Metal forming processes

Metal forming: Large set of manufacturing processes in which the material is deformed plastically to take the shape of the die geometry. The tools used for such deformation are called die, punch etc. depending on the type of process.

Plastic deformation: Stresses beyond yield strength of the workpiece material is required.

Primary Metal Forming Processes

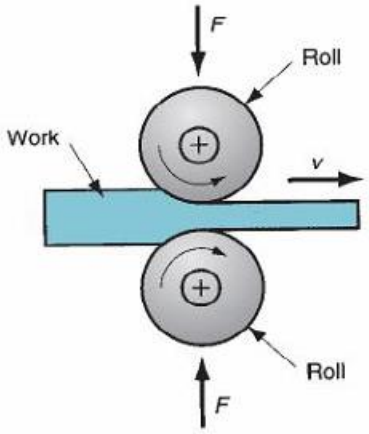
Rolling
Forging
Extrusion
Tube and wire drawing
Deep drawing

Rolling: In this process, the workpiece in the form of slab or plate is compressed between two rotating rolls in the thickness direction, so that the thickness is reduced. The rotating rolls draw the slab into the gap and compresses it. The final product is in the form of sheet.

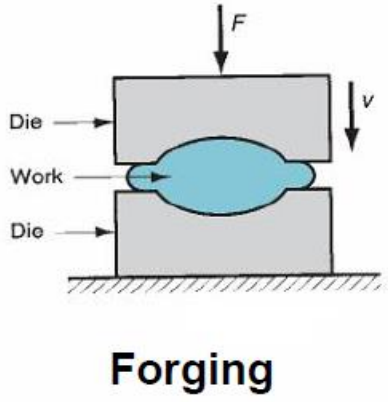
Forging: The workpiece is compressed between two dies containing shaped contours. The die shapes are imparted into the final part.

Extrusion: In this, the workpiece is compressed or pushed into the die opening to take the shape of the die hole as its cross section.

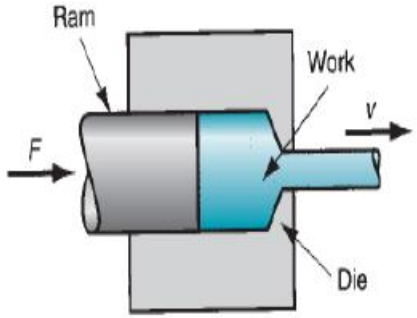
Wire or rod drawing: similar to extrusion, except that the workpiece is pulled through the die opening to take the cross-section



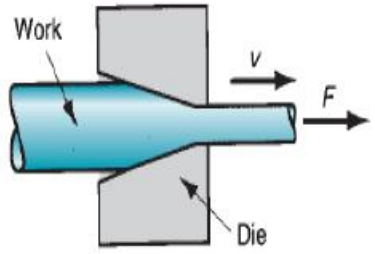
Rolling



Forging



Extrusion



Wire drawing

Cold working, warm working, hot working

Cold working: Generally done at room temperature or slightly above RT.
Advantages compared to hot forming:
(1) closer tolerances can be achieved; (2) good surface finish; (3) Higher strength and hardness is seen in part; (4) since no heating of the work is involved, furnace, fuel, electricity costs are minimized, (5) Machining requirements are minimum resulting in possibility of near net shaped forming.
Disadvantages: (1) higher forces and power are required; sometimes cold forming-annealing-cold forming cycle should be followed, (2) the work piece is not ductile enough to be cold worked.
Warm working: In this case, forming is performed at temperatures just above room temperature but below the recrystallization temperature. The working temperature is taken to be 0.3 *Tm* where *Tm* is the melting point of the workpiece.
Advantages: (1) enhanced plastic deformation properties, (2) lower forces required, (3) intricate work geometries possible

Hot working: Involves deformation above recrystallization temperature, between 0.5*Tm* to 0.75*Tm*.
Advantages: (1) significant plastic deformation can be given to the sample, (2) significant change in workpiece shape, (3) lower forces are required, (4) materials with premature failure can be hot formed,
Disadvantages: (1) shorter tool life, (2) poor surface finish, (3) lower dimensional accuracy,

Forging

• It is a deformation process in which the work piece is compressed between two dies, using either impact load or hydraulic load (or gradual load) to deform it.

• It is used to make a variety of high-strength components for automotive, aerospace, and other applications. The components include engine crankshafts, connecting rods, gears, aircraft structural components, jet engine turbine parts etc.

