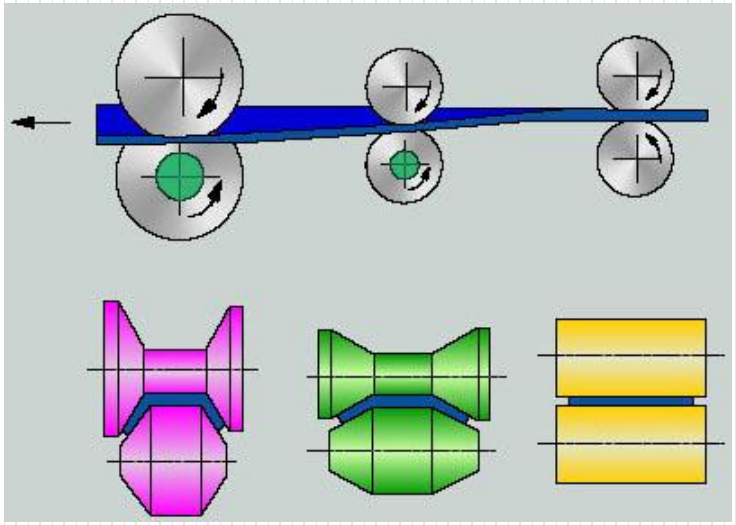
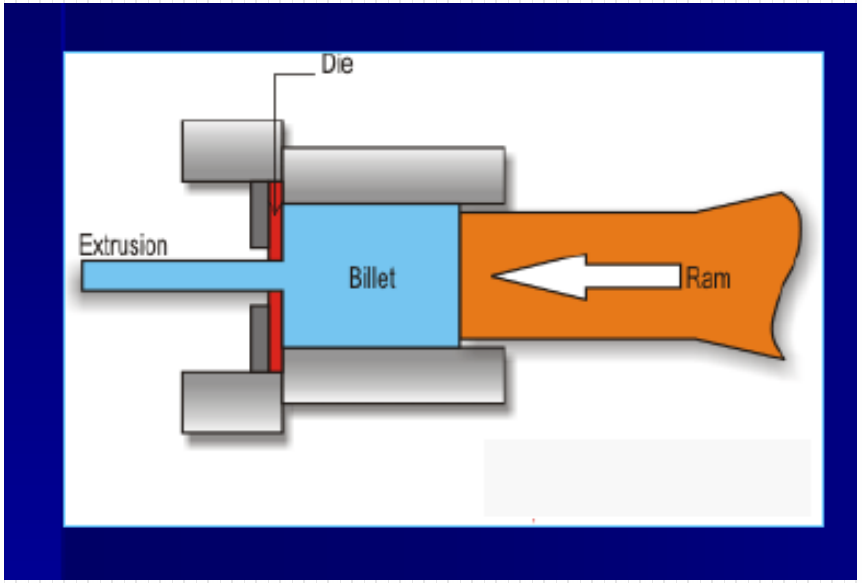
Metal Forming Process





Prof. A. Chandrashekhar

Introduction

- Shaping of a component by the application of external forces is known as the metal forming.
- Metal forming can be described as a process in which the desired size and shape are obtained through the deformation of metals plastically under the action of externally applied forces.
- It is also known as bulk deformation processes, plastic working.

Metal Forming Process

- The process of metal forming is carried out on machines called metal forming machines.
- Metal forming processes can be carried out in Hot or Cold conditions.
- Metal forming processes involve the application of tensile, compressive, shear or a combination of these forces.

Classification of metal forming processes

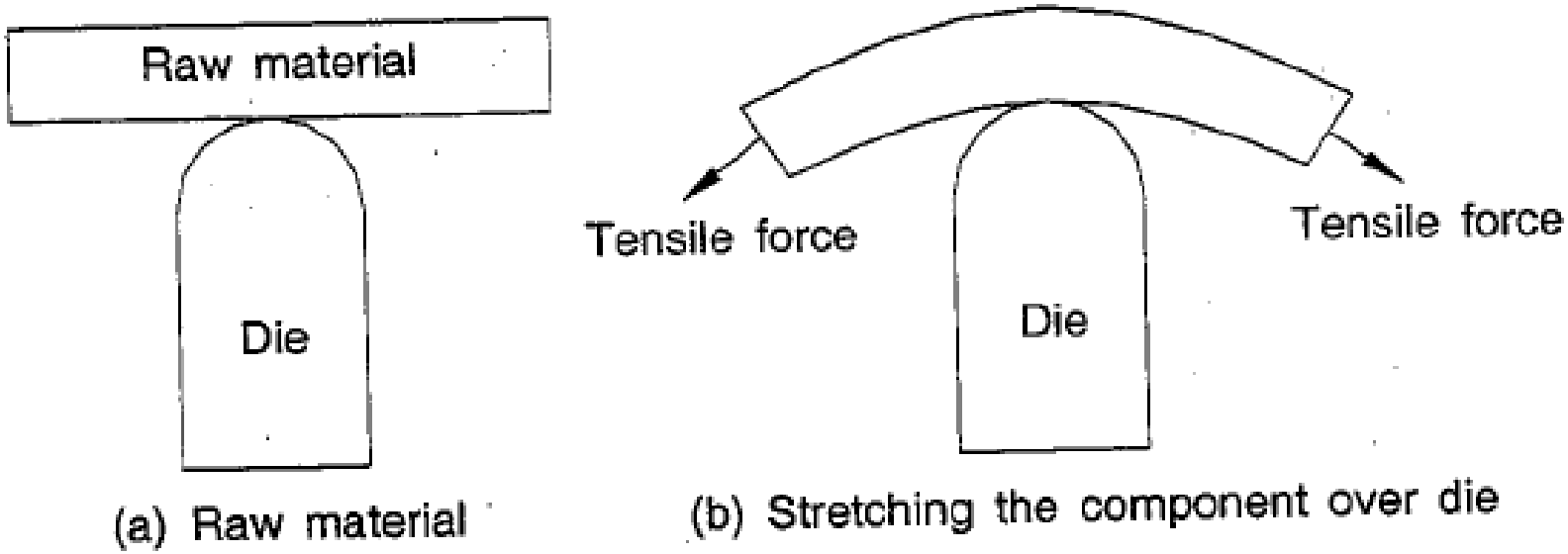
1 Metal forming processes involving compressive stresses:
(a) Forging, (b) Rolling, and (c) Extrusion.

2 Metal forming processes involving tensile stresses:
(a) Stretch forming, (b) Creep forming, and (c) Vacuum forming.

3 Metal forming processes involving shearing stresses:
(a) Shearing, (b) Blanking, and (c) Fine blanking.

4 Metal forming processes involving the combinations of tensile and compressive stresses:
(a) Wire drawing, (b) Deep drawing, and (c) Ironing.

Typical component to be produced.



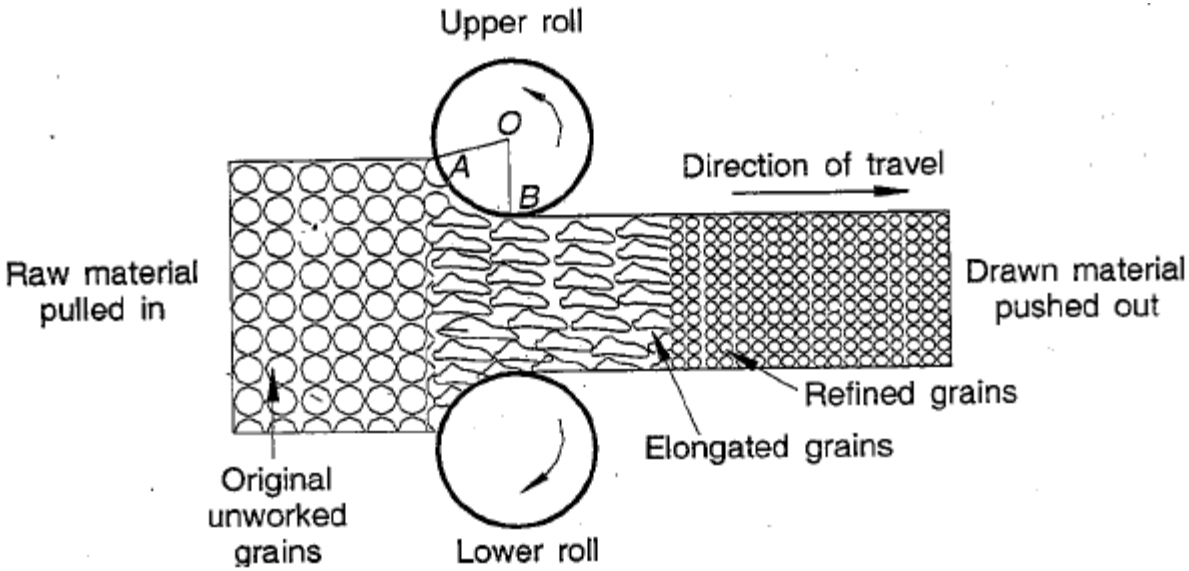
(a) Raw material (b) Stretching the component over die

Producing the desired shape by metal forming.

Rolling Process

- The process of shaping metals and alloys in to semi finished or finished condition by passing between the rolls is known as rolling.
- This process involves the plastic deformation of the metal in which the thickness of the metal reduced, while the length and width are increased.
- Ex: rails for railway lines.

