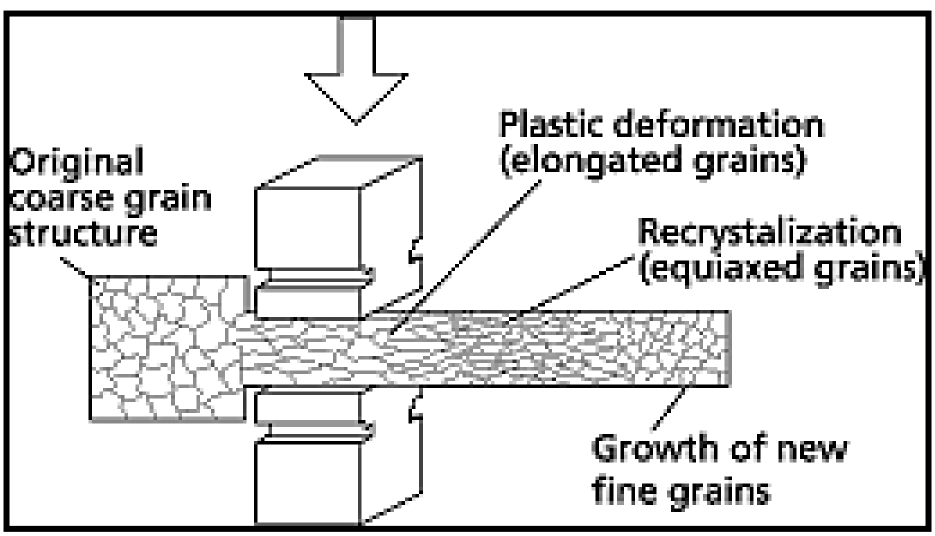
1-1 Forging

Forging is the process where (heated) metal is beaten with a heavy hammer to give it the required shape. It is the plastic working of metal by means of localized compressive forces exerted by manual or power hammers, presses, or special forging machines. It may be done either hot or cold. In forging, three types of deformations are observed:

1. Draw out, in which length is increased and cross section is decreased,
2. Upset, in which cross section is increased and length is decreased,
3. Squeeze, in which multidirectional flow is produced in closed impression dies.

Quality of forged parts:

Usually forged parts are much stronger/tougher than cast or machined parts made from the same material. This is because the hammering process arranges the micro-structure of the metal so that the crystal grains get aligned along the part profile. This leads to an increase in strength. It is therefore common to use forging to make parts that will carry very high stresses during their use, rather than casting. Surface finish/Dimensional control is better than casting (typically).



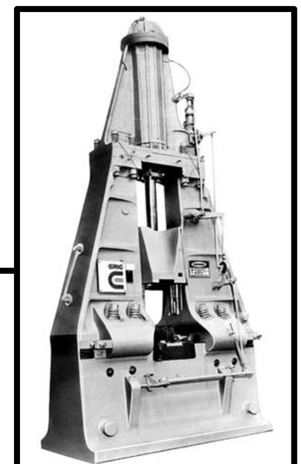
[source:www.scotforge.com]

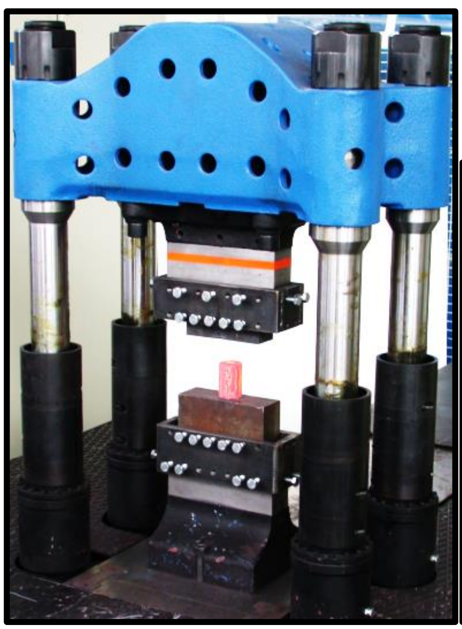
1-2-1 Open Die Hammer or Smith Forging

The same type of forging done by the blacksmith of old, but now massive mechanical equipment is used to impart the repeated blows. The impact is then delivered by some type of mechanical hammer, the simplest type being the gravity drop or board hammer.

Open-die forging does not confine the flow of metal, the hammer and anvil often being completely flat. The operator obtains the desired shape by manipulating the workpiece between blows.

For example, ancient sword-making uses flat hammers beating on a heated strip of metal kept on a flat piece of iron called an anvil.