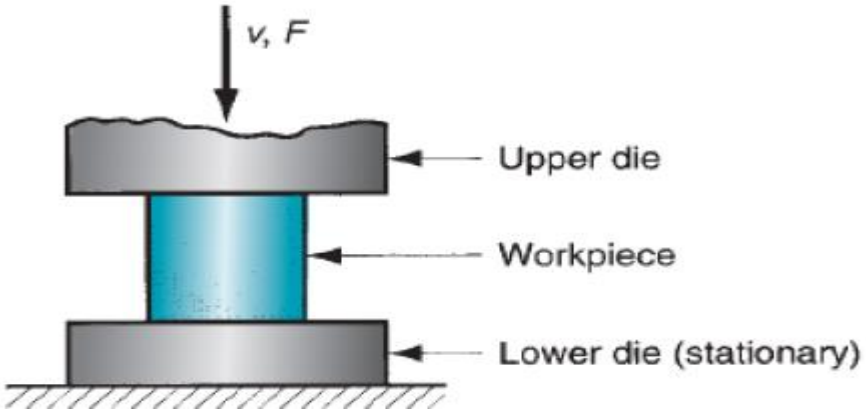
• Category based on temperature : cold, warm, hot forging

• Category based on presses: impact load => forging hammer; gradual pressure => forging press

• Category based on type of forming: Open die forging, impression die forging, flashless forging

Open die forging

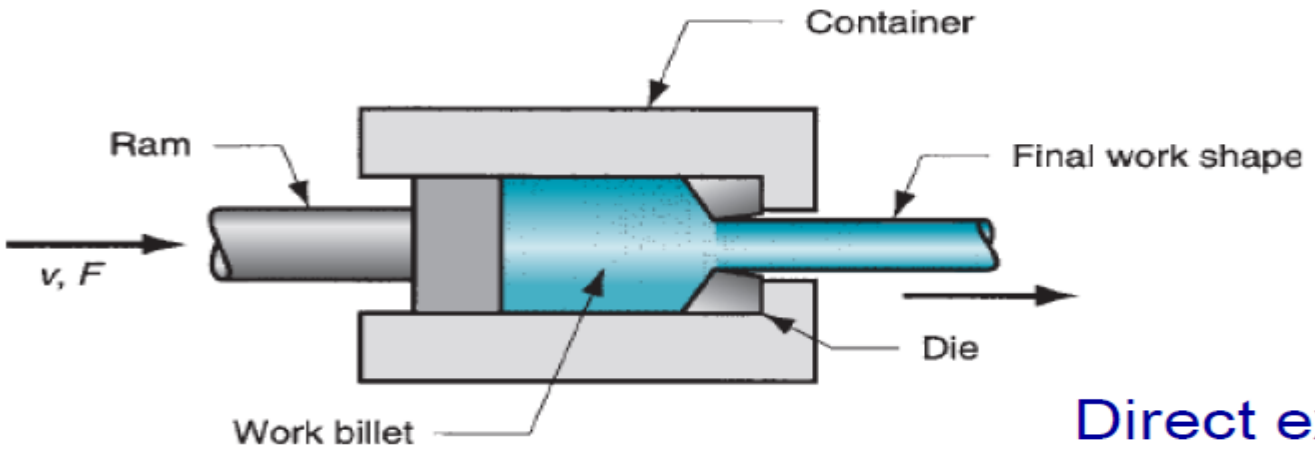
In open die forging, the work piece is compressed between two flat platens or dies, thus allowing the metal to flow without any restriction in the sideward direction relative to the die surfaces.



Extrusion Extrusion is a bulk forming process in which the work metal is forced or compressed to flow through a die hole to produce a desired cross-sectional shape. Example: squeezing toothpaste from a toothpaste tube.

Advantages :

- Variety of shapes are possible, especially using hot extrusion
- Grain structure and strength properties are enhanced in cold and warm extrusion
- Close tolerances are possible, mainly in cold extrusion
- **Types of extrusion:** Direct or forward extrusion, Indirect or backward extrusion
- **Direct extrusion:** - A metal billet is first loaded into a container having die holes. A ram compresses the material, forcing it to flow through the die holes. - Some extra portion of the billet will be present at the end of the process that cannot be extruded and is called *butt*. It is separated from the product by cutting it just beyond the exit of the die