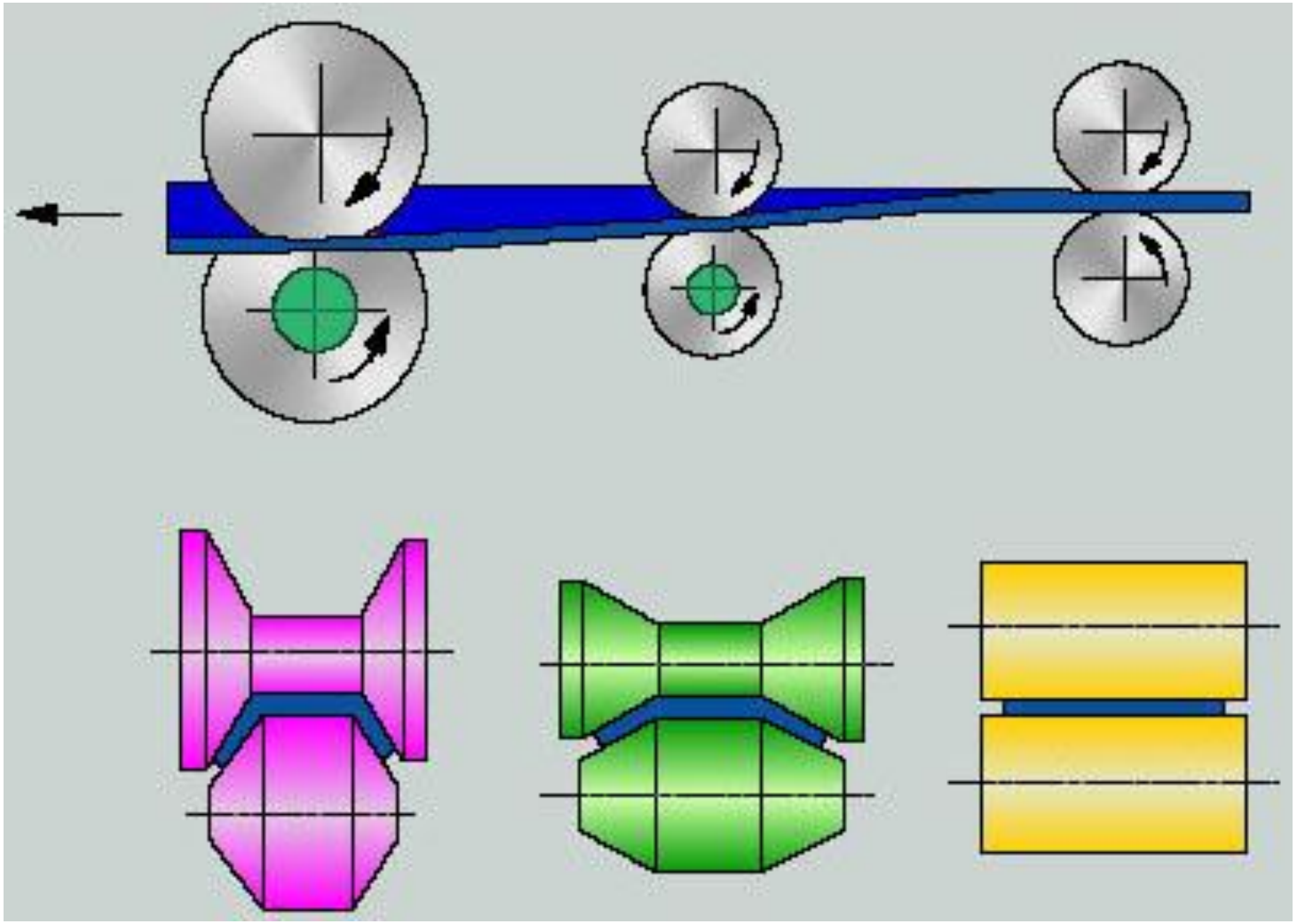
Rolling operation

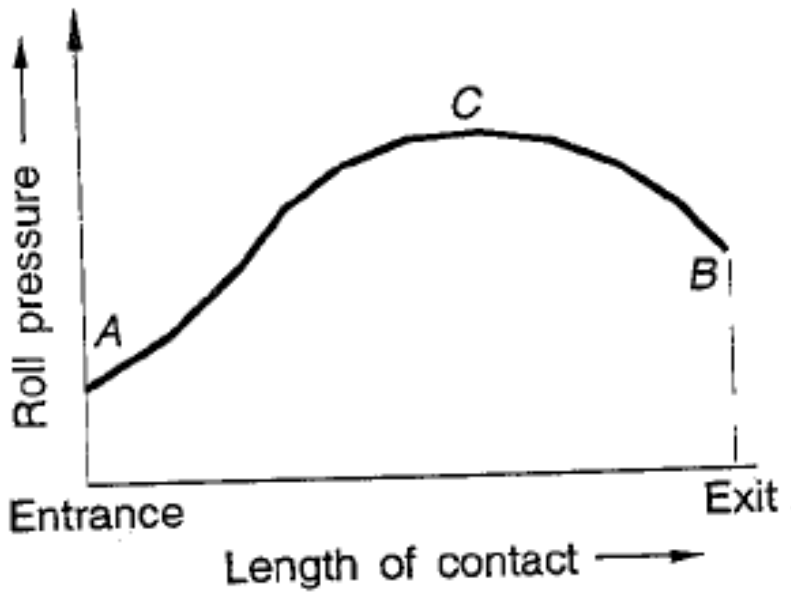


Rolling process and deformation of grains in rolling.

Angle AOB is known as angle of contact or angle of bite.

Roll forming Process





Pressure variation in rolling.

Terminology used in rolling

Ingot:

1. It is the initial product obtained by the casting of molten metal.
2. It may be circular, square or any other convenient cross-section.

Bloom:

1. It is obtained by the hot rolling of an ingot.
2. It is the product of first rolling down of the ingot.
3. It is usually of square cross-section with a cross sectional area above 225 cm^{2}.

Billet:

1. The minimum cross sectional area of the billet is about 4 cm by 4 cm.
2. A billet is any ingot which has been subjected to the hot working by rolling, and forging or the term refers to a casting which is suitable for the hot working.

Slab:

A slab refers to a hot rolled ingot with a cross-sectional area greater than 100cm^2 and a width at least twice the thickness.

Plate and Sheet:

1. These are intermediate products obtained by rolling.
2. The difference between a plate and a sheet is determined by the thickness of the product.
3. In general, plate has a thickness greater than 6mm and sheet has a thickness less than 6mm.

Sheet and strip:

1. These are rolled products with a thickness less than 6mm.
2. Strip refers to the rolled product with a width less than 300mm, while sheet refers to the product of width above 300mm.

Rolling Parameters

- Let

  l_1 be the initial length

  b_1 be the initial breadth and

  T_1 be the initial thickness of the work piece

Similarly,

Let l_1,b_2 and t_2 represent final length, breadth and thickness of work piece after rolling.

Absolute draught : (draft)

The difference between the initial and final thickness of the metal being rolled.

$$\delta_t = t_1 - t_2$$

The maximum possible draft is given by

$$\delta_{max} = \mu^2 R$$

where

μ = coefficient of friction between roll and work

R = radius of roll.

- Absolute elongation:

  it is the difference between the final and initial length of the work piece being rolled.

$$\delta_l = l_2 - l_1$$

Absolute Spread:

it is the difference b/w final and initial breadth of the work piece being rolled.

$$\delta_b = b_2 - b_1$$

Relative Draught:

it is the ratio of absolute draught to initial thickness of the work piece expressed as percentage of the same,

$$R_t = \frac{\delta_t}{t_1} \times 100$$

Elongation Coefficient:

it is the ratio of final length to initial length,

$$\mu_L = \frac{l_2}{l_1}$$

Angle of contact:

It is the angle subtended at the centre of the roll by the arc of contact AB. If ∞ is the angle of contact,

$$\cos \alpha = 1 - \frac{\delta_t}{D}$$

where D = diameter of the roll.

Coefficient of friction:

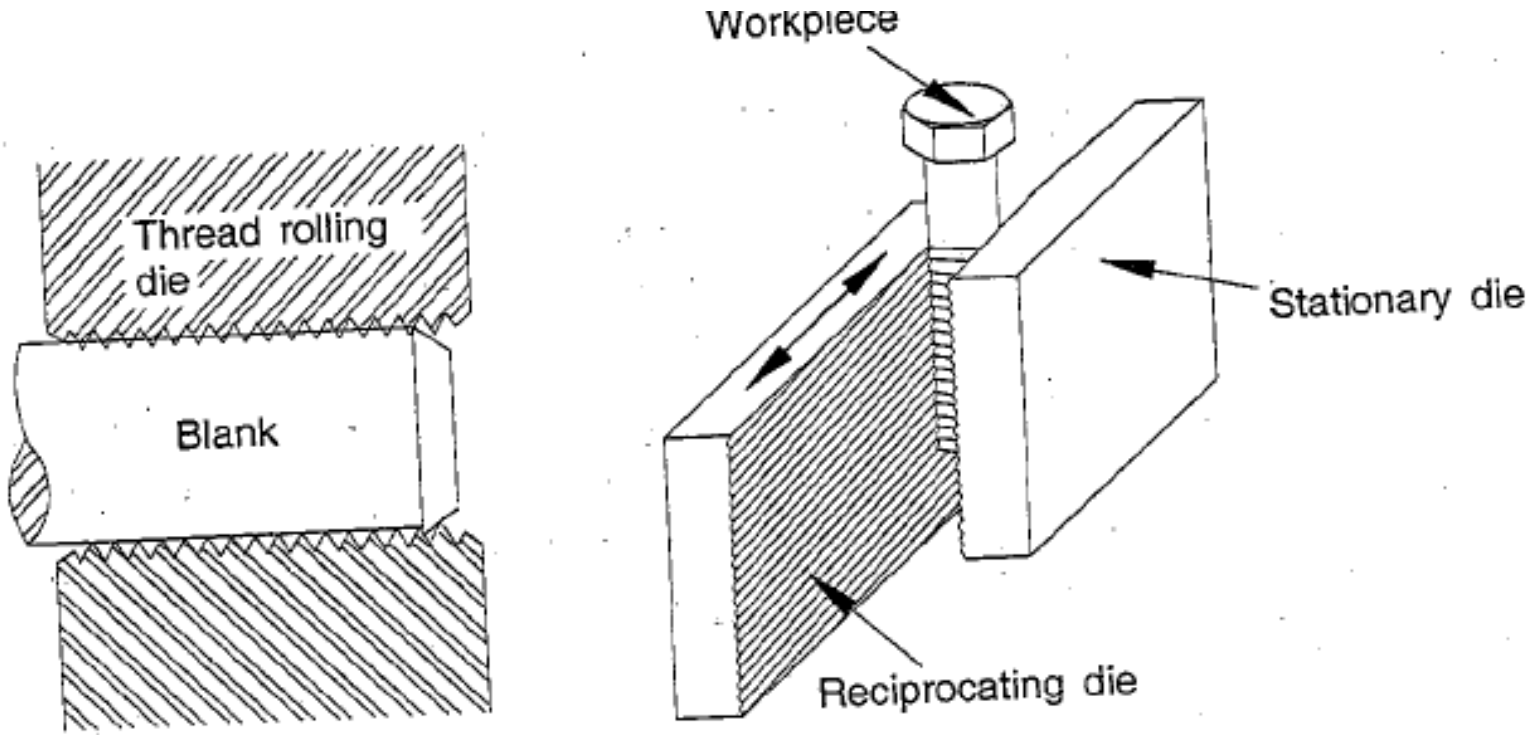
Coefficient of friction B/w roll and the work is

$$\mu = \tan \alpha$$

Thread rolling

- It is essentially a cold working process in which a cylindrical work piece, having a diameter approximately equal to the pitch diameter of the required thread, is rotated between hard dies having the negative contour of the threads to be formed.
- The part to be threaded is rolled between two flat dies – one stationary and the other reciprocating.

