MODULE-IV

EXTRUSIONAND RAPID PROTOTYPING

Extrusion

Process by which long straight metal parts can be produced.

Cross-sections that can be produced vary from solid round, rectangular, to L shapes, T Shapes, tubes and many other different types

Done by squeezing metal in a closed cavity through a die using either a mechanical or hydraulic press.

Extrusion produces compressive and shear forces in the stock.

No tension is produced, which makes high deformation possible without tearing the metal.

Can be done Hot or cold

Drawing

Section of material reduced by pulling through die.

Similar to extrusion except material is under TENSILE force since it is pulled through the die

Various types of sections: - round, square, profiles

Tube Drawing

Utilizes a special tool called a MANDREL is inserted in a tube hollow section to draw a seamless tube

- Mandrel and die reduce both the tube's outside diameter and its wall thickness. The mandrel also makes the tube's inside surface smoother

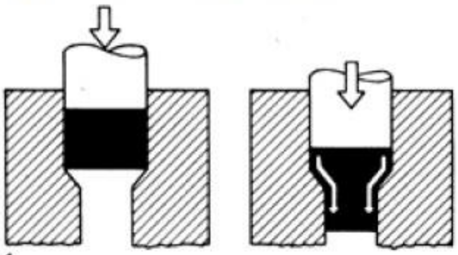
Process Variations. Slab forging, shaft forging, mandrel forging, ring forging, upsetting between flat or curved dies, drawing out.
Application. Forging ingots, large and bulky forgings, preforms for finished forgings.

Closed Die Forging

In this process, a billet is formed (hot) in dies (usually with two halves) such that the flow of metal from the die cavity is restricted. The excess material is extruded through a restrictive narrow gap and appears as flash around the forging at the die parting line.
Equipment. Anvil and counterblow hammers, hydraulic, mechanical, and screw presses.
Materials. Carbon and alloy steels, aluminum alloys, copper alloys, magnesium alloys, beryllium, stainless steels, nickel alloys, titanium and titanium alloys, iron and nickel and cobalt super alloys.
Process Variations. Closed-die forging with lateral flash, closed-die forging with longitudinal flash, closed-die forging without flash.
Application. Production of forgings for automobiles, trucks, tractors, off-highway equipment, aircraft, railroad and mining equipment, general mechanical industry, and energy-related engineering production.

Forward extrusion

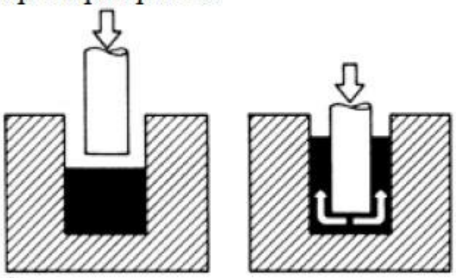
Forward extrusion reduces slug diameter and increases its length to produce parts such as stepped shafts and cylinders.



1

backward extrusion

In backward extrusion, the steel flows back and around the descending punch to form cup-shaped pieces.



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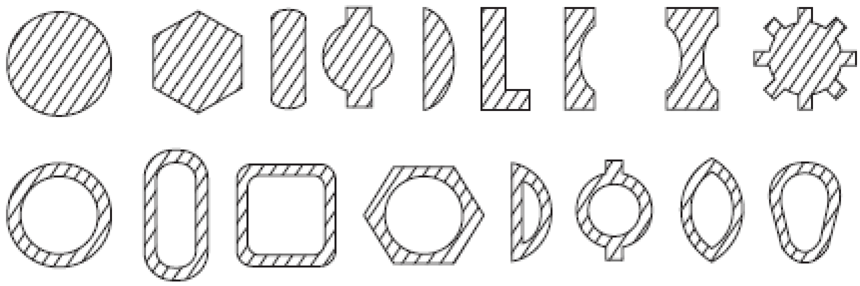
Upsetting, or heading

Upsetting, or heading, a common technique for making fasteners, gathers steel in the head and other sections along the length of the part.

Extrusion is a process in which the metal is subjected to plastic flow by enclosing the metal in a closedchamber in which the only opening provided is through a die. The material is usually treated so that itcan undergo plastic deformation at a sufficiently rapid rate and may be squeezed out of the hole in thedie. In the process the metal assumes the opening provided in the die and comes out as a long strip withthe same cross-section as the die-opening. Incidentally, the metal strip produced will have a longitudinalgrain flow.The process of extrusion is most commonly used for the manufacture of solid and hollow sectionsof nonferrous metals and alloys e.g., aluminium, aluminium-magnesium alloys, magnesium andits 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 areshown in Figure above

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**

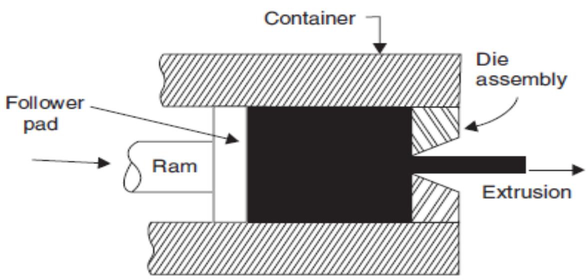
(*i*) Hooker extrusion.