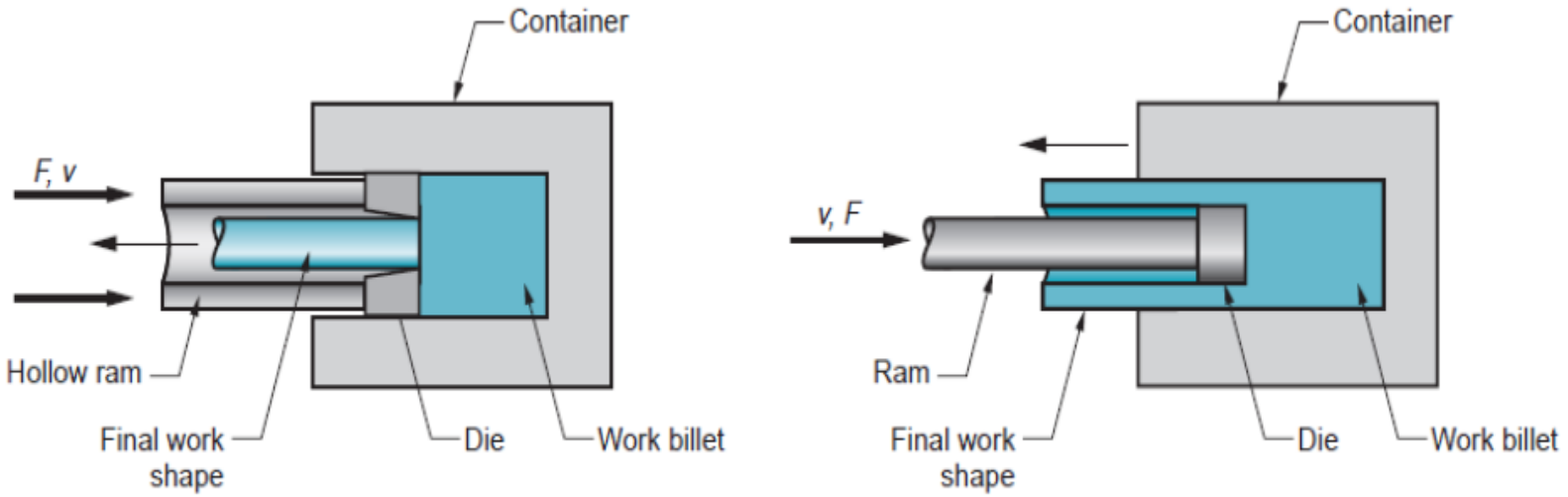


Direct extrusion

Indirect extrusion: - In this type, the die is mounted to the ram and not on the container. As the ram compresses the metal, it flows through the die hole on the ram side which is in opposite direction to the movement of ram.

- Since there is no relative motion between the billet and the container, there is no friction at the interface, and hence the ram force is lower than in direct extrusion. -

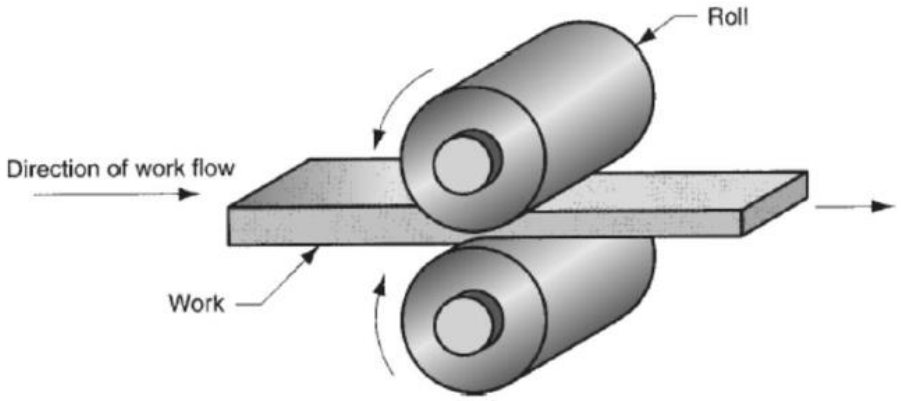
Limitations: lower rigidity of the hollow ram, difficulty in supporting the extruded product at the exit



Indirect extrusion: solid billet and hollow billet

Rolling

Rolling is a metal forming process in which the thickness of the work is reduced by compressive forces exerted by two rolls rotating in opposite direction. Flat rolling is shown in figure. Similarly shape rolling is also possible like a square cross section is formed into a shape such as an I-beam, L-beam.



Flat rolling

Important terminologies:

Bloom: It has a square cross section 150 mm x 150 mm or more.

Slab: It is rolled from an ingot or a bloom and has a rectangular cross section of 250 mm width or more and thickness 40 mm or more.

Billet: It is rolled from a bloom and is square in cross-section with dimensions 40mm on a side or more.

Blooms are rolled into structural shapes like rails for railroad tracks.

Billets are rolled into bars, rods. They become raw materials for machining, wire drawing, forging, extrusion etc.

Slabs are rolled into plates, sheets, and strips. Hot rolled plates are generally used in shipbuilding, bridges, boilers, welded structures for various heavy machines, and many other products.