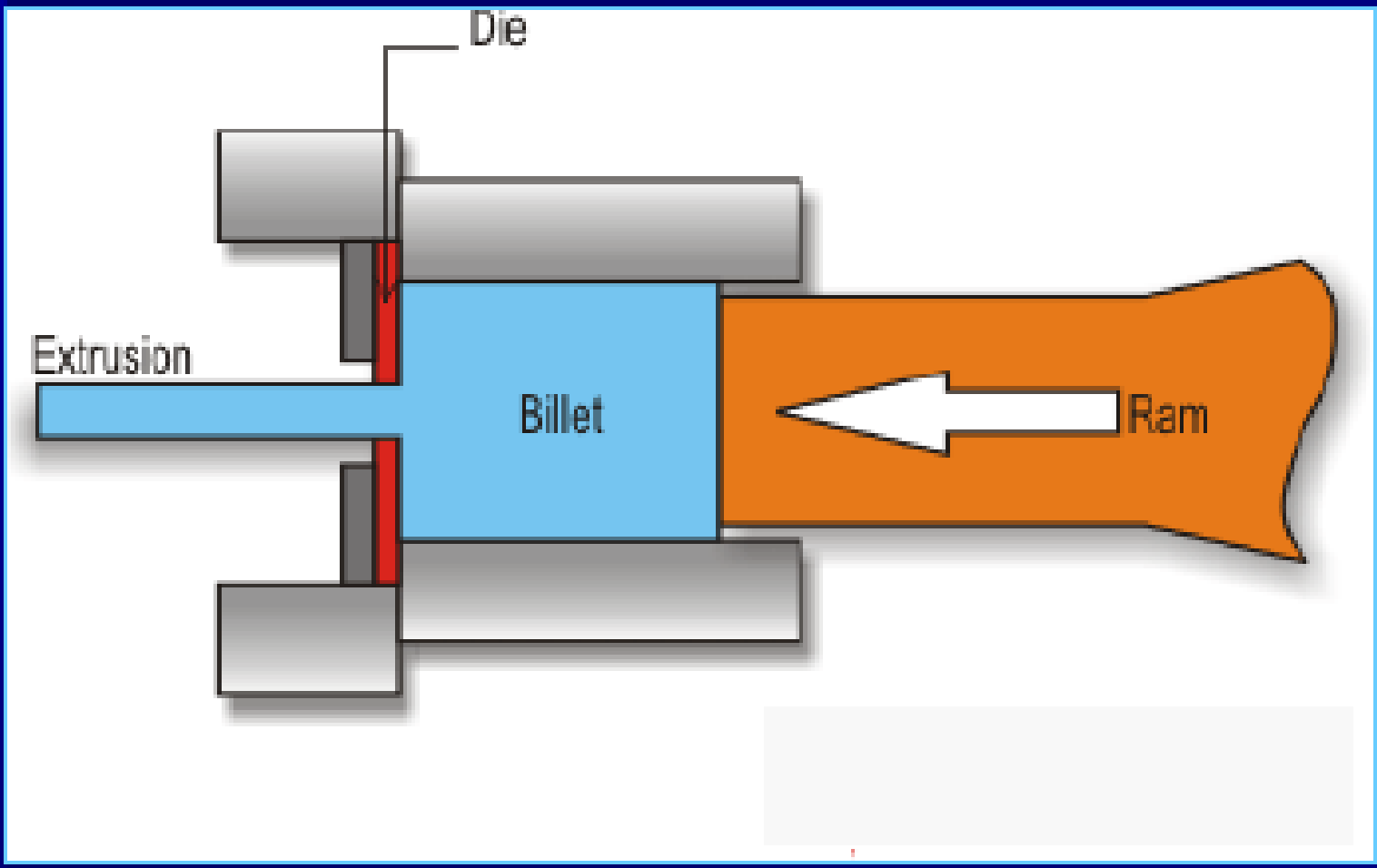
Thread Rolling



Thread rolling.

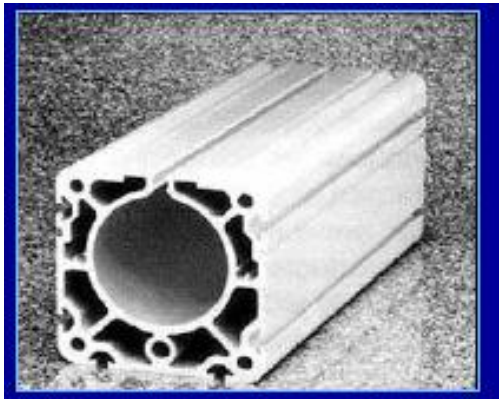
Extrusion Process

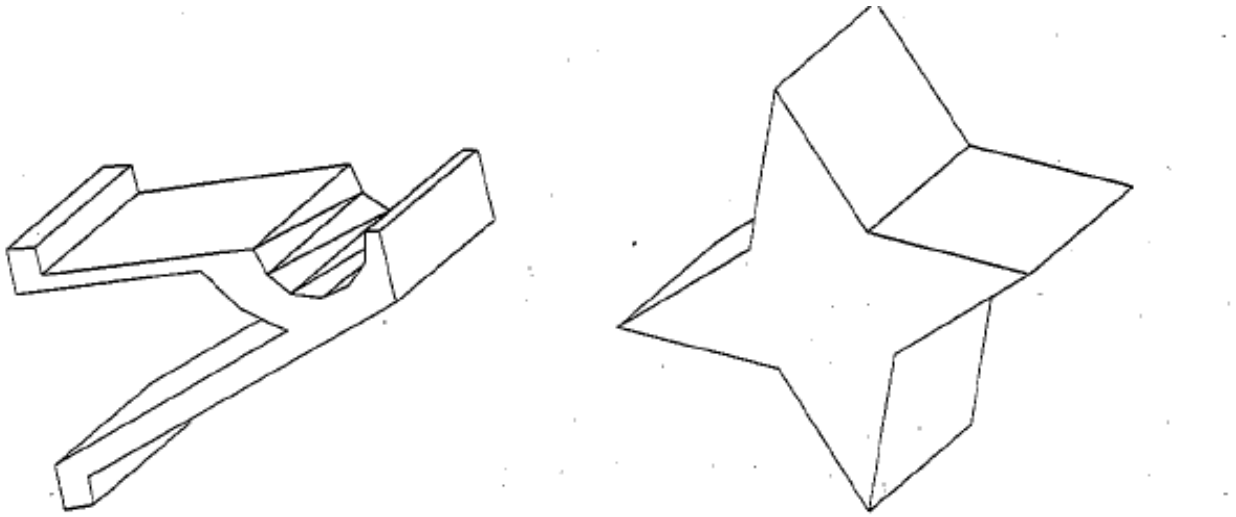
- It is the process by which a block of metal is reduced in cross section by forcing it to flow through a die orifice under high pressure.
- The extrusion process may be done either in cold or in hot condition.
- If extrusion process is done at room temperature or slightly elevated temp. , it is called cold extrusion process.
- Hot extrusion process is done at fairly high temps, approximately 50 to 70 % of the melting point of the metal.


Die
Extrusion
Billet
Ram

Extrusion products

Aluminium for windows and doors





Cross-sections of products made from extrusion process.

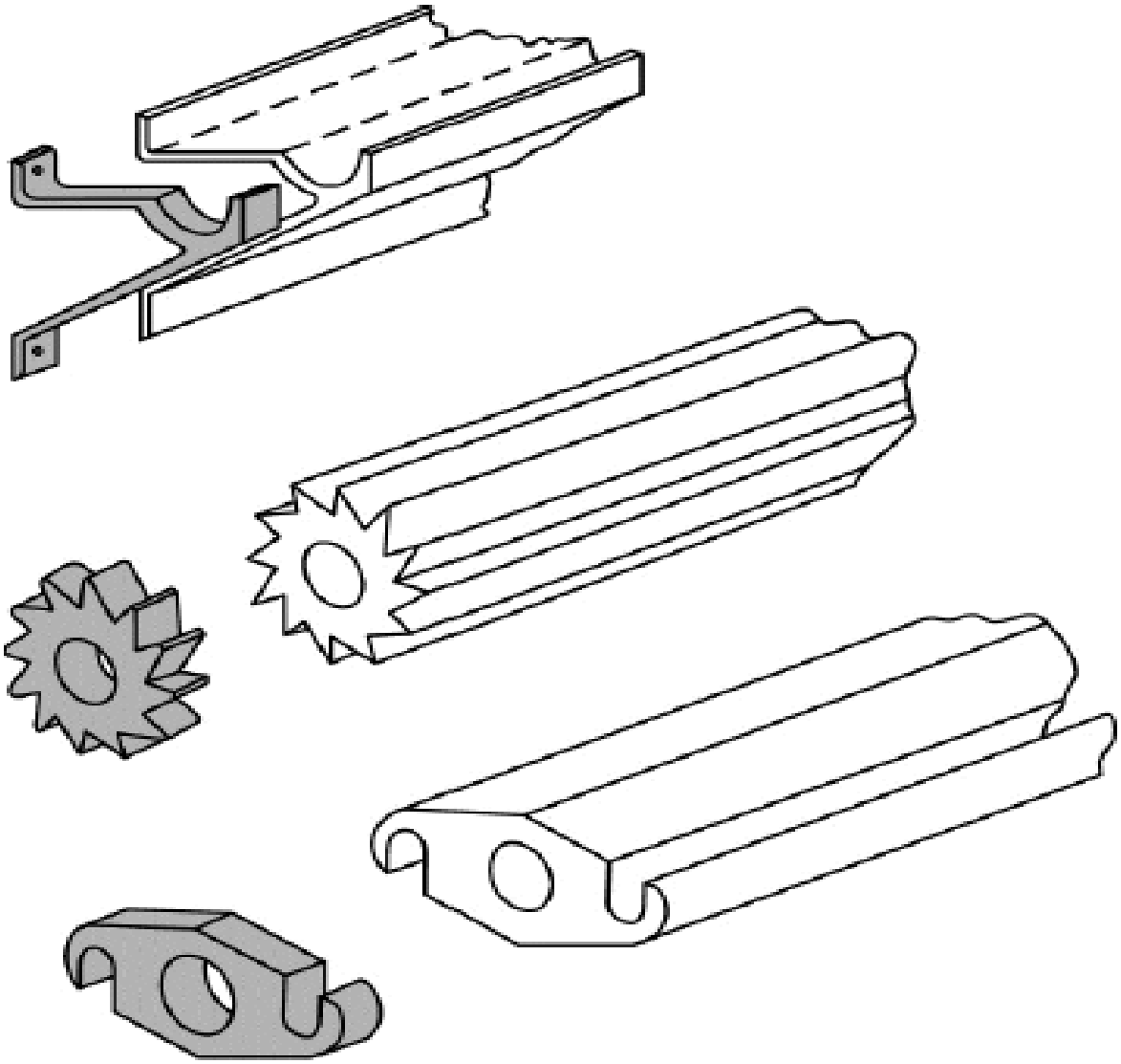


Fig : Extrusions and examples of products made by sectioning off extrusions.

