METAL FORMING

Metal forming is also known as mechanical working of metals. Metal forming operations are frequently desirable either to produce a new shape or to improve the properties of the metal.

Shaping in the solid state may be divided into non-cutting shaping such as forging, rolling, pressing, etc., and cutting shaping such as the machining operations performed on various machine tools.

RECRYSTALISATION TEMPERATURE

If the temperature is sufficiently high, the growth of new grains is accelerated and continuous till the metal comprises fully of only the new grains. This process of formation of new grains is known as recrystallization and is said to be complete when the metal structure consists of entirely new grains. That temperature at which recrystallization is completed is known as the recrystallization temperature of the metal.

Comparison between Hot working and Cold working

S.No.	Hot working	Cold working
1	Hot working is done at a temperature above the recrystallization temperature and below the melting point.	Cold working is done at a temperature below the recrystallization temperature.
2	Refinement of the crystal occurs.	Refinement of the crystal will not occur.
3	Crack propagation will be less.	More crack propagation will be seen.
4	Internal residual stresses are not produced.	Internal residual stresses are produced.
5	It improves value of elongation.	It decreases value of elongation.
6	Surface finish is poor due to oxidation.	Surface finish is good.
7	It is difficult to control the dimension because of contraction.	It is easy to control the dimension within the tolerance limit.
8	Due to re-crystallisation and recovery no or very negligible hardening of metal takes place	Since this is done below re-crystallisation temperature the metal gets work hardened.
9	Less stress is required for deformation.	More stress is required for deformation.
10	Heavy oxidation of metal occurs during working.	No oxidation of metal occurs during working.

Mechanical properties
Hardness
Brittleness
Ductility
Toughness
Strength
Elasticity
Resilience
Plasticity
Resilience
Malleability

Elasticity:

Such property of material from which if we pull it and leave it, then it will come back in its shape again, it is called Elasticity. This property is useful for materials used in tools and machines.

E.g. steel is more elastic than rubber.

Plasticity:

Such a property of material from which if we pull but it cannot regain its original position when leaving it, then it is called plasticity.

Eg: This property of the material is compulsory for forgings, in stamping images on coins and ornamental work.

Ductility:

Such property of a material that we can pull and make it into long wire form, we call it Ductility. A ductile material needs to both strong and plastic. e.g. The ductile material used in mild steel, copper, aluminum, nickel, zinc, tin, and lead.

Malleability:

If we beat any metal that causes it to spread and form into a sheet form, So we call this property Malleability. A malleable material needs to be plastic but it is not essential to be strong.

E.g. Malleable material is used in engineering practice is lead, soft steel., wrought iron, copper, and aluminum.

Hardness:

Suppose there is a metal and we have to scratch it, The harder the scratch is, the harder our material will be considered.

Suppose we have a material called iron and on the other side is silver aluminum So if we impact on both, the highest impact will be on aluminum because it is a weak metal and its hardness is less. But if we talk about iron, It will be more difficult to scratch on the sheet of iron if we compare it with aluminum, so hardness will be more of iron.

So a hard material that we cannot easily scratch, is equally hard.

The hardness of a metal is determined by various of tests :

- Brinell hardness test
- Rockwell hardness test
- Vickers hardness test (also called Diamond Pyramid) test, and
- Shore stereoscope

Toughness

Material that if we bend or twist, how much energy can absorb before it breaks is called Toughness.

The toughness of the material has been decreased when it is heated. So Toughness is properties that provide information about the capacity to absorb maximum energy. In this, we suddenly impact and check how much energy is absorbed at that time.

The toughness of metal is determined by Impact testing machine.

It has a pendulum that suddenly attacks the material, and connects its maximum energy absorbing capacity.

Brittleness

Suppose we have a material and we impact it and it should be broken, without deform is called Brittleness.

Or

If we pull such a material, it breaks instead of pulling it, we call it Brittleness. e.g. Cast iron is a brittle material

Strength

If we put a load on metal, it is without changing its shape or if it is able to bear it without breaking it then it is called its strength. So the ability or capacity of a material to withstand or support a load without fracture is called its strength.

Resilience

Such material in which the strain energy is stored in the body till the elastic limit only, is called as the resilience. so it is the property of a material to absorb energy and to resist shock and impact loads. This property is essential for spring materials. Machineability

Such a material that is easy to work on, such as cutting, using a tool, and machining, we call it machinability. E.g. Brass can be easily machined than steel.

Creep

When we put the material under constant load, for a long time, at high temperature, then the deformation that happens inside it, is called Creep.

It is also known as cold flow. Creep is used for examine in designing internal combustion engines, boilers, and turbines.

Classification of metal forming processes

The classification of hot working processes is given as under.

1. Rolling
2. Forging
3. Extrusion
4. Drawing

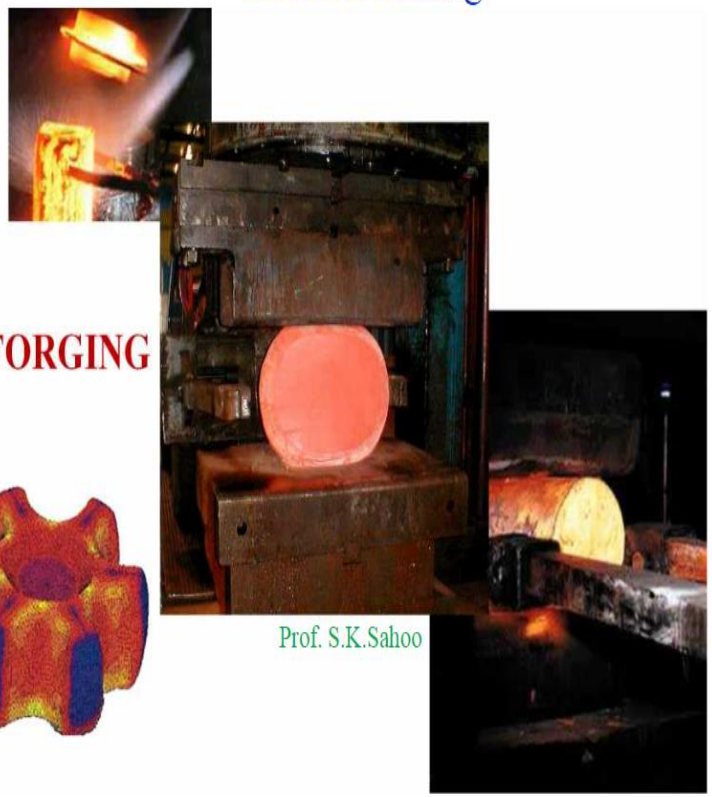
Plastic deformation: Stresses beyond yield strength of the workpiece material is required.