(*ii*) Hydrostatic extrusion.

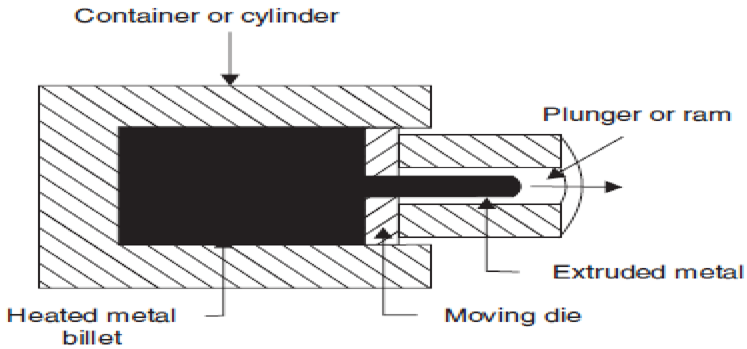
(*iii*) Impact extrusion.

(*iv*) Cold extrusion forging.

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 Figure. 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.

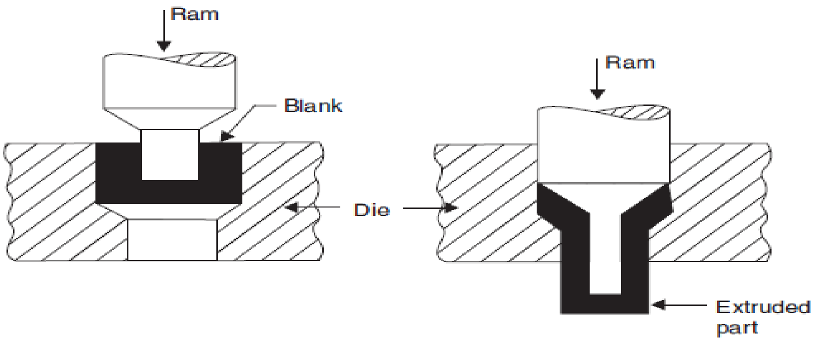


Backward or indirect extrusion: This process is depicted in Figure As shown; the blockof heated metal is inserted into the container/chamber. It is confined on all sides by the container wallsexcept in front; where a ram with the die presses upon the material. As the ram presses backwards, thematerial has to flow forwards through the opening in the die. The ram is made hollow so that the bar ofextruded metal may pass through it unhindered.



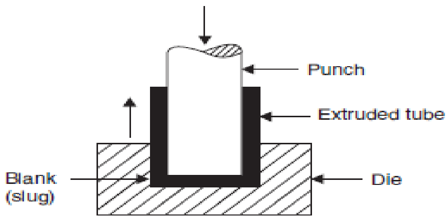
This process is called backward extrusion process as the flow of material is in a direction opposite to the movement of the ram. In the forward extrusion process the flow of material and ram movement were both in the same direction. The following table compares the forwards (direct) and backwards (Indirect extrusion process).

Hooker extrusion process: This process is also known as extrusion down method. It is used forproducing small thin walled seamless tubes of aluminium and copper. This is done in two stages. In thefirst stage the blank is converted into a cup shaped piece. In the second stage, the walls of the cup onethinned and it is elongated. The process can be understood by referring to Figure. This process is adirect extrusion process.

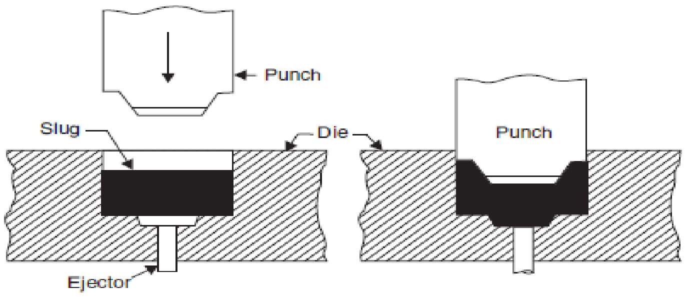


Hydrostatic extrusion: This is a direct extrusion process. But the pressure is applied to the metal blank on all sides through a fluid medium. The fluids commonly used are glycerine, ethyl glycol, mineral oils, castor oil mixed with alcohol etc. Very high pressures are used – 1000 to 3000 MPa. Relatively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

Impact extrusion: In this process, which is shown in Figure below 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.