TYPES OF EXTRUSION

- Based on direction of flow and application of force:

1. Direct Extrusion (forward Extrusion)
2. In Direct Extrusion (Backward Extrusion)
3. Impact Extrusion
4. side Extrusion
5. Tube Extrusion

Classification of extrusion processes

There are several ways to classify metal extrusion processes;

By direction

- Direct / Indirect extrusion
- Forward / backward extrusion

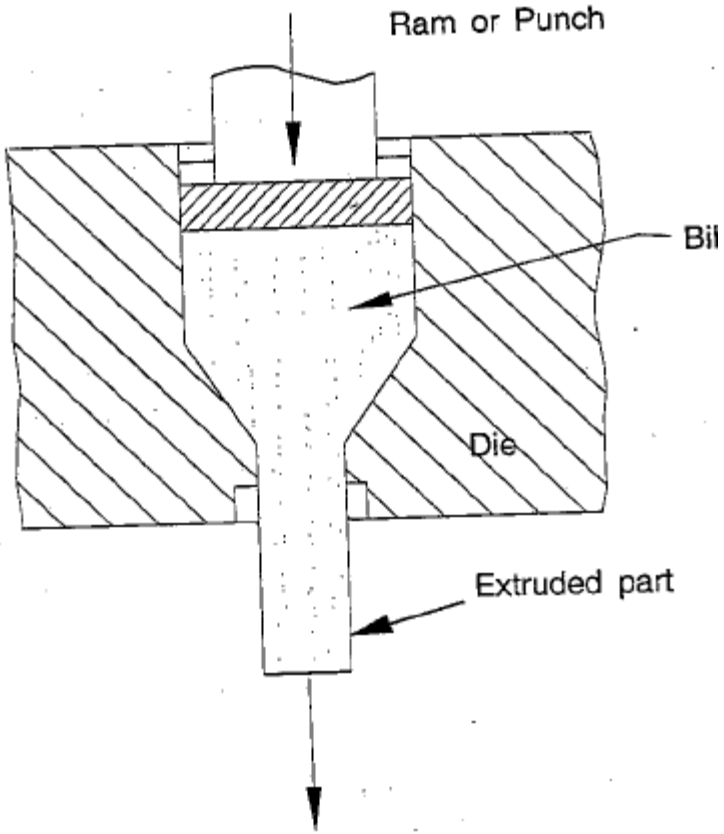
By operating temperature

- Hot / cold extrusion

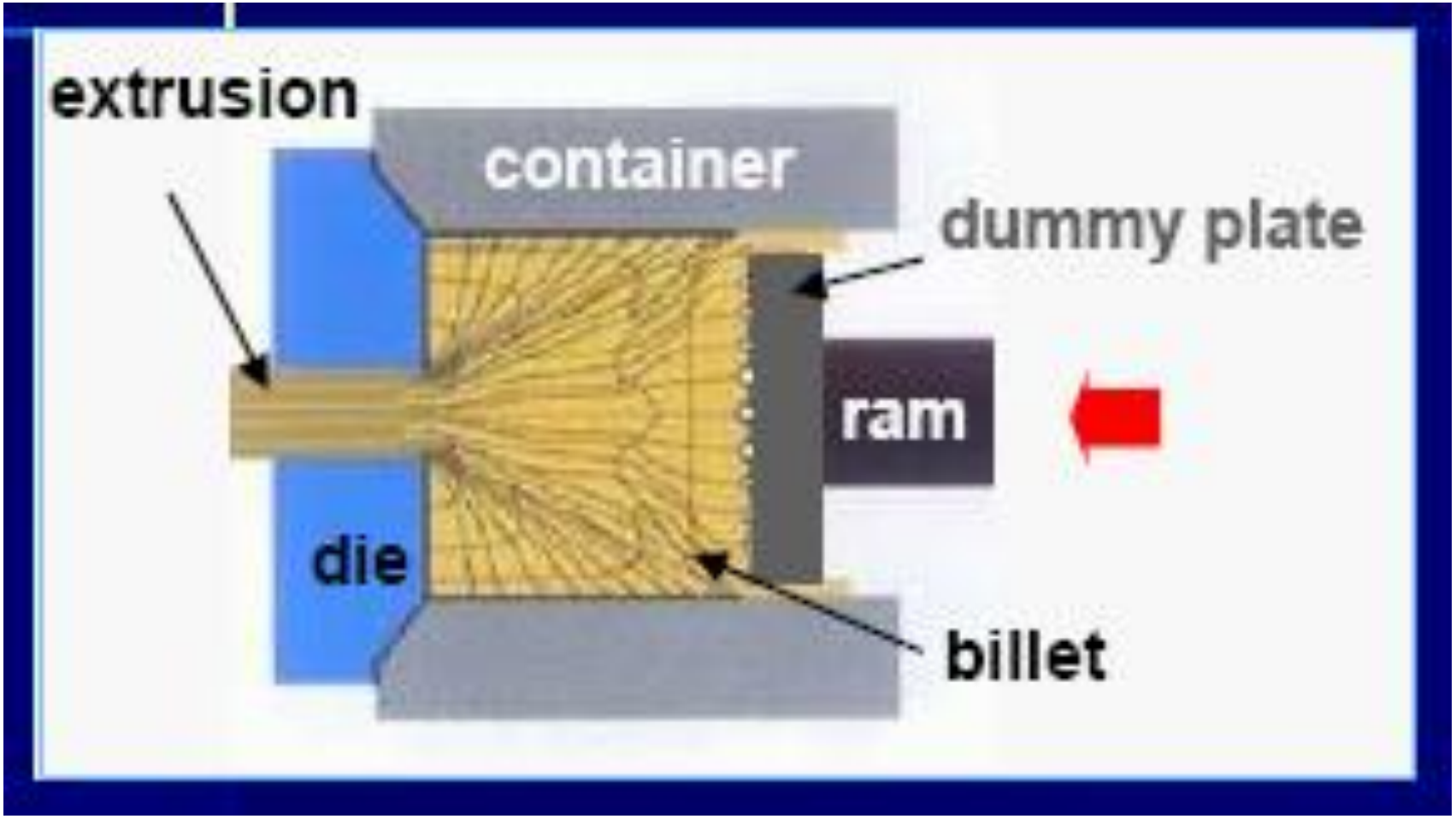
By equipment

- Horizontal and vertical extrusion

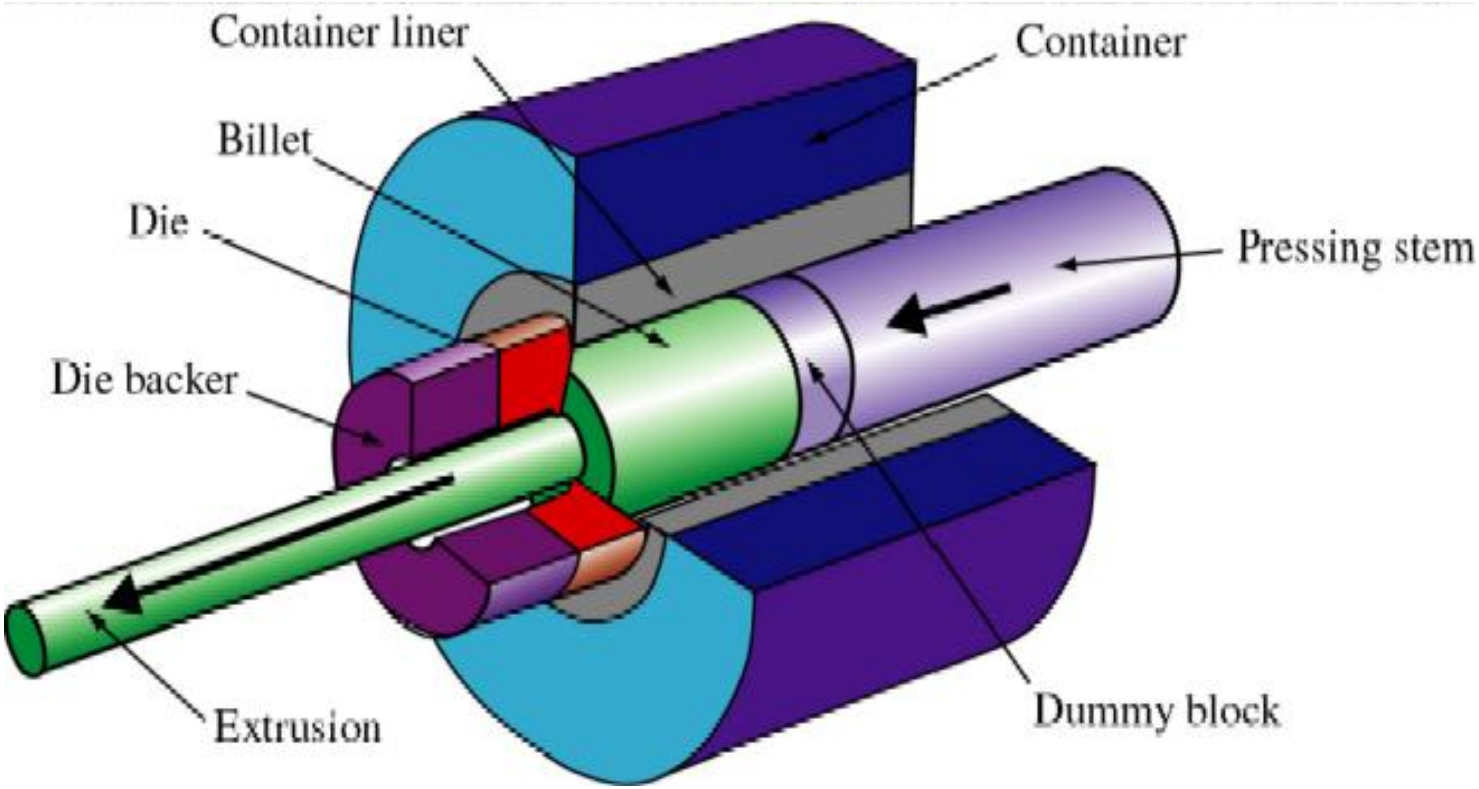
Direct Extrusion (forward Extrusion)