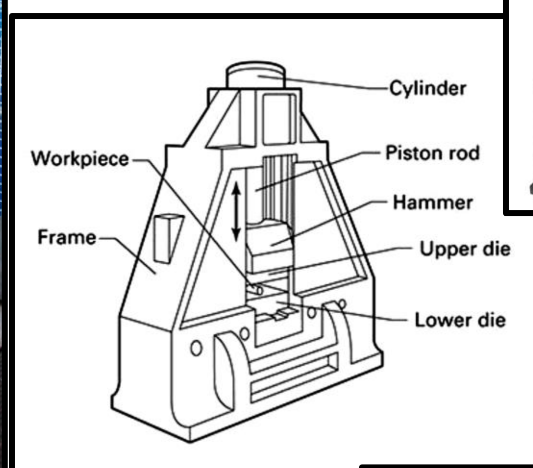
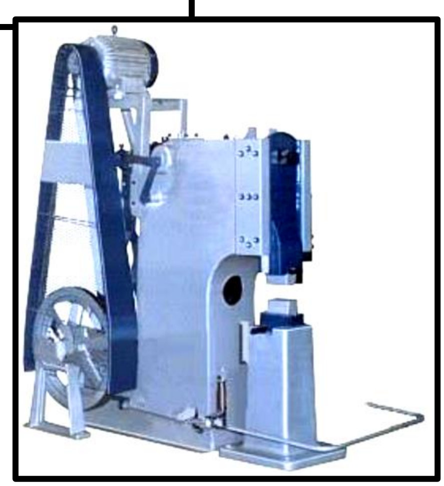
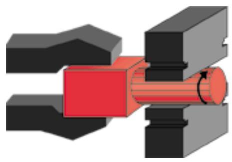


Figure (1): (Left) A simple Hot forging, open-die forging press; note the red hot bar stock in place (Right) Double-frame drop hammer. (Middle) Schematic diagram of a forging hammer.

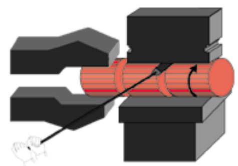


Mechanical drive hammer

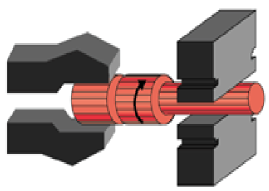
Stages in Open-Die Forging



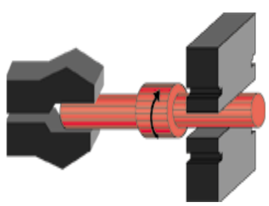
(a) forge hot billet to max diameter



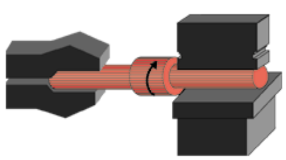
(b) “fuller: tool to mark step-locations



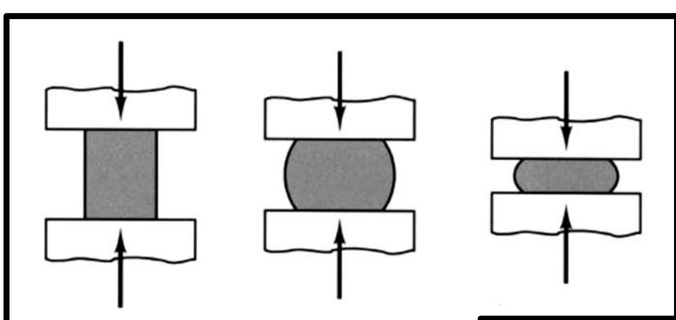
(c) forge right side

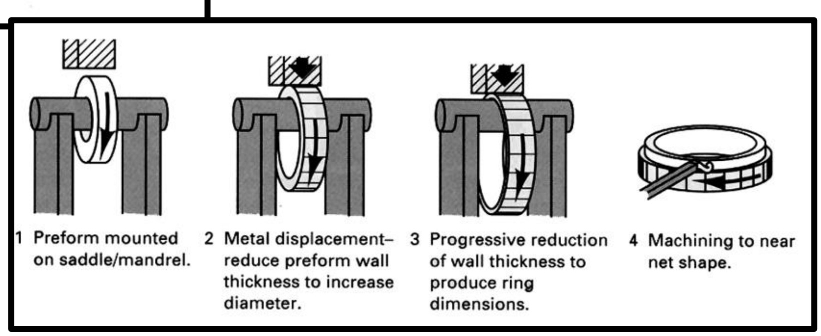


(d) reverse part, forge left side



(e) finish (dimension control)