FORGING PROCESS

Forging is an oldest shaping process used for the producing small articles for which accuracy in size is not so important. The parts are shaped by heating them in an open fire or hearth by the blacksmith and shaping them through applying compressive forces using hammers.

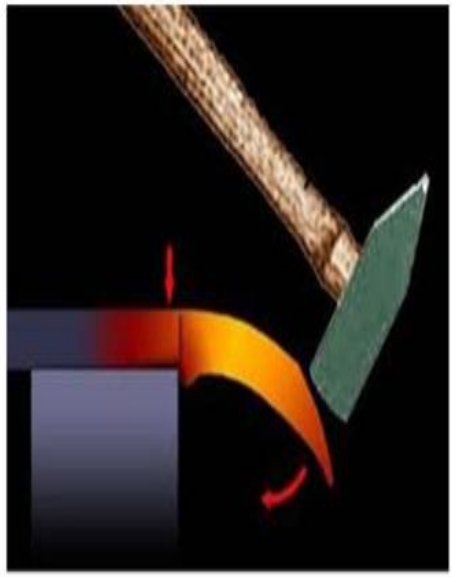
Thus forging is defined as the plastic deformation of metals at elevated temperatures into a predetermined size or shape using compressive forces exerted through some means of hand hammers, small power hammers, die, press or upsetting machine.

Metal Forming

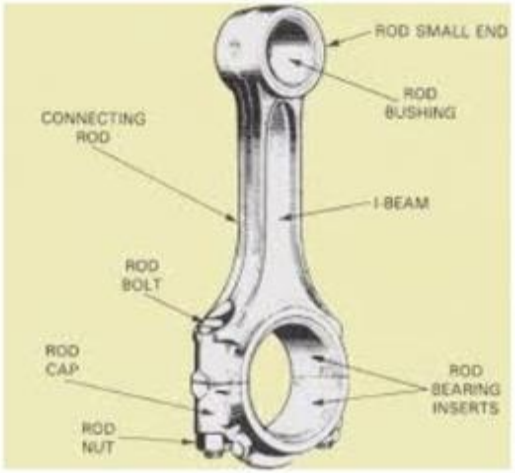


FORGING

Prof. S.K.Sahoo



Products of forging

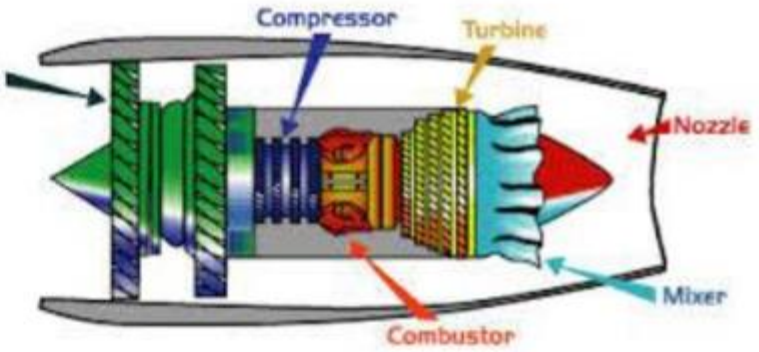


Connecting rods

Engine crankshafts

Aircraft structural components

Products of forging



Jet engine turbine parts

a. Green Si_3N_4 part.

b. Part after pressureless sintering in N_2 at 1750°C.

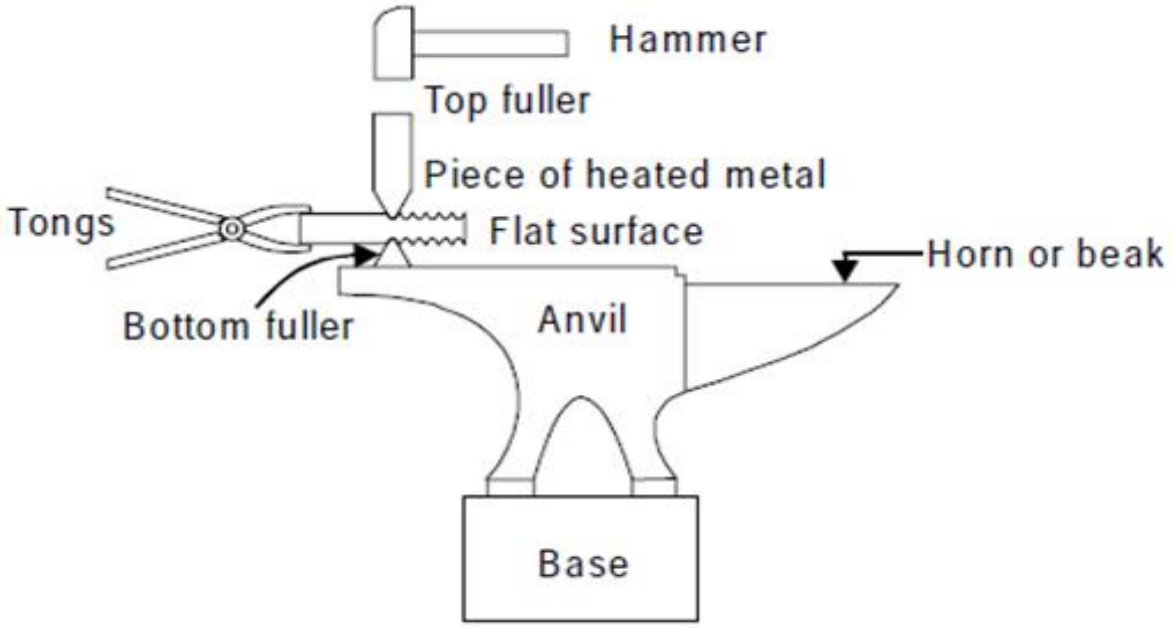
Advantages of forging

- Forged parts possess high ductility and offers great resistance to impact and fatigue loads.
- Forging refines the structure of the metal.
- It results in considerable saving in time, labor and material as compared to the production of similar item by cutting from a solid stock and then shaping it.
- The reasonable degree of accuracy may be obtained in forging operation.
- The forged parts can be easily welded.

