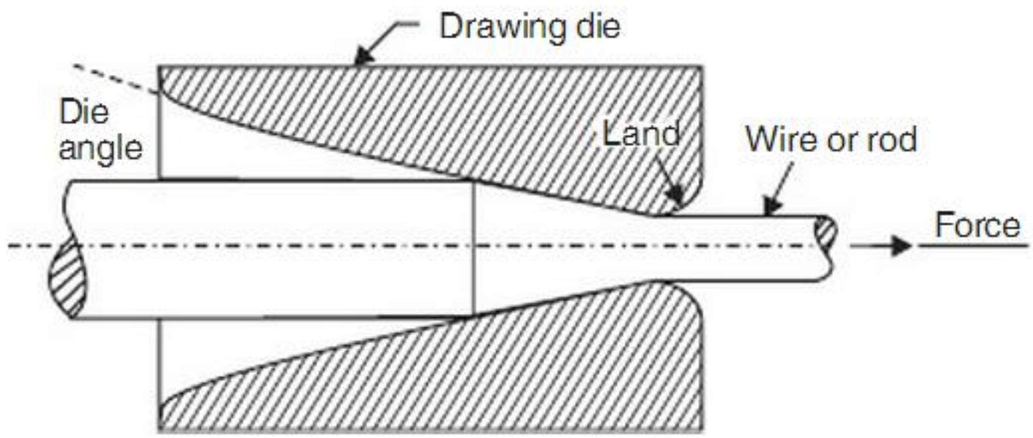
EXTRUSION DEFECTS

Sometimes the surface of extruded metal/products develop surface cracks. This is due to heat generated in the extrusion process. These cracks are specially associated with aluminium, magnesium and zinc alloy extrusions.

The extruded product can develop internal cracks also. These are variously known as centre burst, centre cracking and arrowhead fracture. The tendency for centre cracking increases with increasing die angles and material impurities.

WIRE DRAWING:

Wire drawing is a simple process. In this process, rods made of steel or nonferrous metals and alloys are pulled through conical dies having a hole in the center. The included angle of the cone is kept between 8 to 24°. As the material is pulled through the cone, it undergoes plastic deformation and it gradually undergoes a reduction in its diameter. At the same time, the length is increased proportionately. The process is illustrated in Fig.



The dies tend to wear out fast due to continuous rubbing of metal being pulled through it. Hence they are made of very hard material like alloysteel, tungsten carbide or even diamond. In one pass, the reduction in cross-sectional area achieved is about 25–30%. Hence in a wire drawing plant, the wire has to pass thorugh a number of dies of progressively reducing diameter to achieve the required reduction in diameter. However as the wire passes through dies and undergoes plastic deformation, it gets strain hardened. Its strength increases and capacity to further undergo plastic deformation decreases. Therefore during the entire run of the wire, from time to time, it has to be heated (and cooled) to remove the effect of work-hardening. This process is called "in process annealing". The aim is to make the material soft and ductile again so that the process of drawing may be smoothly carried out.

The metal rods to be drawn into wires must be absolutely clean. If necessary, they are pickled in an acid bath to dissolve the oxide layer present on the surface. Its front end is then tapered down so that it may pass through the hole in the die which is firmly held in the wire drawing machine. The wire is drawn by means of a number of power driven spools or rotating drums.

During wire drawing, a great deal of heat is generated due to friction between the wire rod and the die. To reduce friction, dry soap or a synthetic lubricant is used. But despite reducing friction, the dies and drums may have to be water cooled.

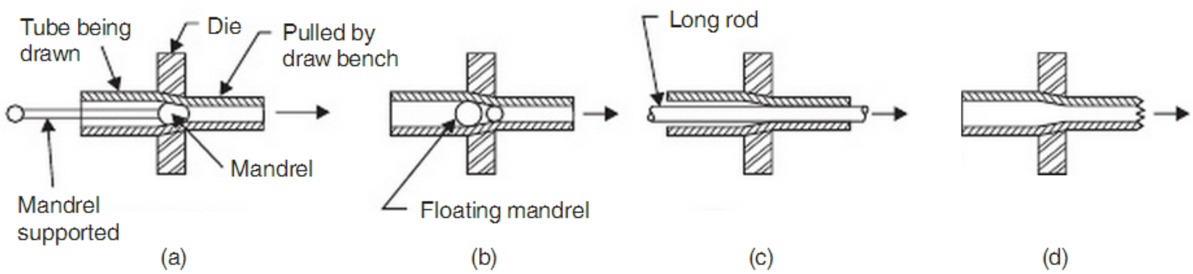
The preferred material for dies is tungsten carbide but for drawing fine wire, use of ruby or diamond dies is preferred.

The drawing machines can be arranged in tandem so that the wire drawn by the previous die may be collected (in coil form) in sufficient quantity before being fed into the next die for further reduction in diameter. As the diameter becomes smaller, the linear speed of wire drawing is increased.

The major variable in wire drawing process are (1) Reduction ratio (2) Die angle and (3) Friction. Improper control of these parameters will cause defects in the drawn material. Defects include centre cracking (as in extrusion and for the same reasons) and formation of longitudinal scratches or folds in the material.

TUBE DRAWING

The 'drawing' process can also be used for tube drawing. Tube drawing does not mean manufacturing a tube from solid raw material. It means lengthening a tube reducing its diameter. Various arrangements used for tube drawing are shown in Fig. 4.8.



- Method (*a*) is most commonly used.
- Method (*b*) uses a floating mandrel which adjusts itself to the correct position because of its stepped contour.

The method shown in Fig. 4.8 (*a*) is the most common method used for tube drawing. A conventional tube drawing bench is used. Method shown in Fig. 4.8 (*b*) employes a floating mandrel. Method shown in Fig. 4.8 (*c*) uses a long circular rod to control the size of tube-bore. Method shown in Fig. 4.8 (*d*) uses neither a mandrel nor a bar and controlling size of bore is difficult.

TUBE MAKING

Tubes and pipes are required in large quantities by industries all over the world. Tubes are basically of two types. They are either seamless (*i.e.*, without any joint) or with joint all along the length of the tube. Seamless tubes are made by processes such as casting, extrusion or rolling. Tubes with joint are made by welding. Usually, the weld joint is made by electric resistance welding process, such tubes are referred to as ERW tubes. The size of a tube or pipe is indicated by the size of its bore in mm.

Since the requirement of tubes is so large, a special rolling process called Mannesmann rotary piercing process has been developed. In this process, a heated round billet with its leading end, in the centre of which a short guide hole has been punched or drilled, is pushed longitudinally between two large tapered rolls as shown in Fig. 4.9.

As the billet mores forward and keeps rotating the tearing action is propagated throughout the length of the billet. End result is a roughly formed seamless tube of ellipitical cross-section.

This roughly formed seamless tube is further rolled in a “plug rolling mill”. The final operations of “reeling” and “sizing” are further conducted on cooled tube to improves size and finish of tubes.

Fig. 4.9 Tube making

The rolls revolve in the same direction and their axes are inclined at opposite angles of approx 6° from the axis of the billet. As the billet is caught by the rolls and is rotated, their inclination causes the material to be drawn forward. The small clearance between the rolls forces the material to deform into an elliptical shape. Due to compressive forces, secondary tensile stresses start acting in a direction perpendicular to the direction of the compressive stresses. The guide hole drilled/punched at centre of billet tears open. This action is assisted by a suitably placed mandrel.