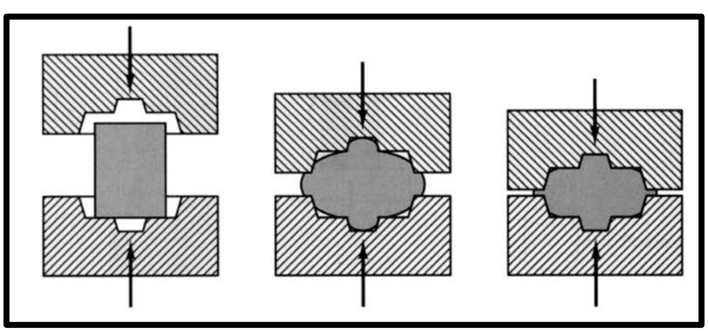
1-2-2 Impression-Die Drop or Closed-Die Forging

The open-die hammer or smith forging is a simple flexible process, but it is not practical for large-scale production because it is slow and the resulting size and shape of the workpiece are dependent on the skill of the operator.

Impression-die or closed-die forging overcomes these difficulties by using shaped dies to control the flow of metal to make many more complex shapes, the hammer and the supporting pieces are cut into the reverse of the required shape.
. Board hammers, steam hammers, and air hammers are all used in impression die drop forging.

If we desire to hammer down the stock to a well-defined shape, then it is customary to see a **closed-die forging process**; in this process, the hammer-head and the anvil are basically hardened dies with the inverse of the shape we want. The figure below shows a schematic of the dies and stock in the closed-die forging process. Usually, the stock volume is a little in excess of the part volume; this ensures that the entire die cavity gets filled properly. However, the excess material flows out through the gap between the dies; this excess is called flash, and must later be machined away (this operation is called trimming). If the stock and the final part are very different in shape, then the forging is done in several stages. The figure shows an example of a common forged part – a connecting rod. This part is used in almost all petrol engines. The part is made from bar stock in four stages, marked in the figure as (i) edging, (ii) blocking, (iii) finishing, and (iv) trimming. Note that only the dies for the third stage are exactly the inverse, geometrically, of the final part shape.

Stages in Closed-Die Forging



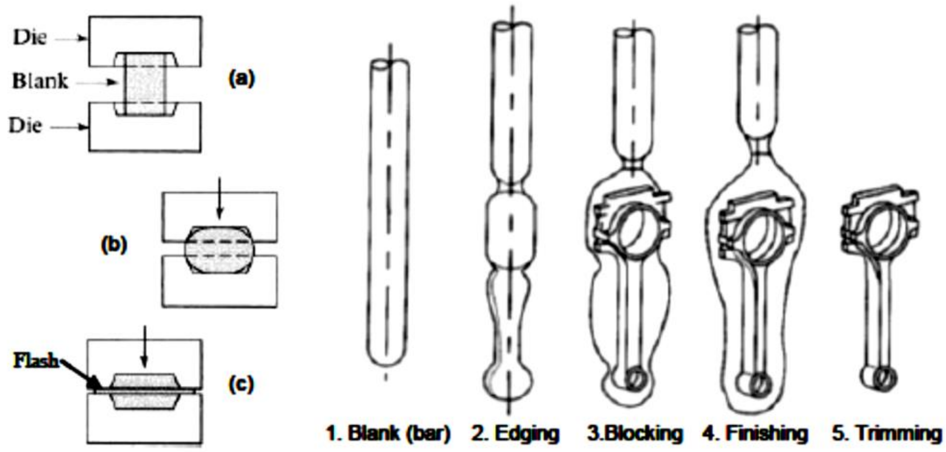
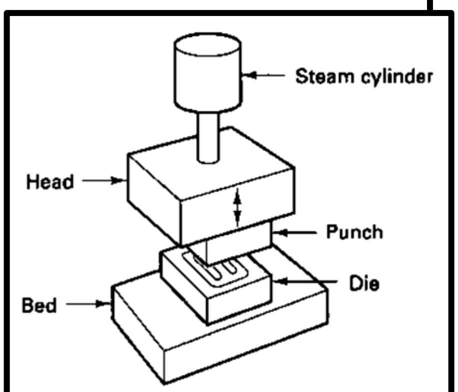
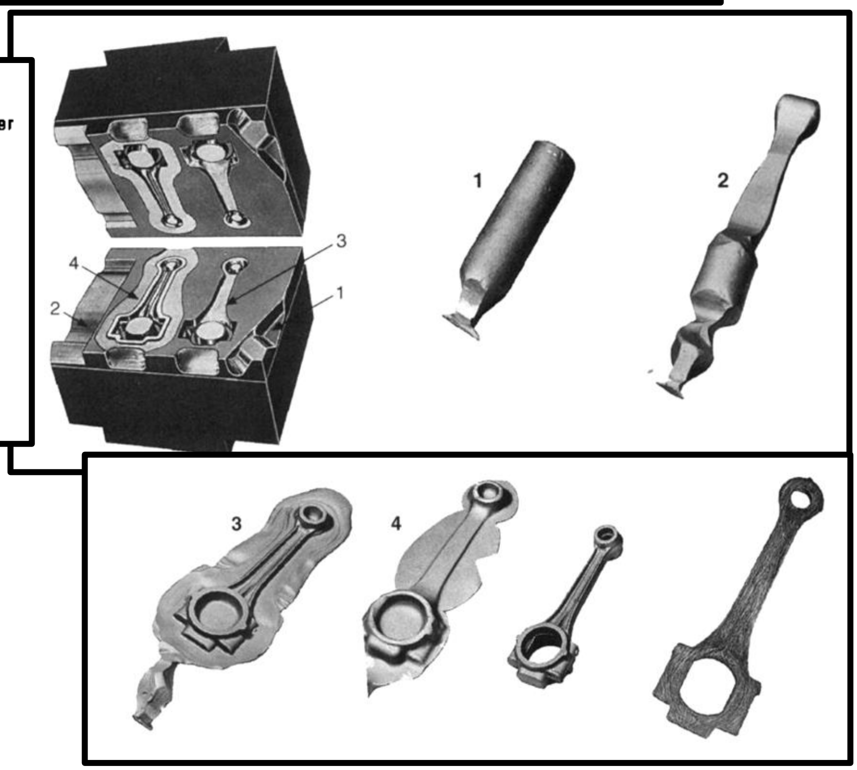