FORGING METHODS

(i)Hand forging

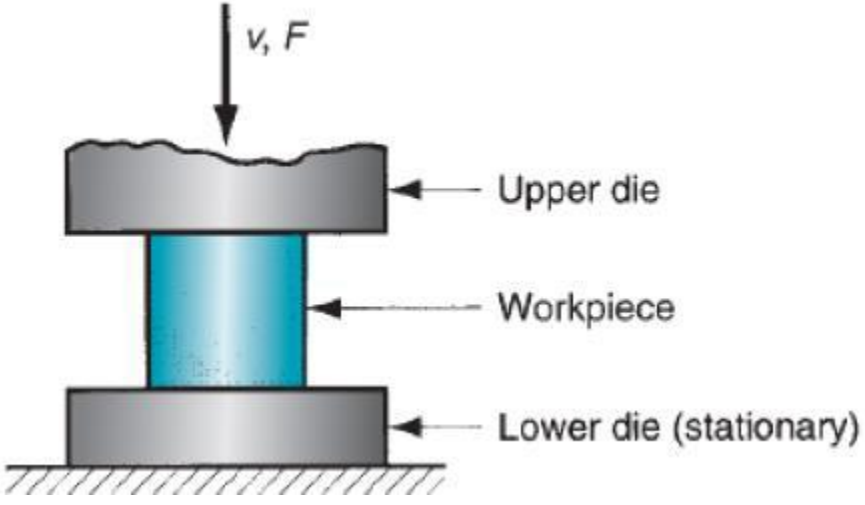
Hand forging is performed in the black smithy shop. The job is heated at the forging temperature in hearth and it is then brought on anvil using tong. It is then forged using hand hammers and other hand forging tools for imparting specific shape.



(ii)Power Forging

Hand hammer blows impact will not be always sufficient enough to affect the proper plastic flow in a medium sized or heavy forging. It also causes fatigue to the hammer man. To have heavy impact or blow for more plastic deformation, power hammer are generally employed.

These hammers are operated by compressed air, steam, oil pressure, spring and gravity.



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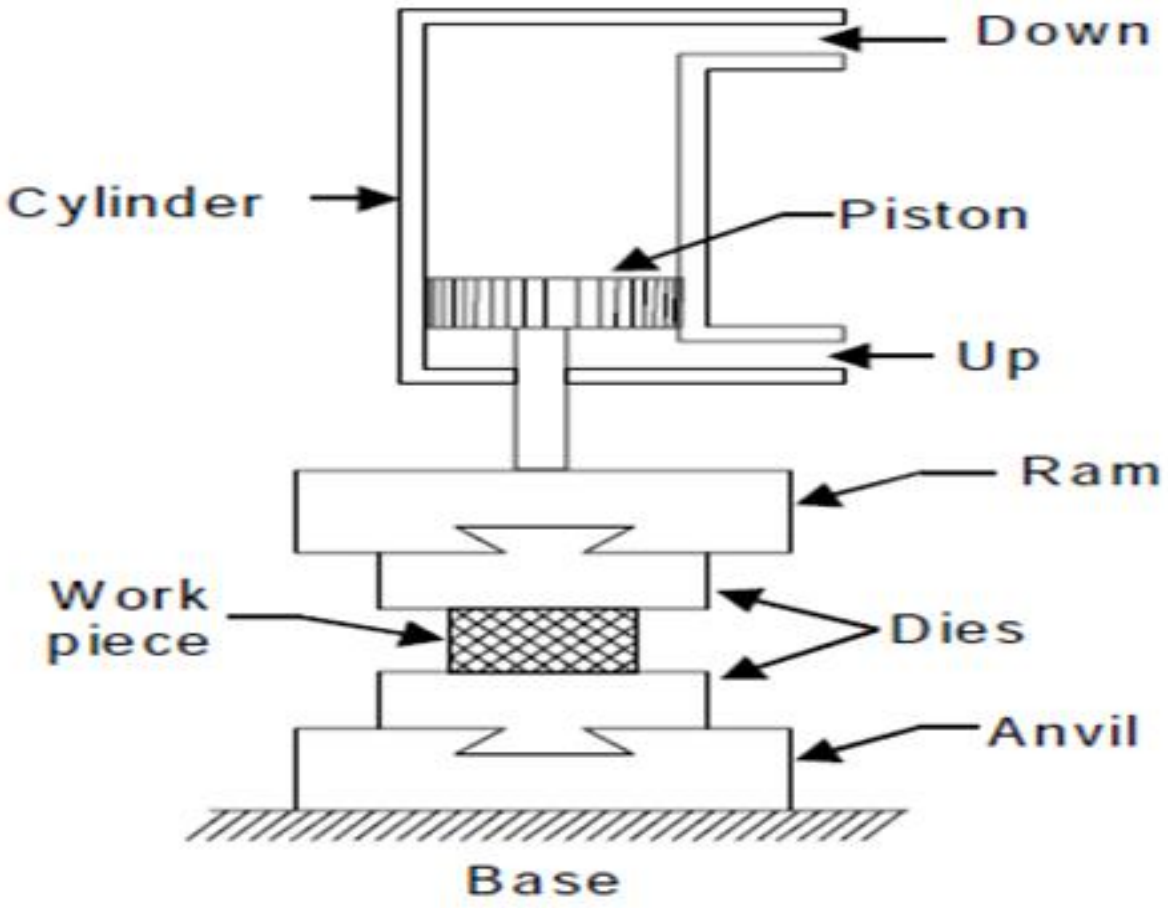
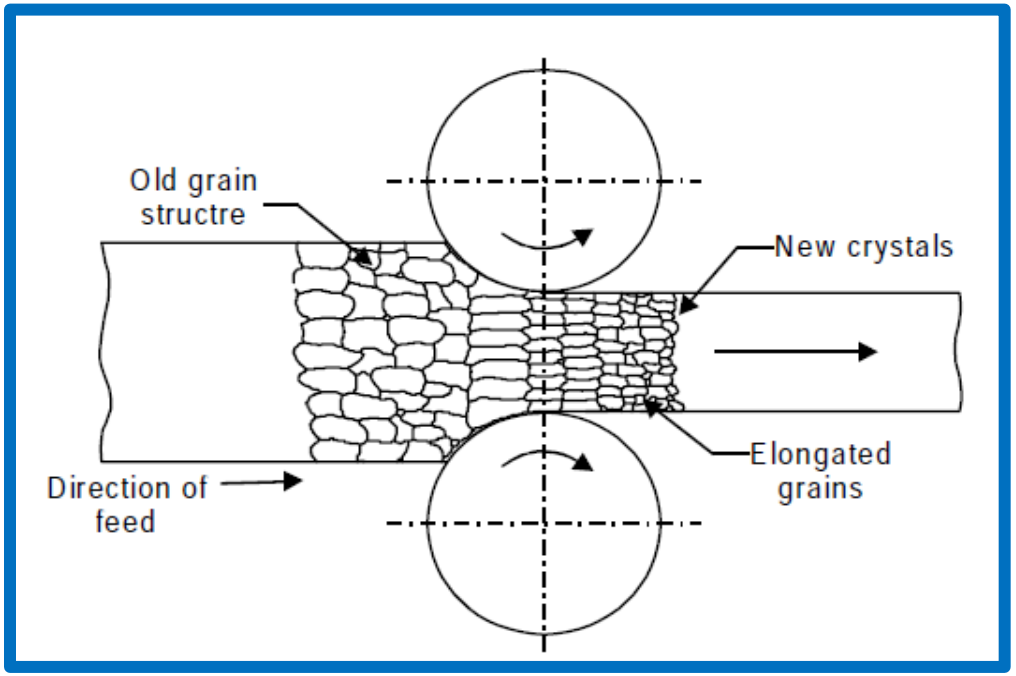


