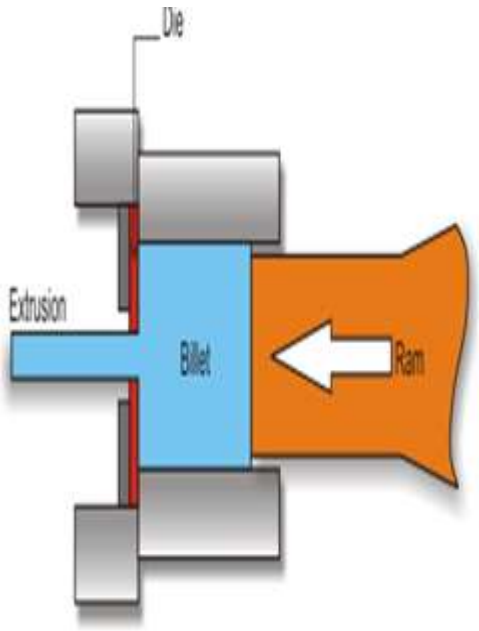
Extrusion

Extrusion

* *Extrusion is the process by which a block/billet of metal is reduced in cross section by forcing it to flow through a die under high pressure.*

* It is a manufacturing process, in which a block of metal enclosed in a container is forced to flow through the opening of a die.
* The metal is subjected to plastic deformation & it undergoes reduction & elongation.