Figure 5.

(a) Schematic of closed-die forging (b) Stages of forging a connecting rod





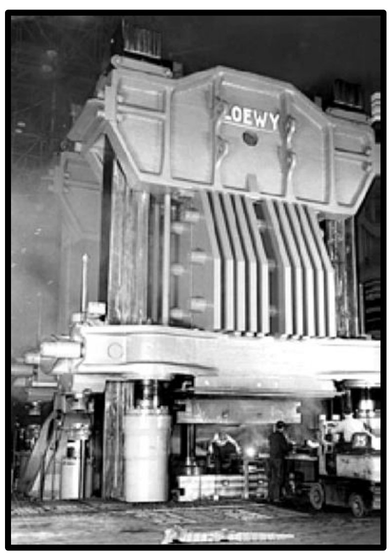
In some modern applications, the volume of the stock and the precision of the last-stage dies are controlled very tightly. Such applications are sometimes called precision forging. One form of precision forging is used to make coins. If you look closely at a newly manufactured coin, you can see very high quality details in the forging; usually, good quality coins may need between three and five stages of

forging. This is because in coin-making, no lubricant or oil can be applied to the die surface; these may get trapped in the tiny cavities of the design and lead to poor feature definition in the forged coin.

Counterblow or impact forging is an alternative to the hammer and anvil arrangement. Counterblow (impact) machines have two horizontal hammers that move together simultaneously and forge the workpiece between them. By using these machines, necessity for a heavy base is eliminated, and the machine operates more quietly and with less vibration.