Rolling

It is one of the most widely used of all the metal working processes. The main objective of rolling is to convert larger sections such as ingots into smaller sections which can be used either directly in as rolled state or as stock for working through other processes.



Important terminologies:

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

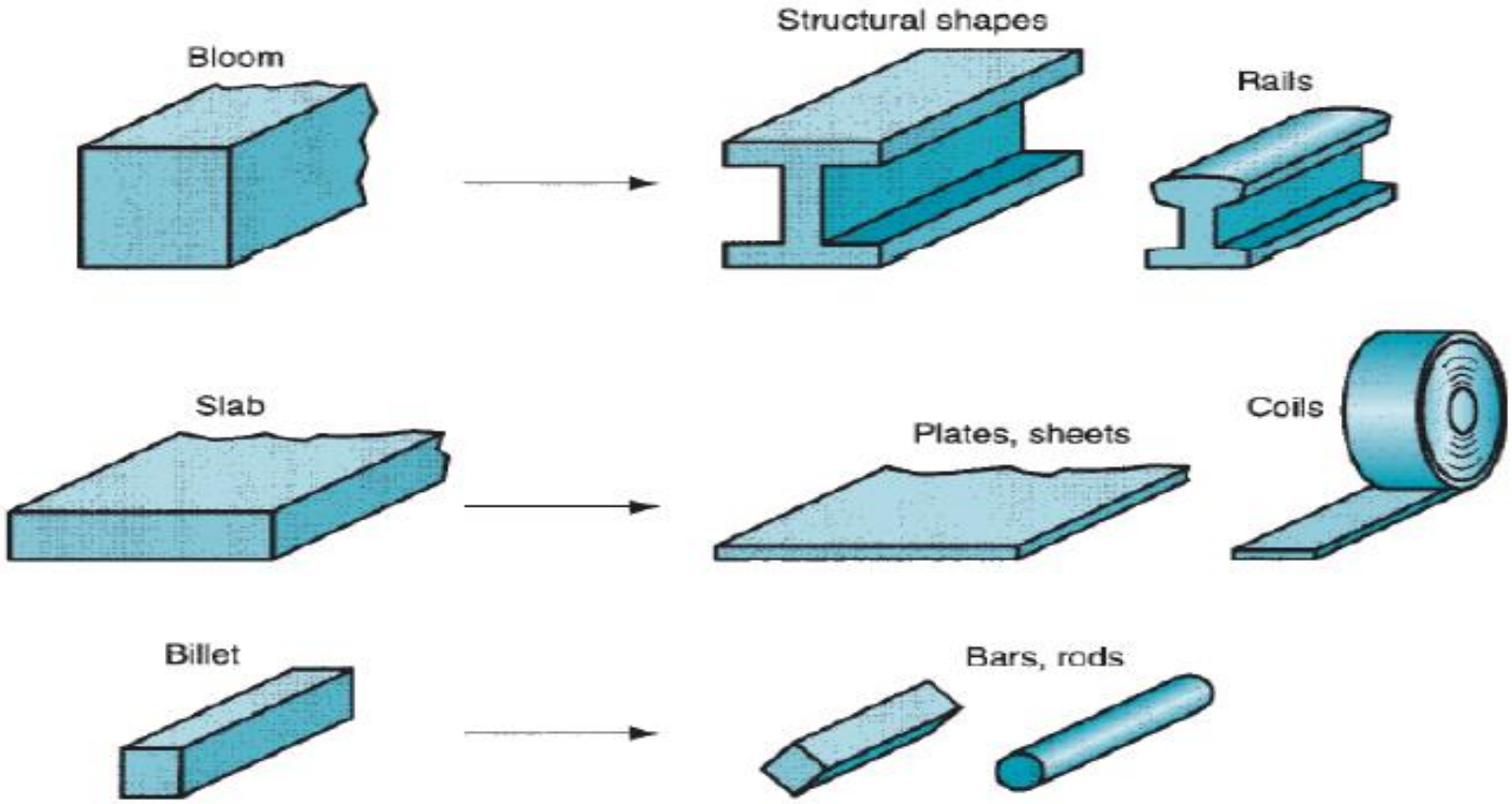
Slab: It is rolled from an ingot or a bloom and has a rectangular cross section of 250 mm width or more and thickness 40 mm or more.