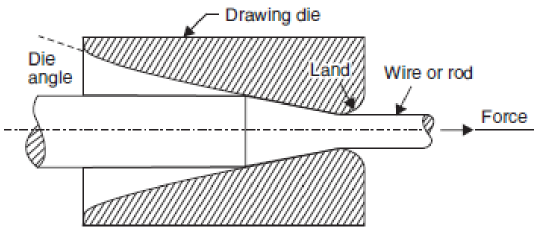
Cold extrusion forging: This process is depicted in Figure below. This is generally similar to the impactextrusion process; but there are two differences:1. In this process the punch descends slowly, and2. The height of extruded product is short and the side walls are much thicker than the thinwalled products produced by the impact extrusion process. In essence, this process is one of backwardextrusion.



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 reducefriction between metal and extrusion chamber walls, lubricants are used. The dies and punches aremade 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 generatedin the extrusion process. These cracks are specially associated with aluminium, magnesium and zincalloy extrusions.The extruded product can develop internal cracks also. These are variously known as centreburst, centre cracking and arrowhead fracture. The tendency for centre cracking increases with increasingdie angles and material impurities.

WIRE DRAWING
Wire drawing is a simple process. In this process, rods made of steel or non ferrous metals and alloys are pulled through conical dies having a hole in the centre. The included angle of the cone is keptbetween 8 to 24°. As the material is pulled through the cone, it undergoes plastic deformation and itgradually undergoes a reduction in its diameter. At the sametime, the length is increased proportionately.



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, thereduction in cross-sectional area achieved is about 25–30%. Hence in a wire drawing plant, the wire hasto pass through a number of dies of progressively reducing diameter to achieve the required reduction indiameter. However as the wire passes through dies and undergoes plastic deformation, it gets strainhardened. Its strength increases and capacity to further undergo plastic deformation decreases. Thereforeduring the entire run of the wire, from time to time, it has to be heated (and cooled) to remove theeffect of work-hardening. This process is called “in process annealing”. The aim is to make the materialsoft 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 inan acid bath to dissolve the oxide layer present on the surface. Its front end is then tapered down so thatit may pass through the hole in the die which is firmly held in the wire drawing machine. The wire isdrawn by means of a number of power driven spools or rotating drums.

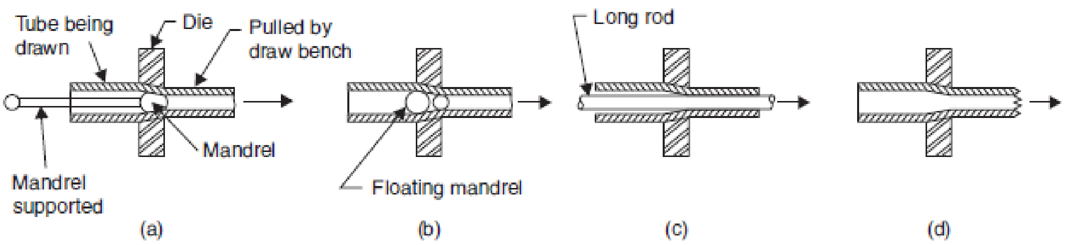
During wire drawing, a great deal of heat is generated due to friction between the wire rod andthe die. To reduce friction, dry soap or a synthetic lubricant is used. But despite reducing friction, thedies and drums may have to be water cooled.The preferred material for dies is tungsten carbide but for drawing fine wire, use of ruby ordiamond dies is preferred.

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

The major variables 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. Variousarrangementsused for tube drawing as shown in figure below

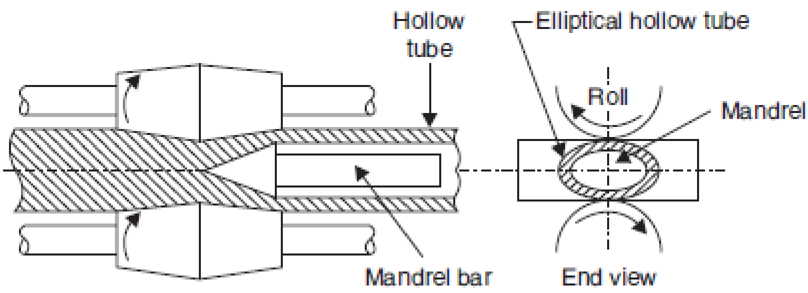


- Method (*a*) is most commonly used.
- Method (*b*) uses a floating mandrel which adjusts itself to the correct position because of its stepped contour.

The method shown in Fig. (*a*) is the most common method used for tube drawing. A conventional tube drawing bench is used. Methodshown in Fig. (*b*) Employs a floating mandrel. Method shown in Fig. (*c*) uses a long circular rod to control the size of tube-bore. Method shown inFig.(*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 Figure below



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.

As the billet mores forward and keeps rotating the tearing action is propagated throughout thelength 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 operationsof “reeling” and “sizing” are further conducted on cooled tube to improves size and finish of tubes.