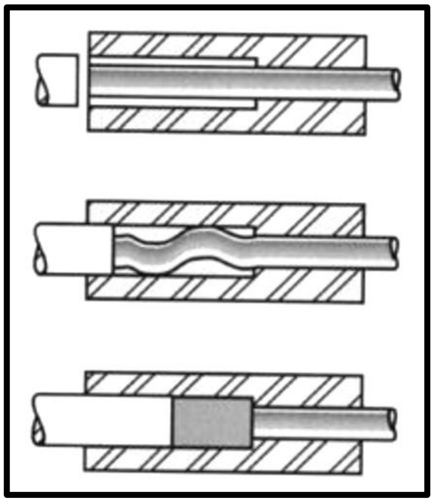
1-2-3 Press Forging

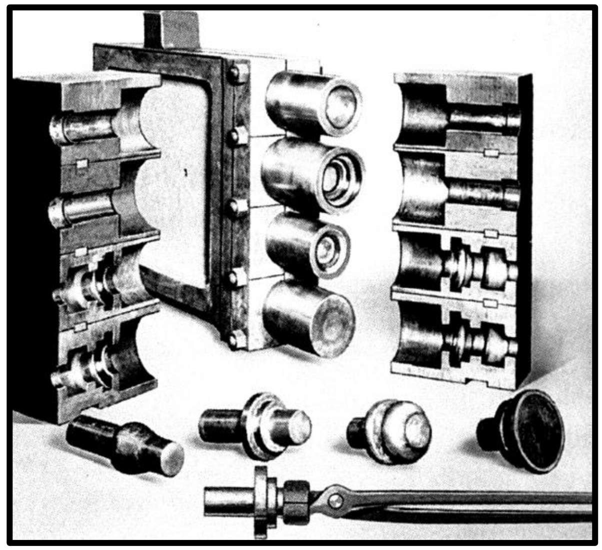
When the forging of large sections is required, press forging, rather than hammer or impact forging, should be employed. Here the slow squeezing action penetrates throughout the metal and produces a more uniform metal flow. To prevent cooling due to long time of contact, heated dies are often used.

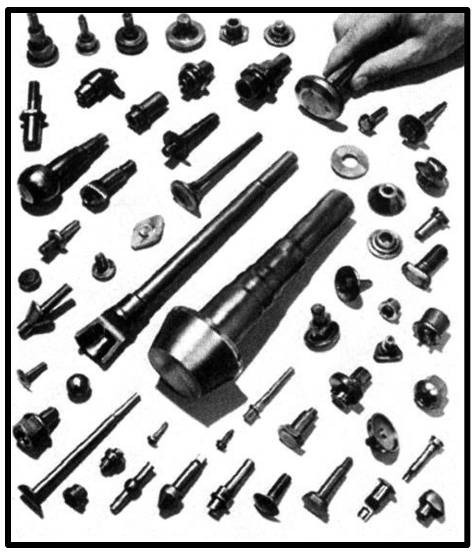


1-2-4 Upset Forging

Upset forging involves increasing the diameter of the end or central portion of a bar by compressing its length. In this type of forging, split dies having several positions or cavities are commonly used.

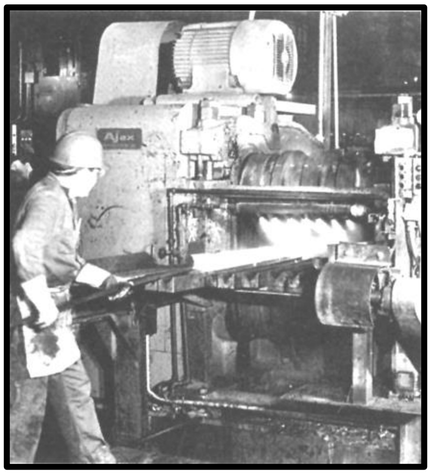


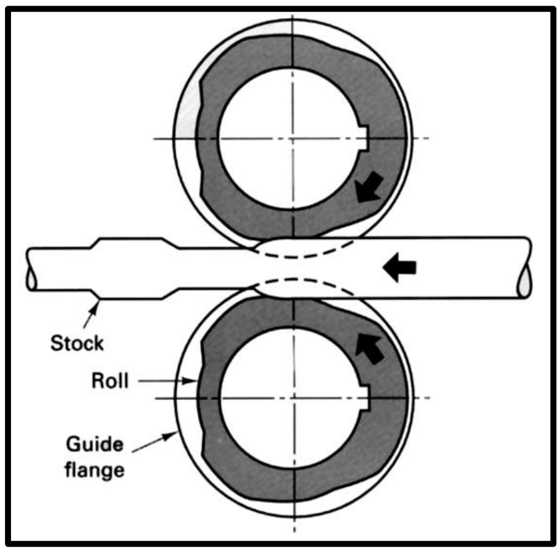




1-2-5 Roll Forging

Round or flat bar stock is reduced in thickness and increased in length. Done on machines that have two semi cylindrical rolls, containing shaped grooves that are slightly eccentric with the axis of rotation. As rolls turn one half revolution, the bar is progressively squeezed and rolled out toward the operator. The operator then inserts the forging between another set of smaller grooves and the process is repeated until the desired size and shape are obtained. Components such as axles, tapered levers, and leaf springs are produce.





1-1 Extrusion

Extrusion is a process in which metal is compressively forced, or squeezed, to flow out through a suitably shaped hole (die). The process is similar to squeezing toothpaste out of the tube. Although extrusion may be performed either hot or cold, hot extrusion is employed for many metals to reduce the forces required, eliminate cold-working effects, and reduce directional properties. This process is used mostly for metals that are ductile, including, lead, copper, aluminum, magnesium, and alloys of these metals are commonly extruded, taking advantage of the relatively low yield strengths and extrusion temperatures. it is also used for some

plastics and rubbers.