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.

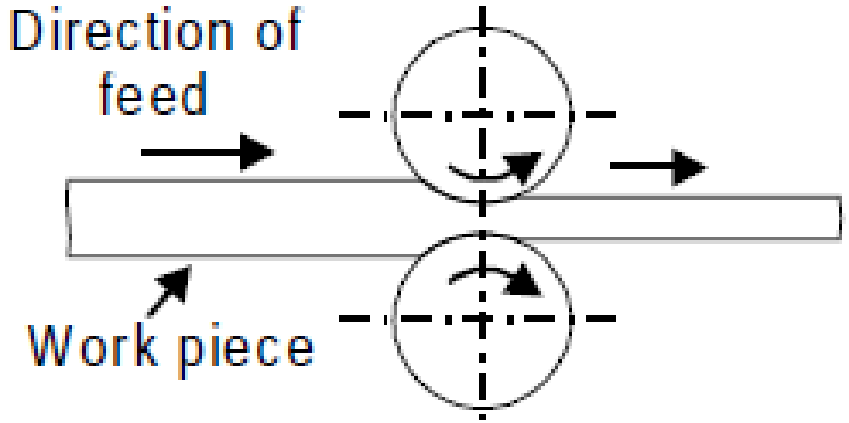

Bloom
Structural shapes
Rails
Slab
Plates, sheets
Coils
Billet
Bars, rods

Types of Rolling stand

- Two-High Rolling Mills
- Three-High Rolling Mills
- Four-High Rolling Mill
- Cluster Mill

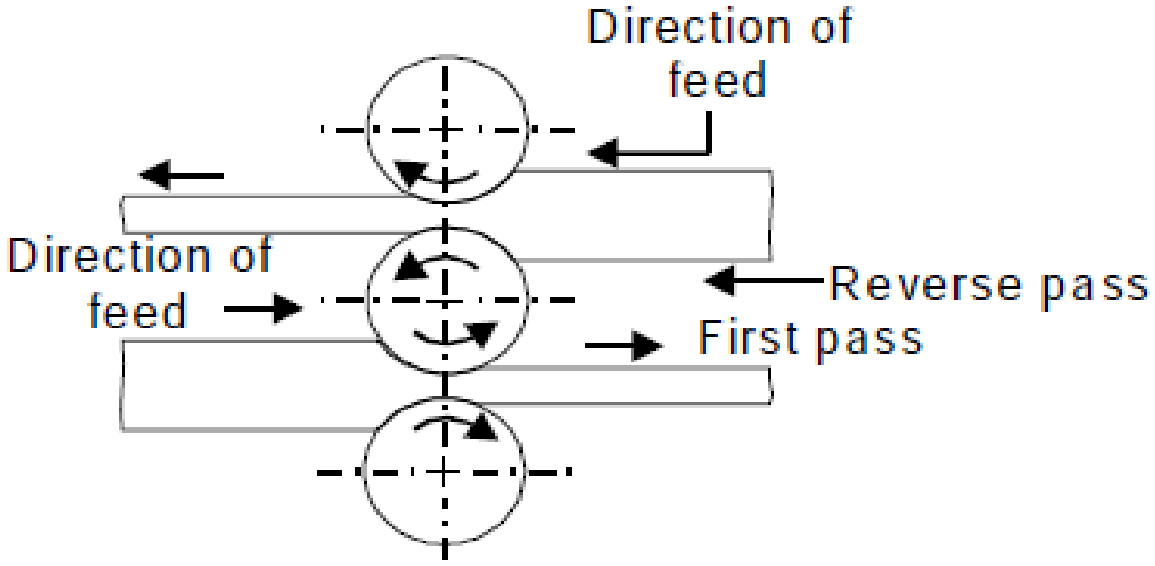
Two-High Rolling Mill

In two-high rolling mill the rolls are supported on bearings housed and rolls revolving at the same speed but in opposite direction. The space between the rolls can be adjusted by raising or 1owering the upper roll.



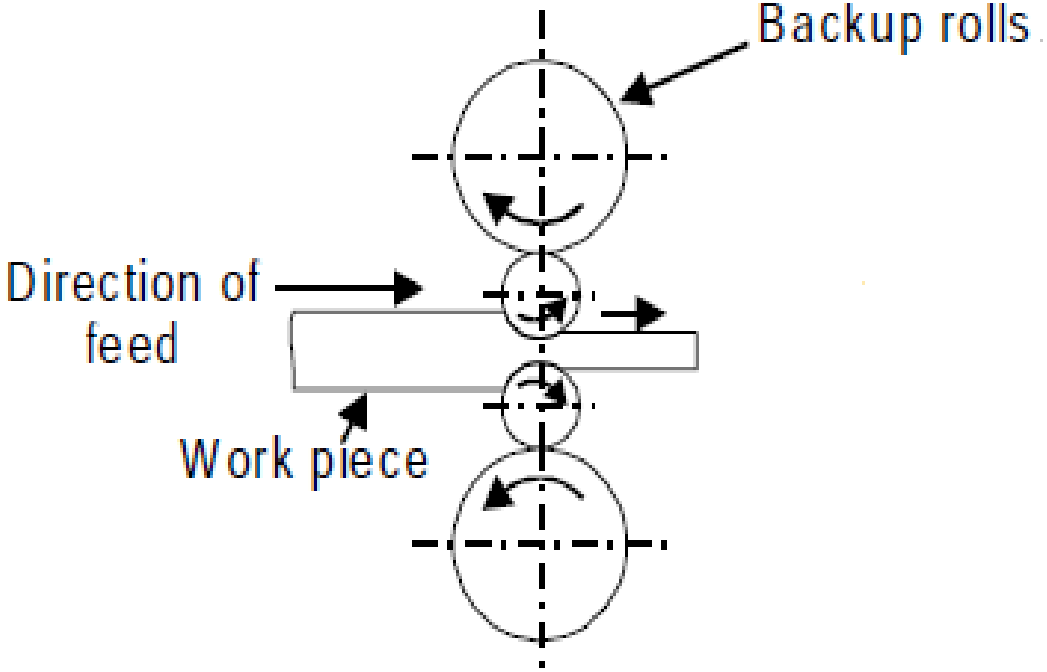
Three-High Rolling Mills

In three high rolling processes the directions of rotation of the upper and lower rolls are the same but the intermediate roll rotates in a direction opposite to both of these. This type of rolling mill is used for rolling of two continuous passes in a rolling sequence without reversing the drives.