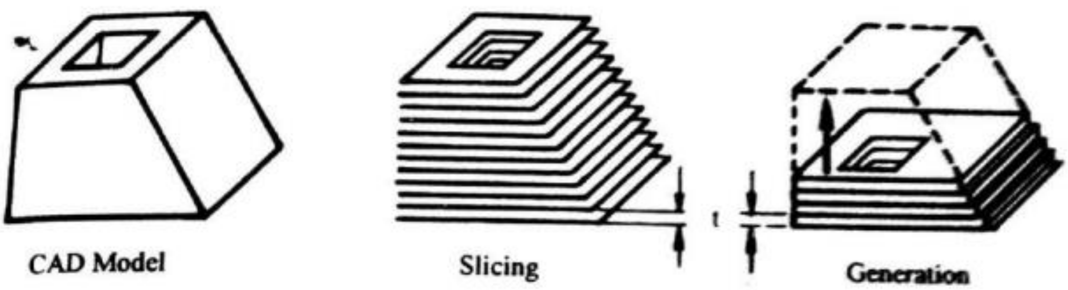
Rapid prototyping

Though the principle of concurrent engineering (CE) is quite clear and the advantages of the concept for improved quality and reduced cost are implicit, it is not possible to incorporate CE effectively in the absence of some technique for quick development of prototype. To reduce the development time and adopt concurrent engineering in its true spirit, quick and inexpensive fabrication of prototype parts is essential and rapid prototyping technology has made that possible. A family of unique fabrication processes developed to make engineering prototypes in minimum lead time based on a CAD model of the item. The traditional method is machining −Machining can require significant lead-times –several weeks, depending on part complexity and difficulty in ordering materials •RP allows a part to be made in hours or days given that a computer model of the part has been generated on a CAD system.

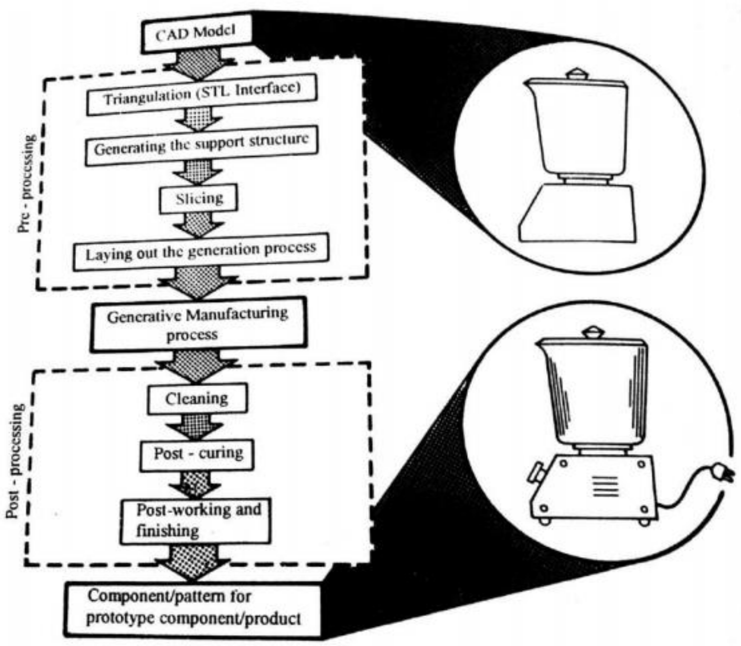
Why Rapid Prototyping? Because product designers would like to have a physical model of a new part or product design rather than just a computer model or line drawing −Creating a prototype is an integral step in design −A virtual prototype (a computer model of the part design on a CAD system) may not be sufficient for the designer to visualize the part adequately −Using RP to make the prototype, the designer can visually examine and physically feel the part and assess its merits and shortcomings.

Basic principles of RP

In this process a solid object with prescribed shape, dimension and finish can be directly produced from the CAD based geometric model data stored in a computer without human intervention. Conventional method for producing parts like casting, forming, machining etc are not suitable for this purpose and a host of new processes for shaping objects directly from the CAD data have been developed and machines are in the market. Rapid prototyping can be of two types: ¬ The parts obtained by RP technology can form the prototype directly without requiring any further processing. The parts obtained by RP technology can be used to make moulds for casting the prototype component. This type is needed because till today, the commercially available RP machines are non metallic materials with low strength and low melting temperature. In general this technology is called as Generative manufacturing Process (GMP) as the shape of the work piece is not obtained by removal of chips or forming or casting. It is achieved by addition of material without any prior recognizable form or shape and no tool is necessary.



The slice thickness and slicing direction can be varied for convenience of generation. To generate an object of same shape as that of sliced CAD model, the distance between the slicing planes (t) must be equal to the thickness of the corresponding layers during the actual generation process.



Steps involved in rapid prototyping