Steel is more difficult to extrude.With the development and use of phosphate-based and molten glass lubricants, substantial quantities of hot steel extrusions are now produced. These lubricants adhere to the billet and prevent metal-to-metal contact throughout the process.

Common examples of parts made by extrusion are the aluminum frames of white-boards, door- and window-frames, etc. Usually, long strips of the required cross-section are extruded and sold as raw-stock. Any hardware store will have between ten and hundred different cross-section bars – almost all are made by extrusion. The process can be used to make hollow as well as solid cross-sections, as seen from the example parts in the figure below.

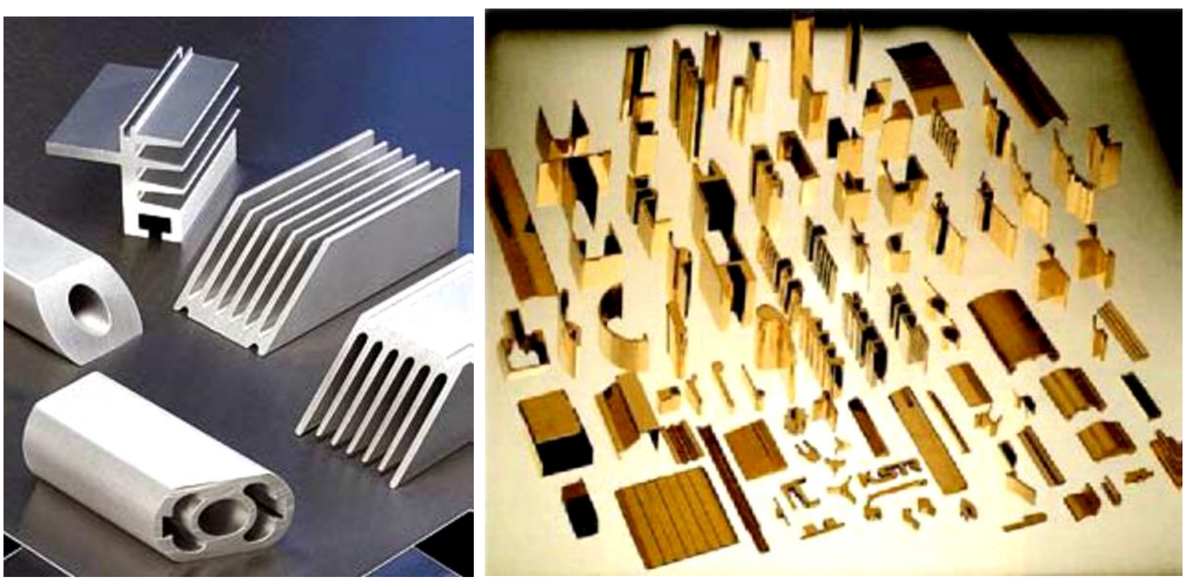


Figure (2): Examples of parts made by extrusion (each part is cut from a long length)

The extrusion press has a pressure chamber into which the raw stock is loaded; the die is made of hardened steel, with a hole that is the shape of the required cross-section. The metal is then squeezed out of the die hole by the use of

a high pressure hydraulic piston. The schematic below shows the basic process, and the images show two examples of aluminum extrusion dies.