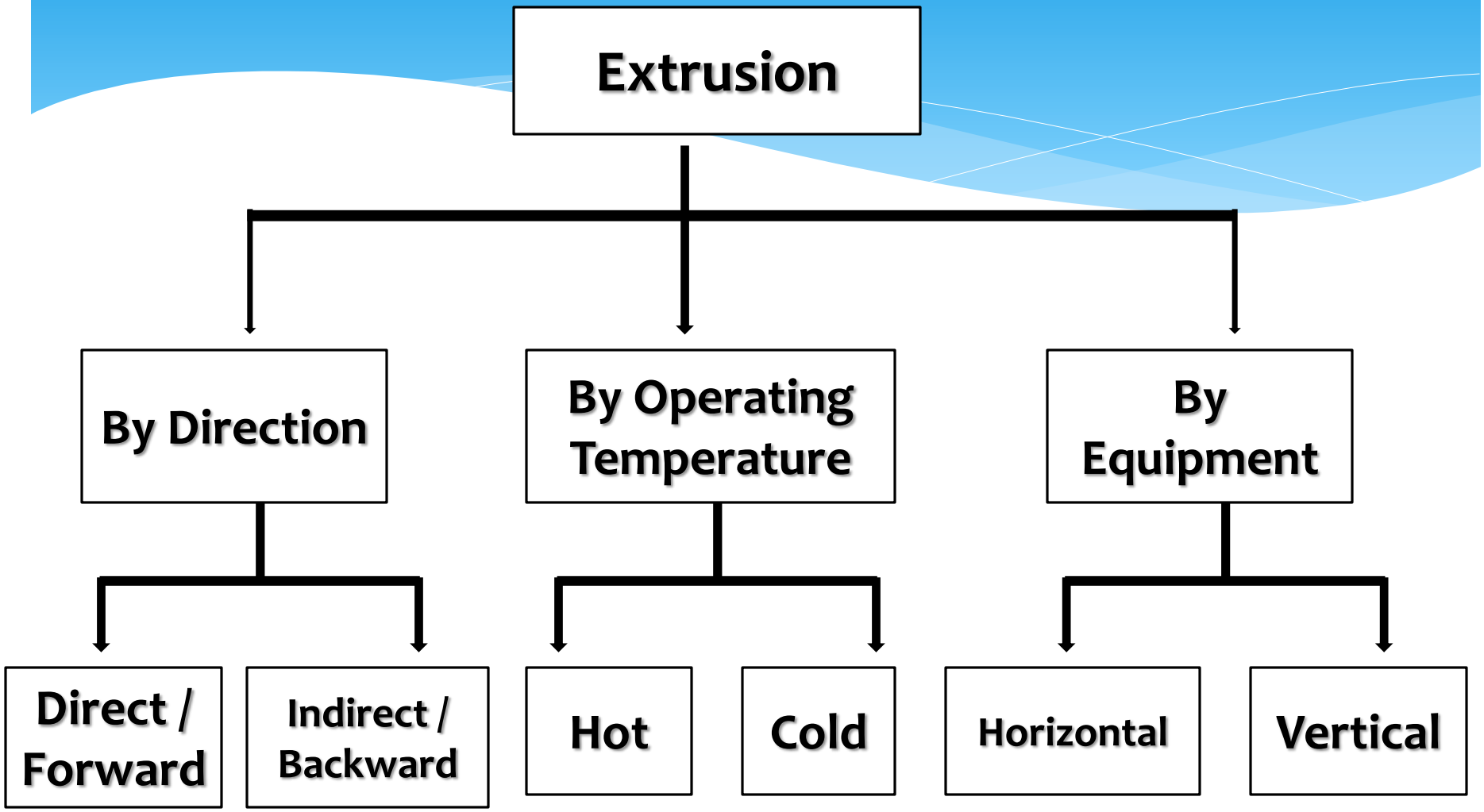


What Is Extrusion

* *In general, extrusion is used to produce cylindrical bars or hollow tubes or for the starting stock for drawn rod, cold extrusion or forged products.*

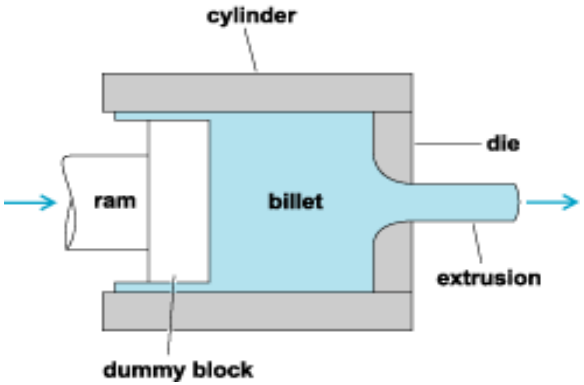
  Most metals are hot extruded due to large amount of forces required in extrusion. Complex shape can be extruded from the more readily extrudable metals such as Aluminium.
* *The products obtained are also called extrusion.*

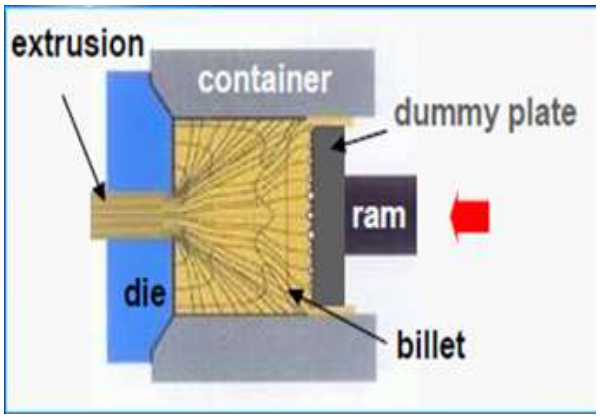
CLASSIFICATION OF EXTRUSION PROCESSES



Direct Extrusion

* It is a process in which the metal billet, placed in a container is forced by a ram to pass through a die.
* In this type the direction of flow of metal is, in same as that of movement of ram.
* The punch closely fits the die cavity to prevent backward flow of the material.
* *The dummy block or pressure plate, is placed at the end of the ram in contact with the billet.*
* *Friction is at the die and container wall requires higher pressure than indirect extrusion.*