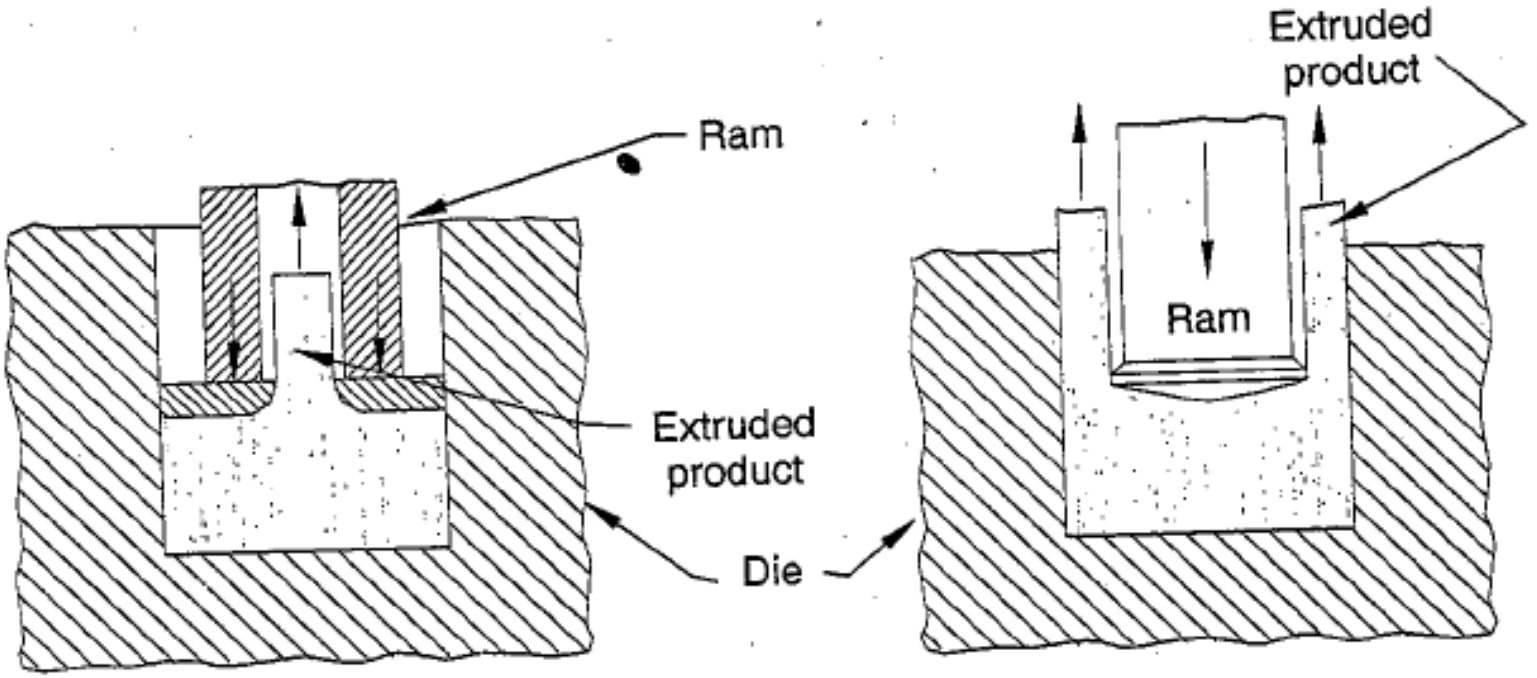
Direct or forward extrusion.


extrusion
container
dummy plate
ram
die
billet

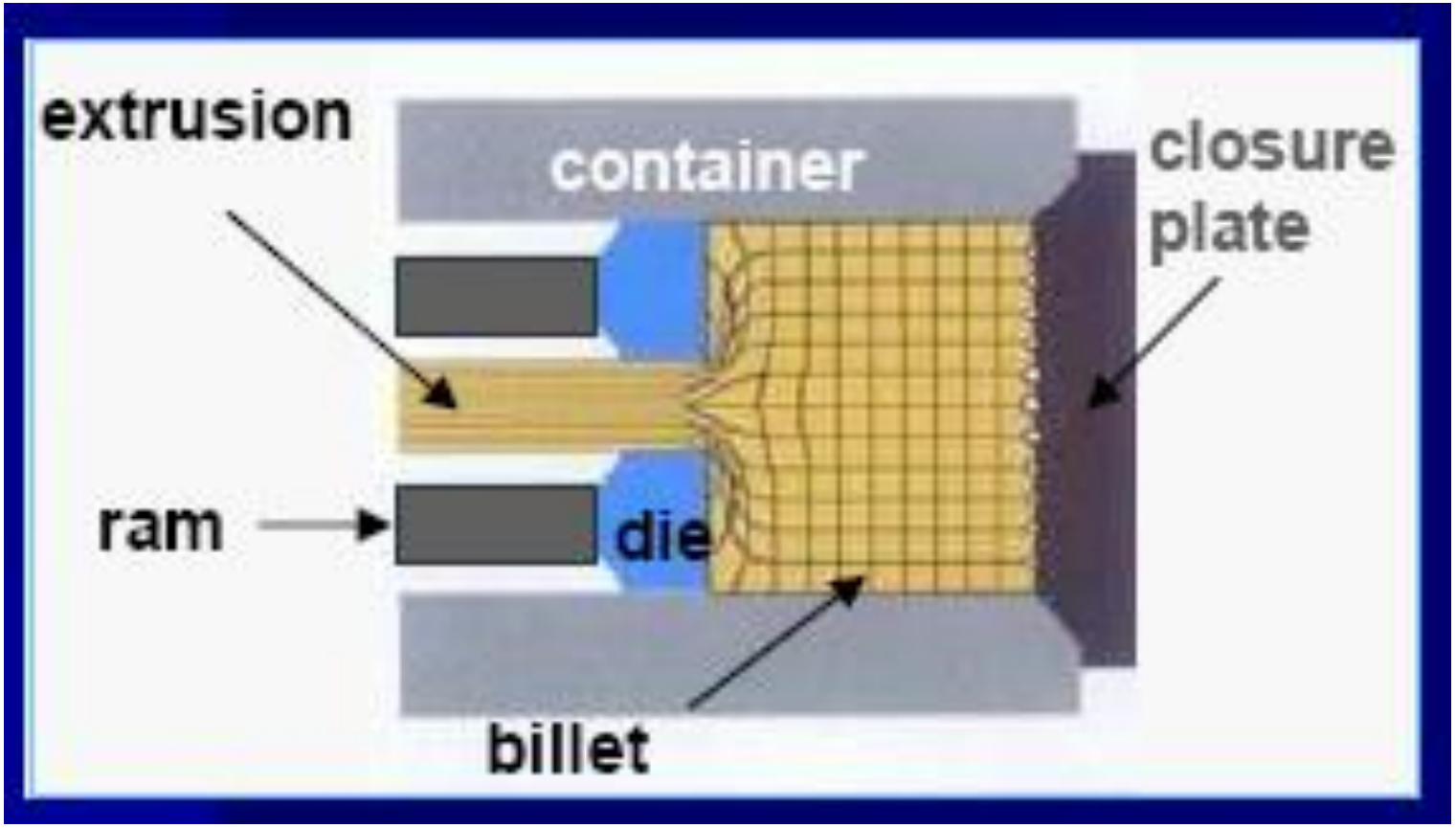
Direct Extrusion



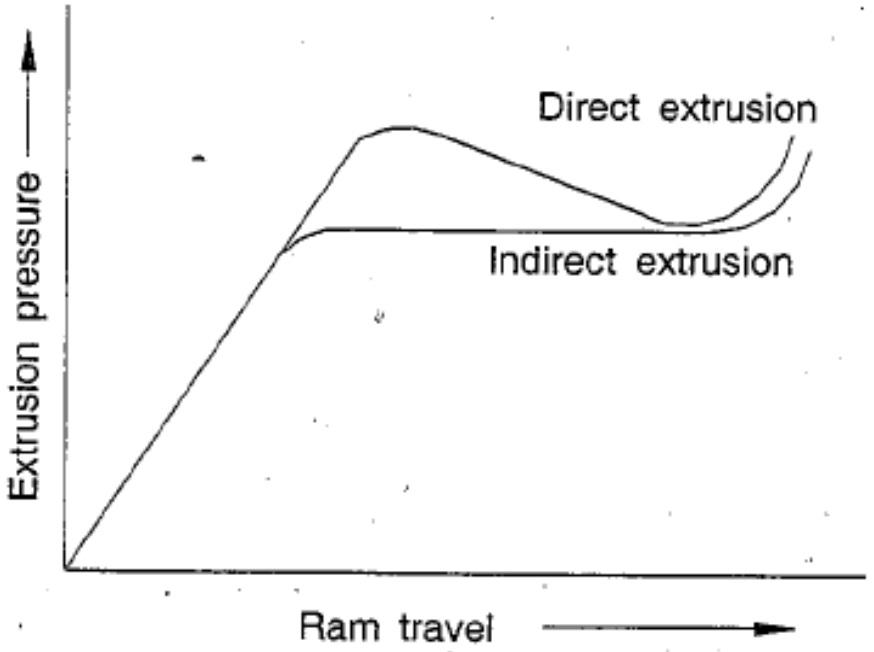
Indirect Extrusion (Backward Extrusion)



Indirect or backward extrusion.