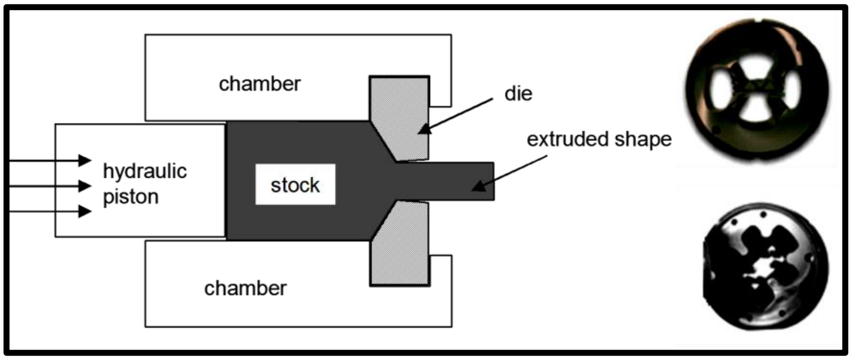
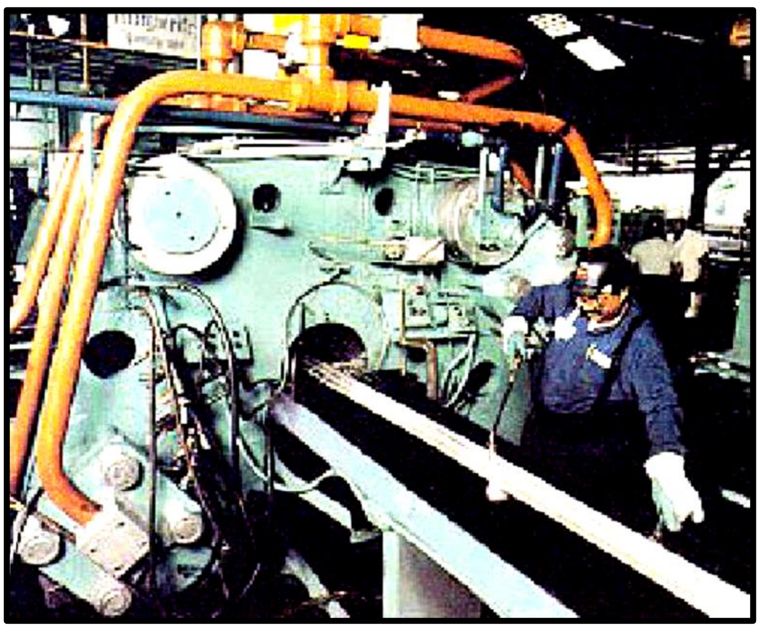
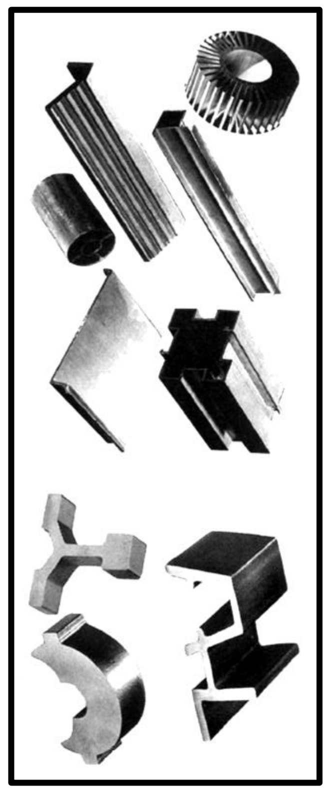


Figure (3): Schematic of extrusion and examples of extruding dies





Almost any cross-sectional shape can be extruded.

● The amount of reduction in a single step is limited only by the capacity of the equipment.

● Extrusion dies are relatively inexpensive.

● Product changes require only a die change, so small quantities of a desired shape can often be produced economically by extrusion.

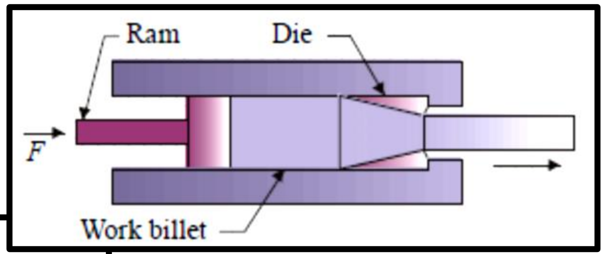
● The major limitation of the process is the requirement that the cross section must be the same for the length of the product being extruded.

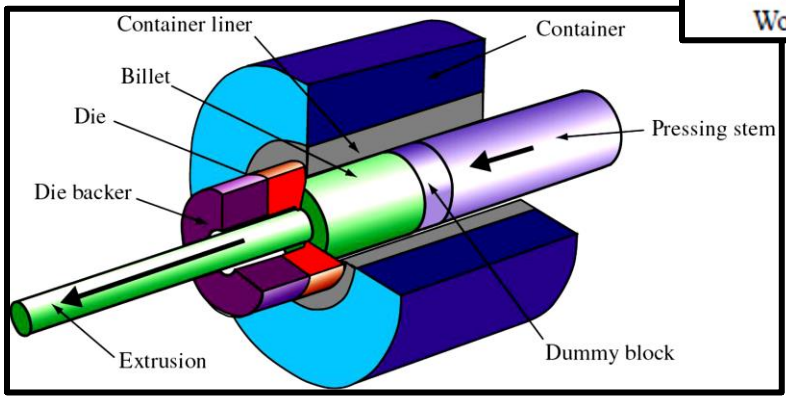
● The dimensional tolerances of extrusions are very good. For most shapes ± 0.003 mm/mm or a minimum of ± 0.07 mm is easily attainable.