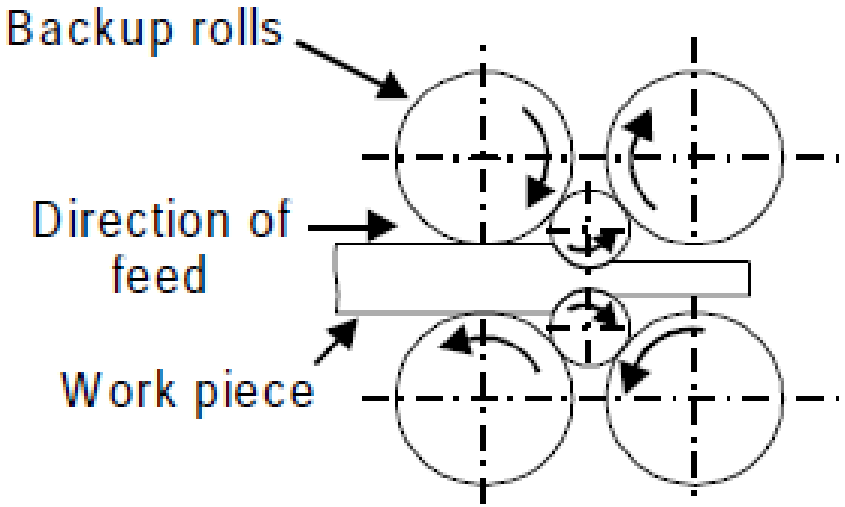
Four-High Rolling Mill

In four high rolling it consists of four horizontal rolls, the two middle rolls are smaller in size than the top and bottom rolls. The smaller size rolls are known as working rolls which concentrate the total rolling pressure over the workpiece.



Cluster Mill

In cluster mill each of the two smaller working rolls are backed up by two or more of the larger back-up rolls. For rolling hard thin materials, it may be necessary to employ work rolls of very small diameter but of considerable length. In such cases adequate support of the working rolls can be obtained by using a cluster-mill.



EXTRUSION

Extrusion process is identical to the squeezing of tooth paste out of the tooth paste tube. In this process the heated billet of metal is enclosed in a closed cavity and then pushing it to flow from only one die opening so that the metal will take the shape of the opening. Pressure force is applied through hydraulically or mechanically.

Advantages of extrusion

Low cost per part

Flexibility of operation

In hot extrusion, post execution alterations are easy because product is still in heated condition

Continuous operation

High production volumes

Many types of raw materials can be used

Good mixing (Compounding)

Surface finish obtained is good

Good mechanical properties obtained in cold extrusion

Disadvantages of extrusion

Variations in size of product

Product limitations because of only one type of cross section can be obtained at a time

High initial cost setup

Applications of extrusion process

Electrical wires, bars and tubes are some of the items produced by hot extrusion

Collapsible tubes, gear blanks, aluminum cans, cylinders are some of the items produced by cold extrusion

Types of Extrusion

Extrusion can be broadly classified into two types:

- Hot Extrusion
- Cold Extrusion.

They are further categorized into the following categories:

Hot Extrusion

- Forward Extrusion
- Backward Extrusion

Cold Extrusion

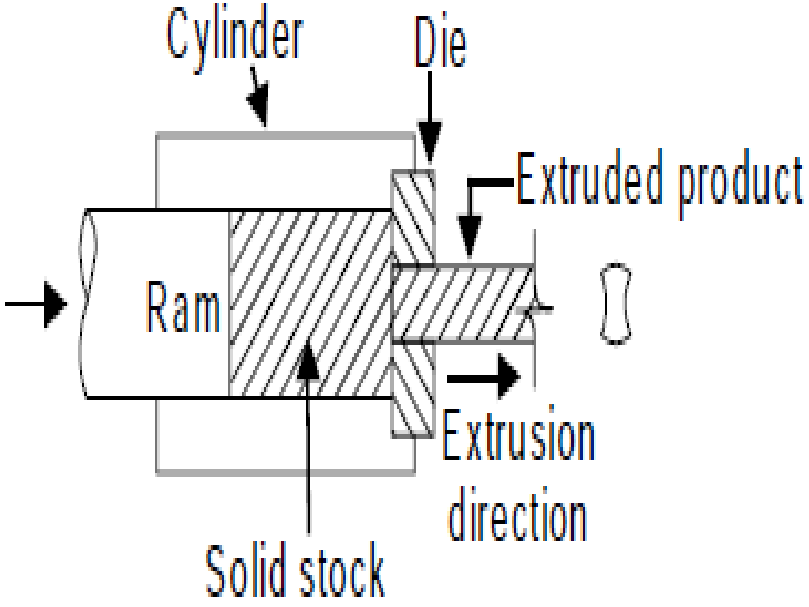
- Forward Extrusion
  - Hydrostatic Extrusion
  - Hooker Extrusion
- Backward Extrusion
  - Impact Extrusion
  - Cold Extrusion Forging