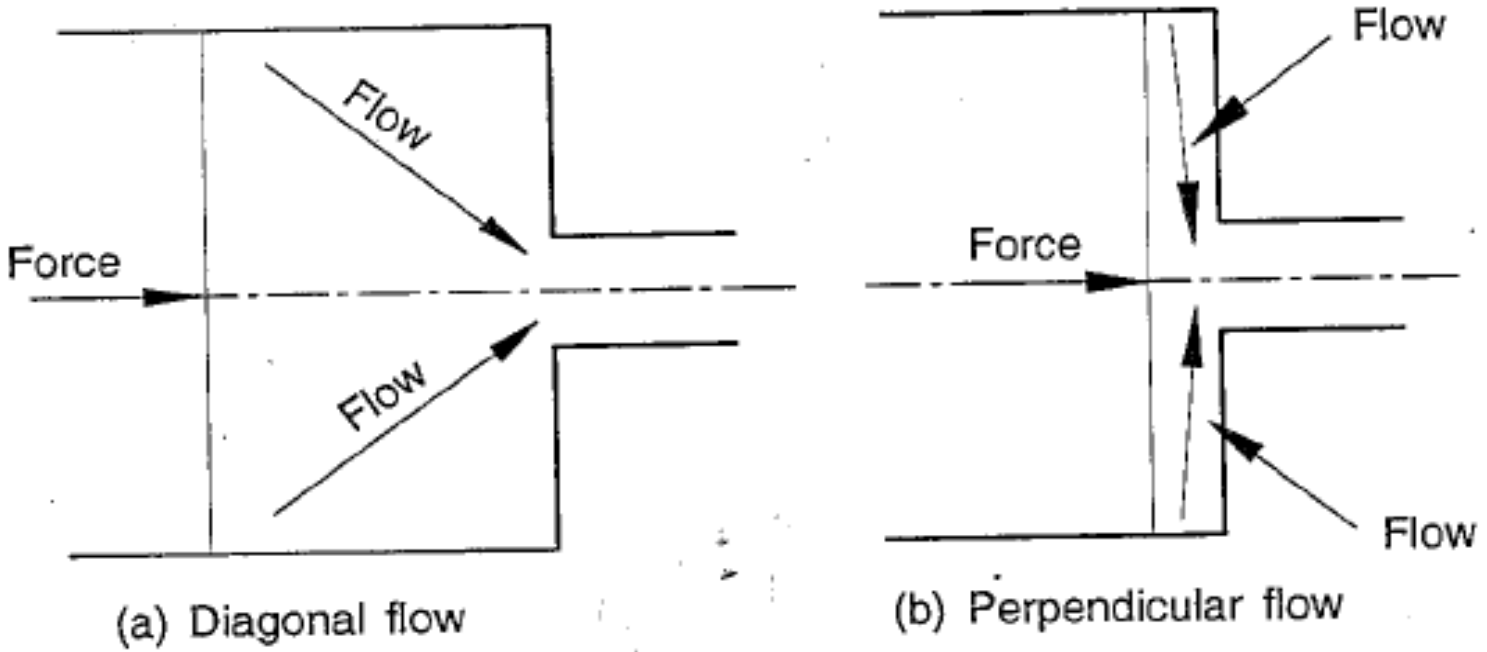

extrusion
container
closure
plate
ram
die
billet

Extrusion pressure in direct and indirect extrusion

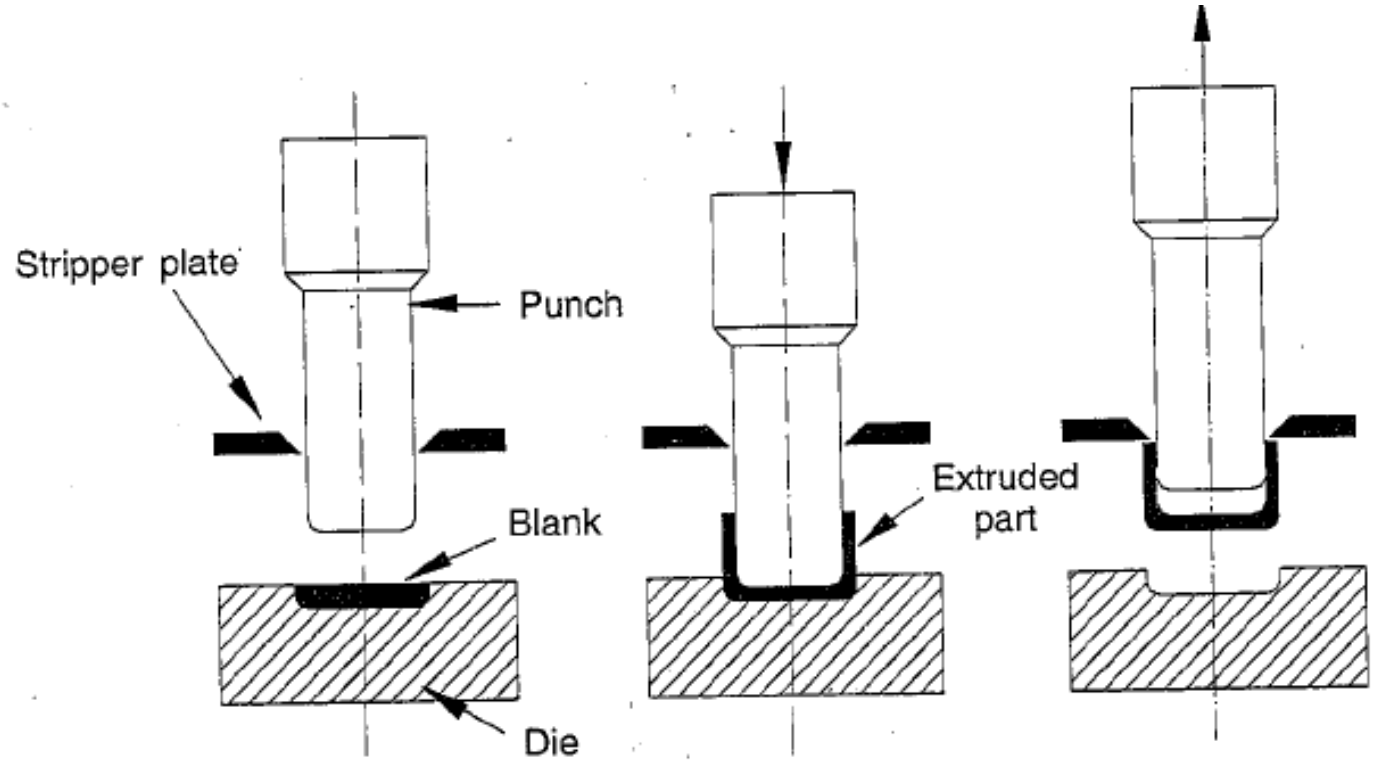


Variation of extrusion pressure in direct and indirect extrusion

Direction of Flow of metal in the Extrusion Chamber

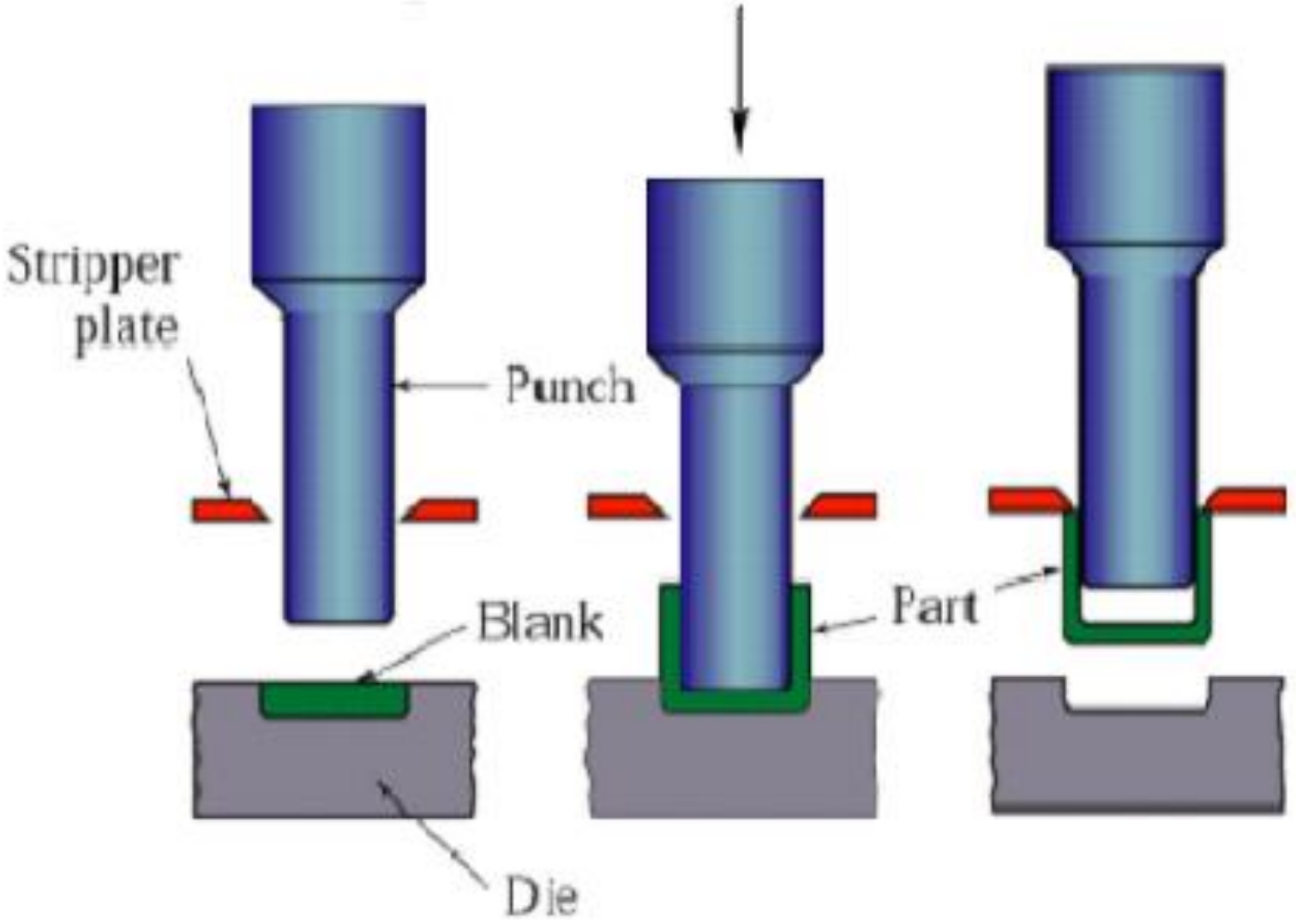


Impact Extrusion



Impact extrusion process.

** Small objects, soft metal, large numbers, good tolerances*.*

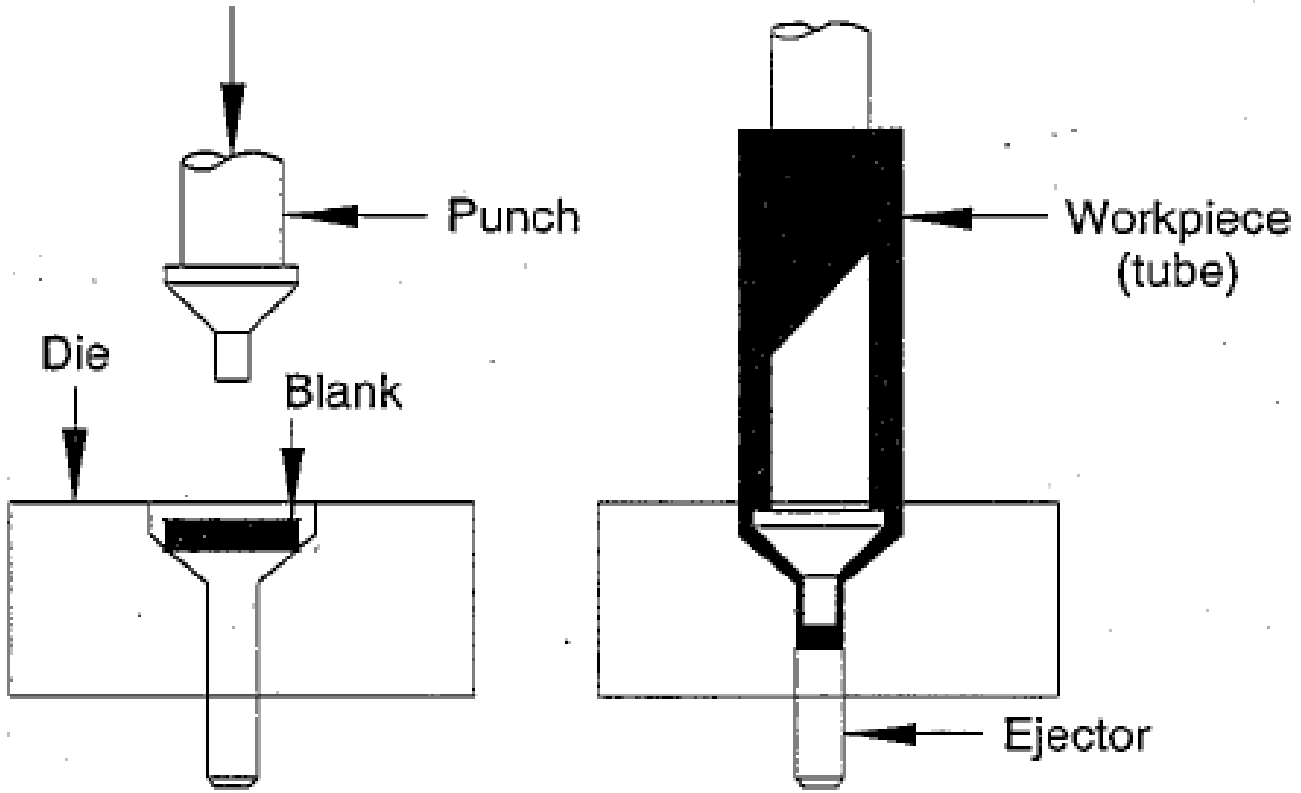

Stripper plate
Punch
Blank
Part
Die

- Produce ***short lengths of hollow shapes***, such as collapsible toothpaste tubes or spray cans.