Extrusion Methods

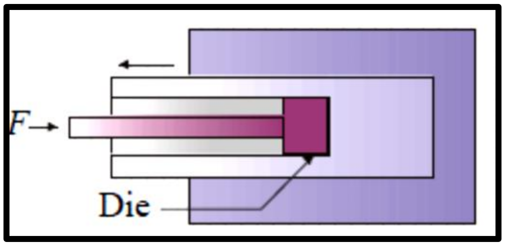
1. Direct extrusion (hot),

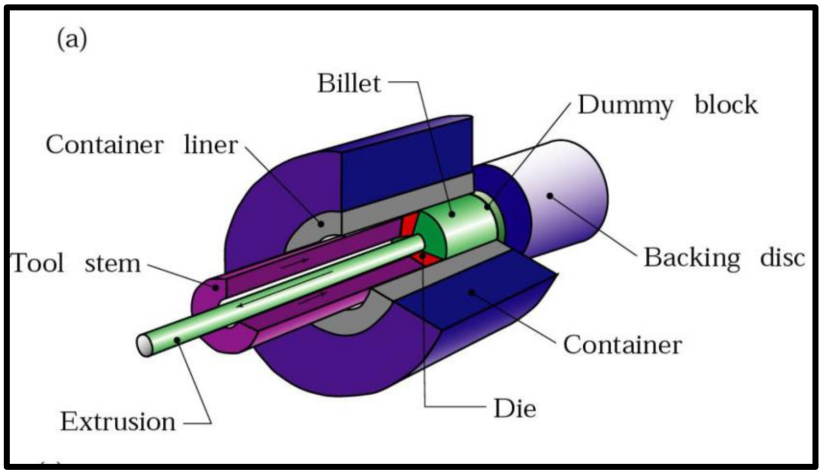
Although the indirect extrusion configuration reduces friction between the billet and chamber wall, added equipment complexity and restricted length of product favors the direct method.





2. Indirect extrusion (hot),



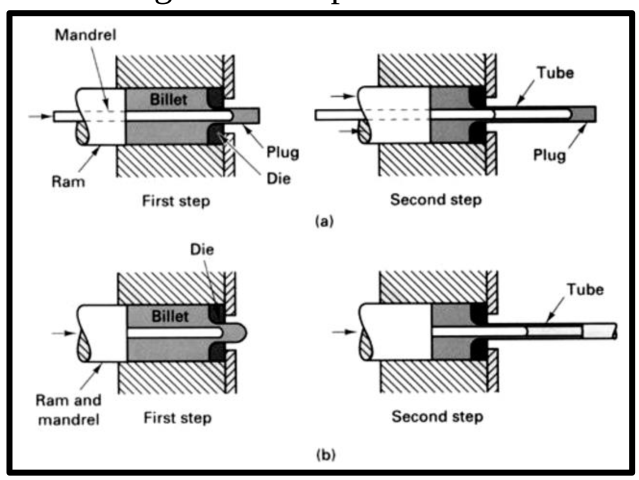


3. Impact extrusion (usually cold).

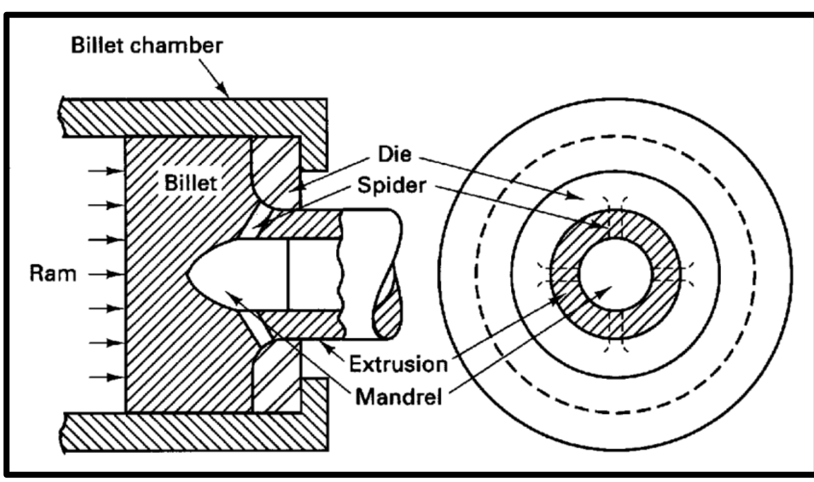
Extrusion of Hollow Shapes

1. For tubular products, the stationary or moving mandrel processes are often employed.

2. For more complex internal cavities, a spider mandrel (torpedo die) is used.



Extrusion of Tubes



pider Mandrel (Torpedo Die)