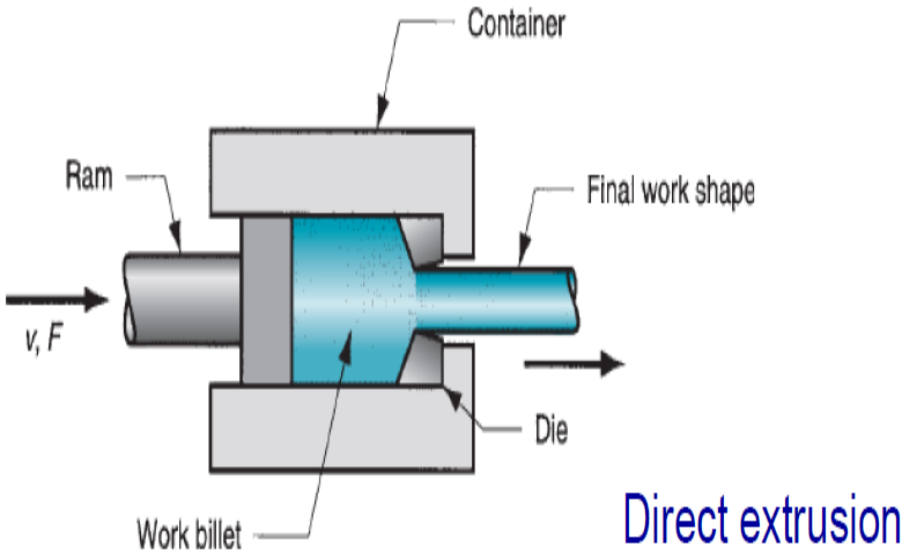
Some common extrusion processes are-

1. Direct or forward extrusion
2. Indirect or backward extrusion
3. Hydraulic extrusion

Direct or Forward Extrusion-

In direct extrusion method, the heated metal billet is placed in to the die chamber and the pressure is applied through ram. The metal is extruded through die opening in the forward direction, i.e. the same as that of the ram. In forward extrusion, the problem of friction is prevalent because of the relative motion between the heated metal billet and the cylinder walls.