- Requires ***soft materials*** such as aluminium, lead, copper or tin are normally used in the impact extrusion.

- A small shot of solid material is placed in the die and is impacted by a ram, which causes cold flow in the material. It may be either direct or indirect extrusion and it is usually performed on a ***high-speed mechanical press***.

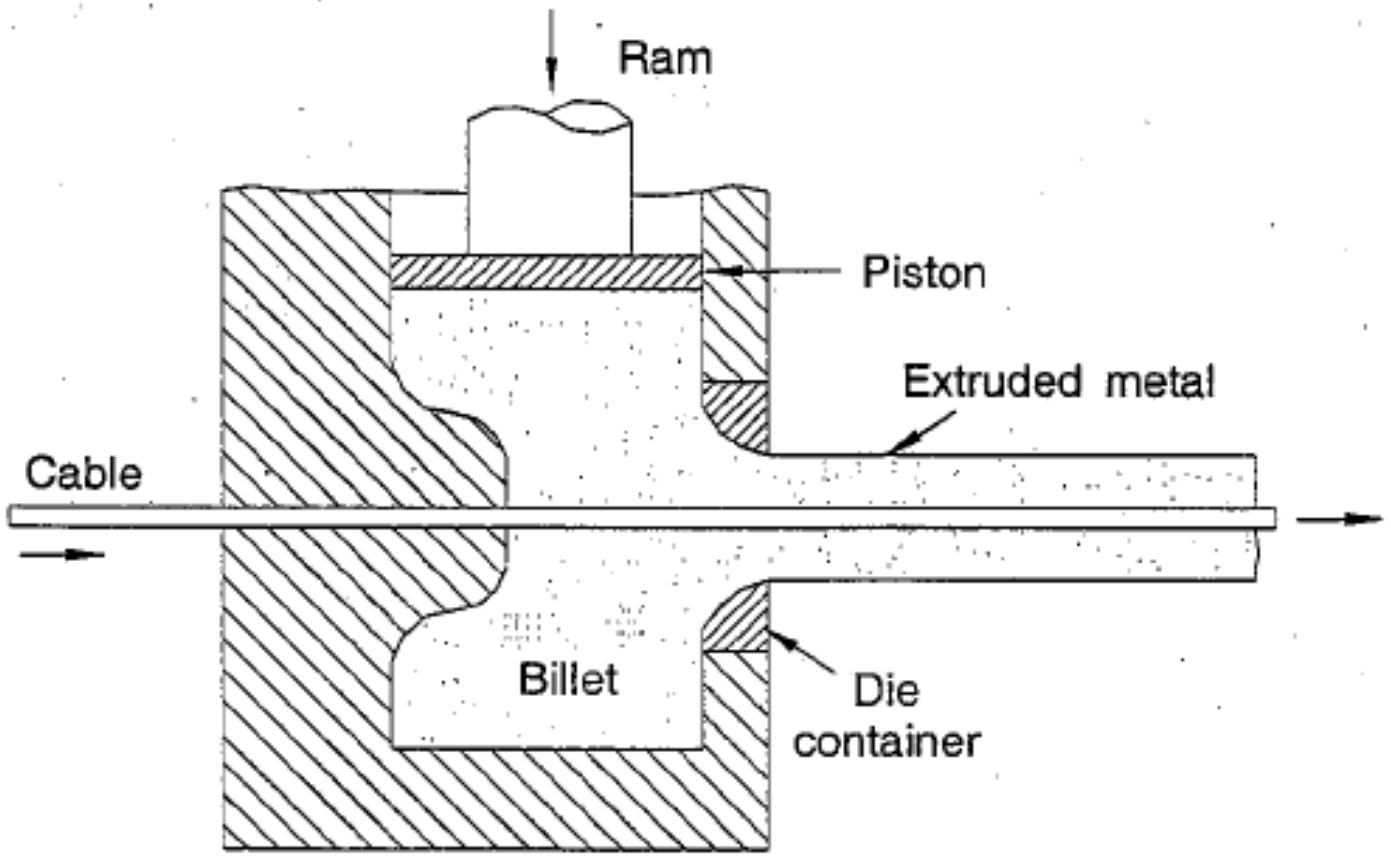
- Although the process is generally performed cold, considerable heating results from the ***high speed deformation***.



Impact extrusion of collapsible tube with a nozzle.

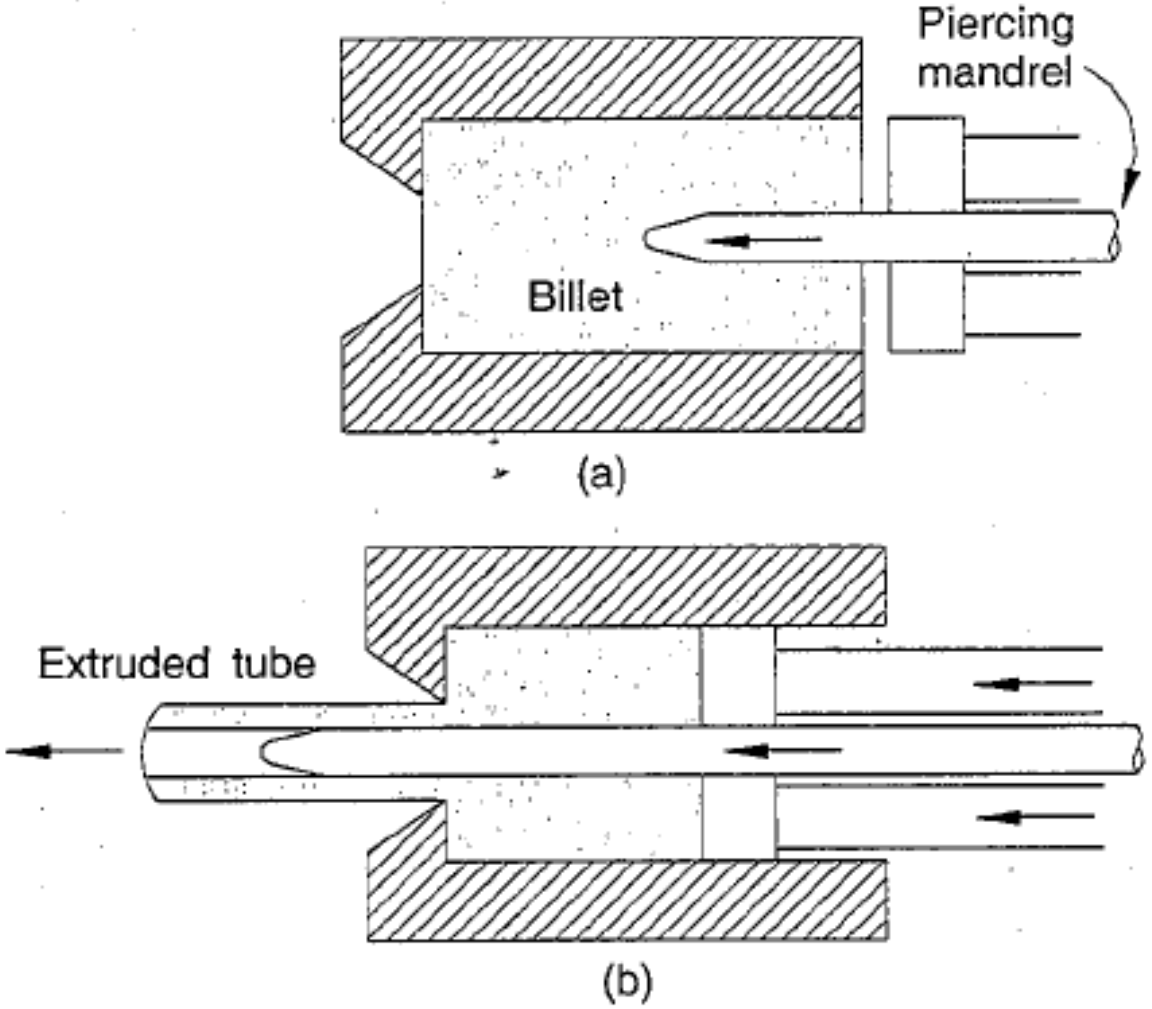
Side Extrusion

Generally used in the case of nonferrous metals or highly plastic materials like lead.