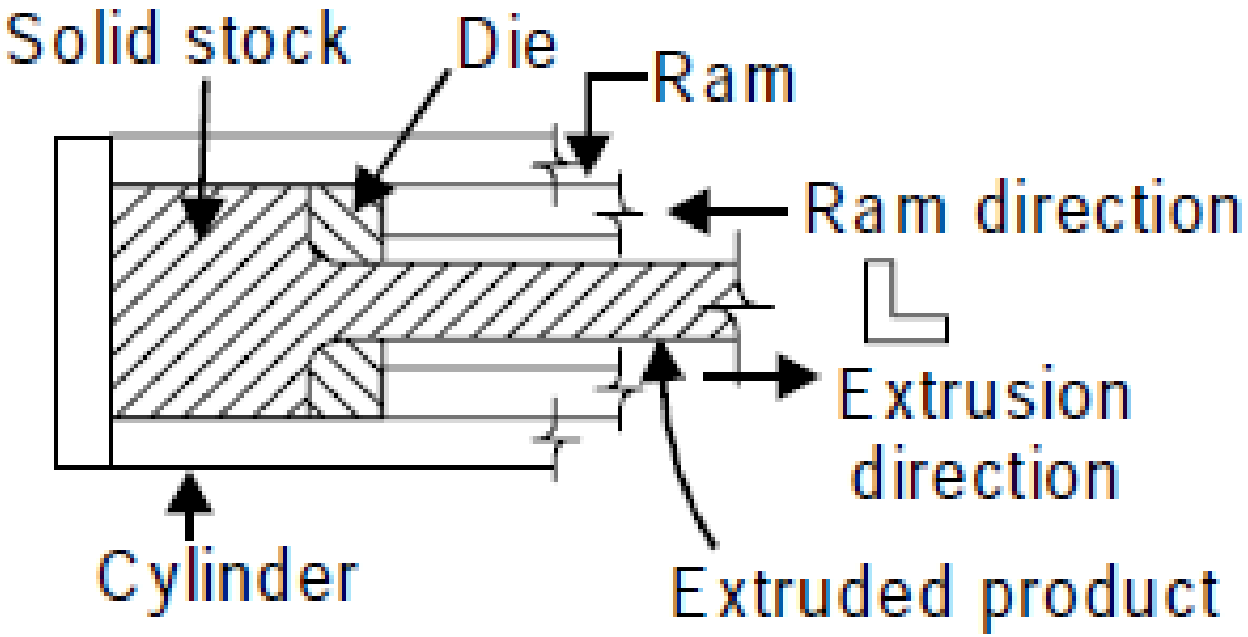




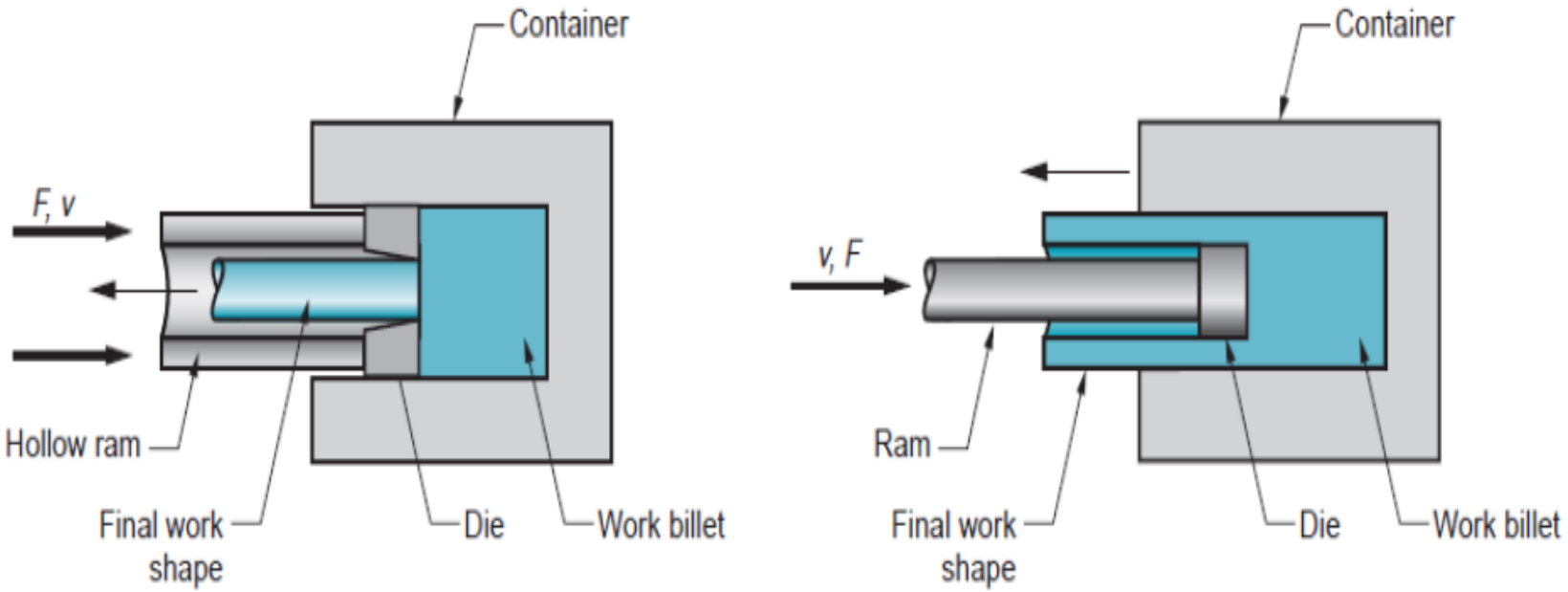
Direct extrusion

Indirect or Backward Extrusion

In indirect extrusion, the billet remains stationary while the die moves into the billet by the hollow ram (or punch), through which the backward extrusion takes place. Since, there is no friction force between the billet and the container wall, therefore, less force is required by this method. However this process is not widely used because of the difficulty occurred in providing support for the extruded part.



Indirect or Backward Extrusion



Indirect extrusion: solid billet and hollow billet

Hydraulic extrusion

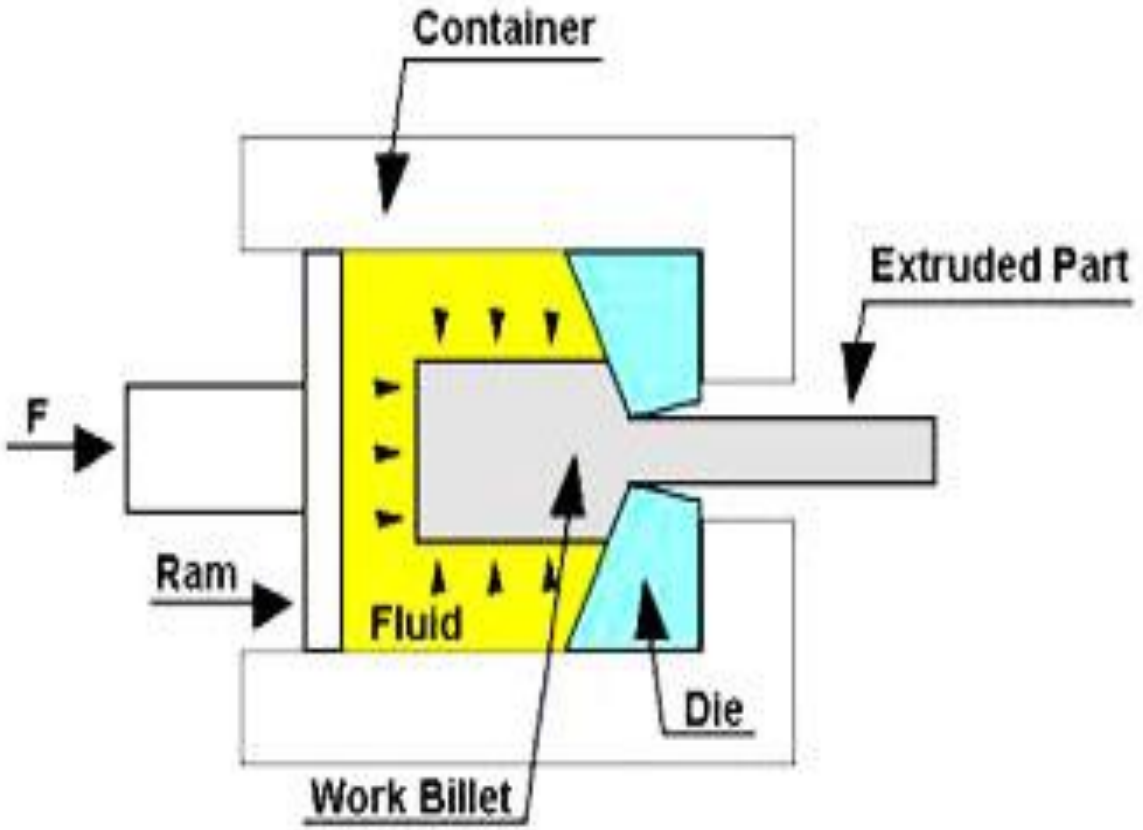
Hydraulic extrusion is a process in which the billet is completely circumscribed by a pressurized liquid in all the cases, with the exception being the case where billet is in the contact with die. This process can be carried out in many ways including warm, cold or hot but due to the stability of the used fluid, the temperature is limited. Hydrostatic extrusion has to be carried out in a completely sealed cylinder for containing the hydrostatic medium.

Conti..

The fluid may be pressurized in following two ways:

1. Constant-Rate Extrusion: A ram or plunger is used for pressurizing the fluid in the container

2. Constant-Pressure Extrusion: A pump with a pressure intensifier is used for pressurizing the fluid, which is then pumped into the container



Hydraulic extrusion

Advantages

- No friction amidst the container and billet. This minimizes the force requirements, allowing higher reduction ratios, faster speeds, & lower billet temperatures.
- Friction of the die can be largely reduced by a film of pressurized lubricant amidst the die surface and deforming metal.
- On applying high pressures, the ductility of material increases.
- Large billets & large cross-sections are extruded.
- Uniform hydrostatic pressure inside the container eliminates the requirement of billets being straightened and extrusion of coiled wire.
- No billet residue is left on the walls of container.