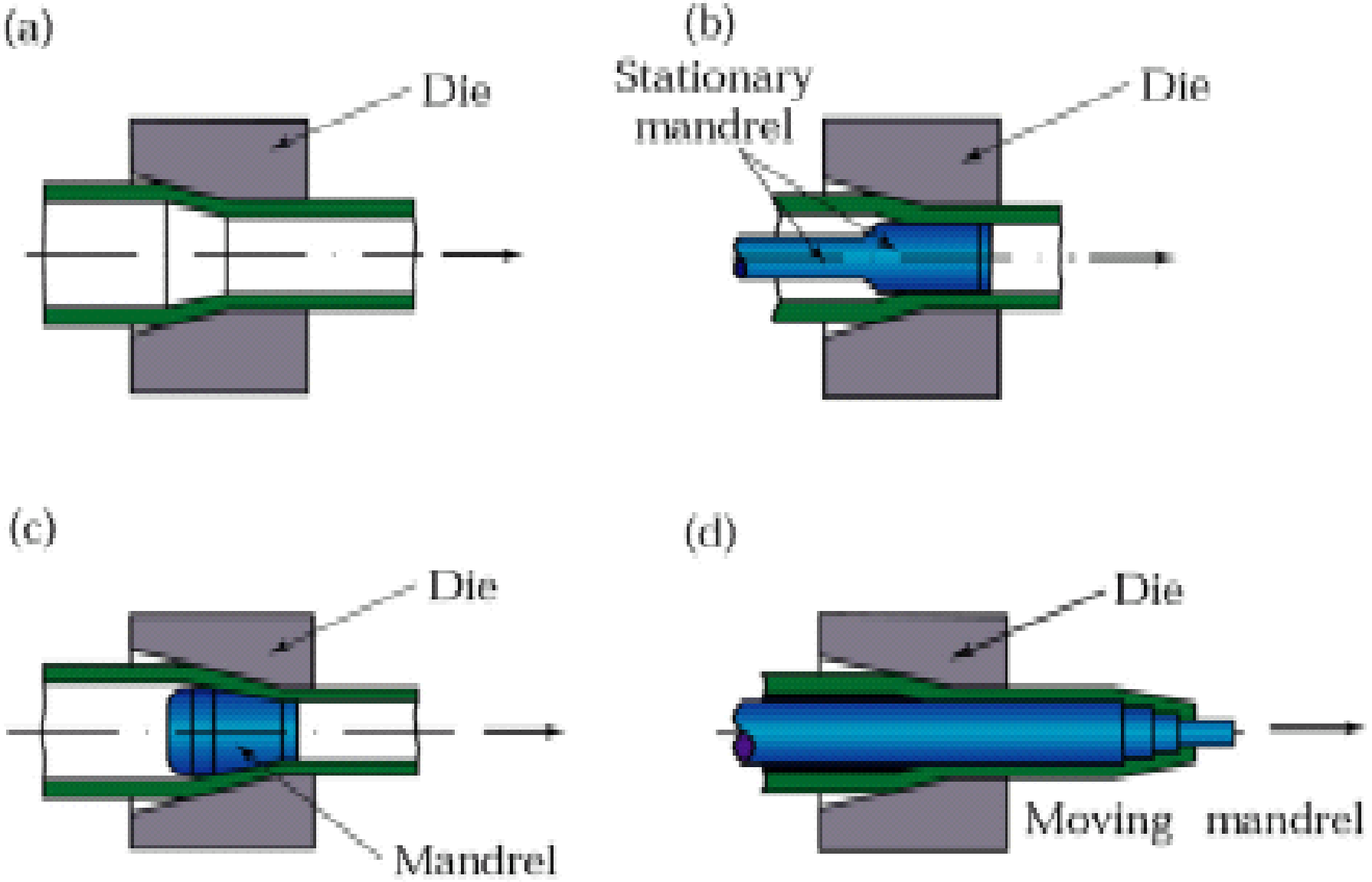


Side extrusion process.

Tube Extrusion



Tube extrusion process.


(a)
Die
(b)
Stationary
mandrel
Die
(c)
Die
Mandrel
(d)
Die
Moving mandrel

Forging process

- It is a process in which the metal is first heated and then shaped by the plastic deformation.
- The material to be forged is heated to a temperature at which its elastic properties entirely disappear, it becomes soft and obeys the laws of plastic flow, following the direction of least resistance, when deformed by pressure.
- Forging refines the grain structure and improves physical properties (strength, ductility and toughness) of the metal.
- Forging produces products, which are consistent from piece to piece, without any porosity, voids, inclusions and other defects as in the case of casting.

The process of forging involves the application of compressive forces to shape the material.

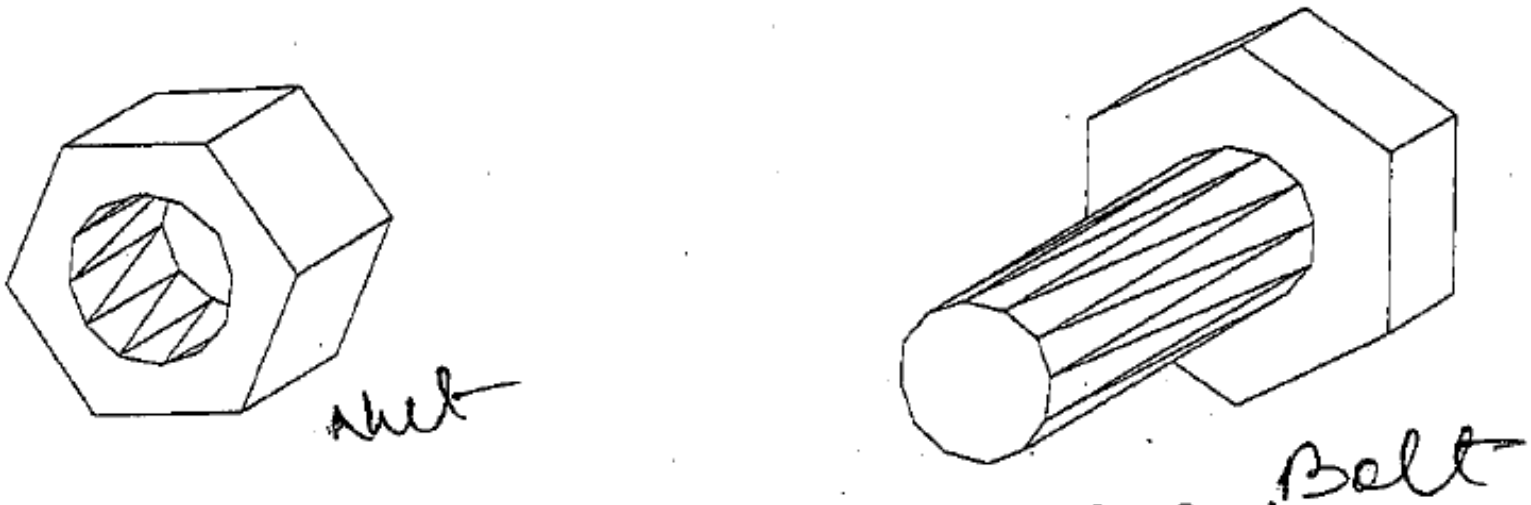


Figure 12.16 Typical products made by forging.

Forging Materials

- Ductility : ability to sustain substantial plastic deformation without fracture even in the presence of tensile stresses.
- The metals and alloys that can be forged include carbon steel, alloy steel, stainless steel, wrought iron, copper – base alloys, nickel and nickel-copper alloys and magnesium alloys.
- The metal or alloys to be forged is got in the form of bars or billets with round or rectangular cross - sections.

Classification of forging operations

1. Open die forging : it is carried out between flat dies or dies of very simple shape. The simplest example is upsetting operations.

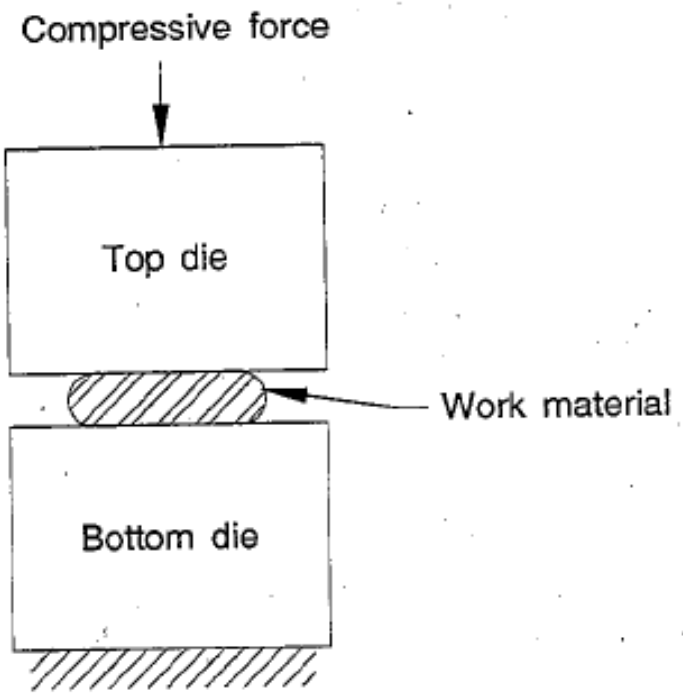


Figure 12.17 Upsetting operation.

UPSETTING OPERATION

- The work piece is deformed between two flat dies.
- This process increases cross section of the material with a corresponding decrease in its length.

2. Closed die Forging

- Work piece is deformed between two die halves, which have the impressions of the desired final shape.
- Also known as impression die forging.

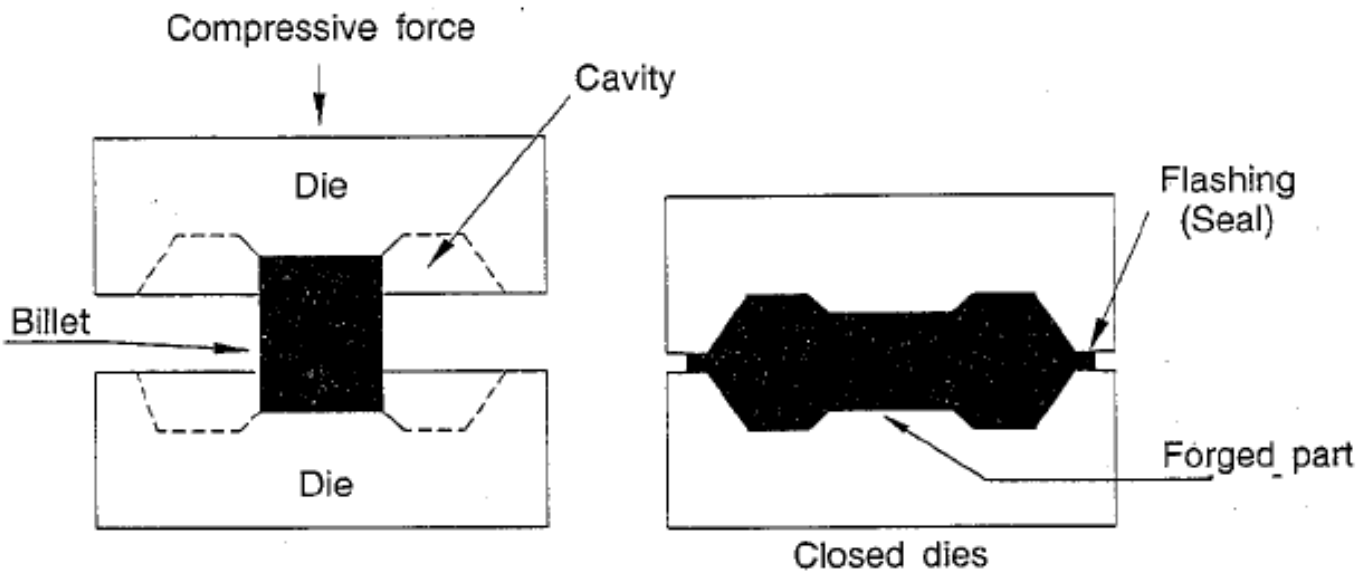


Figure 12.18 Closed die forging.