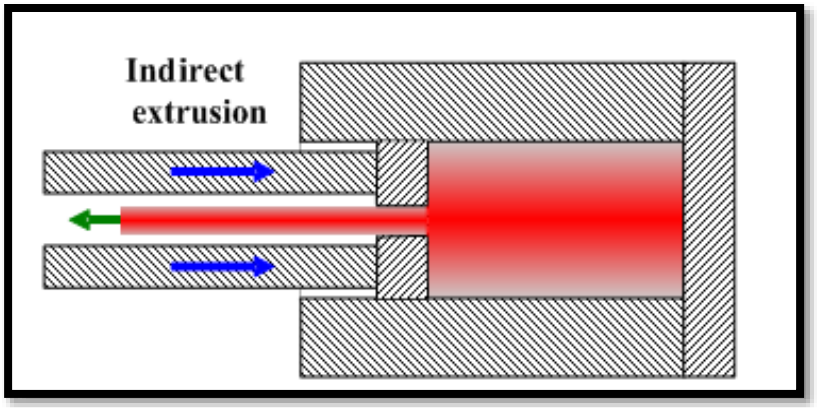


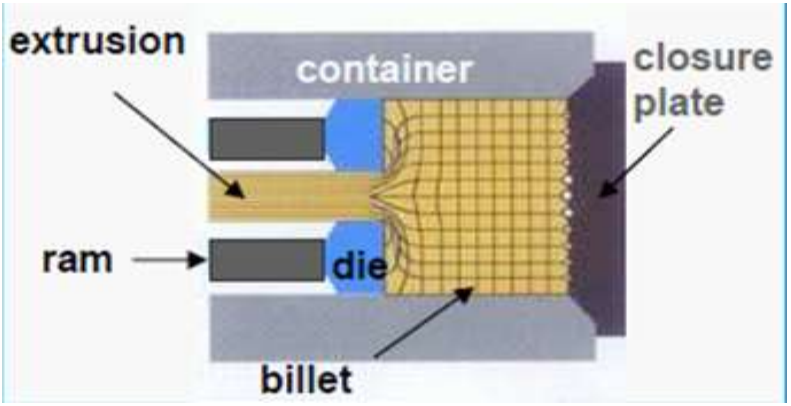
Function Of Dummy Block

* To repeatedly transmit the force of the ram, at high temperature, to the alloy.
* To expand quickly under load and maintain a secure seal with the container wall.
* To separate cleanly from the billet at the end of the stroke.
* To cause no gas entrapment that can result in blistering, or damage the face of the container and/or dummy block.
* To compensate for minor press misalignment.
* To be quickly and easily removed and replaced.
* To function effectively until a production run is complete.

In-direct Extrusion

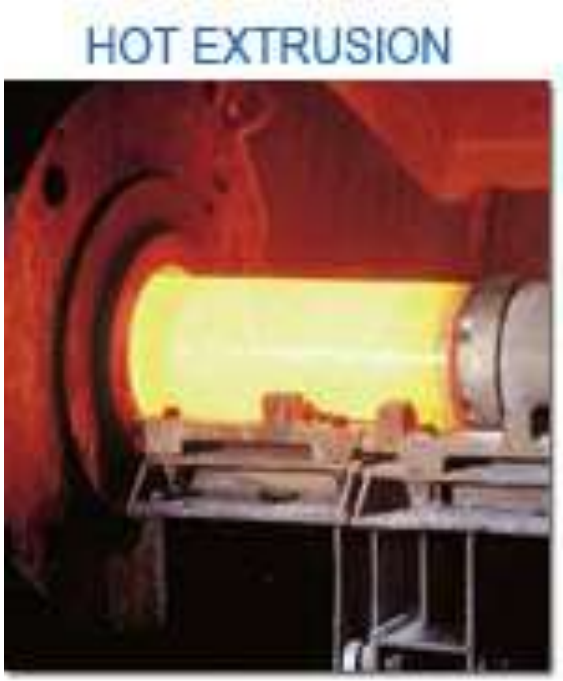
* It is a process in which a hollow ram containing the die is forced into the container, containing metal.
* Hollow ram limits the applied load.
* The movement of metal is opposite to the direction of ram motion.
* *The hollow ram containing the die is kept stationary and the container with the billet is caused to move.*
* *Friction at the die only (no relative movement at the container wall) requires roughly constant pressure. Hollow ram limits the applied load.*



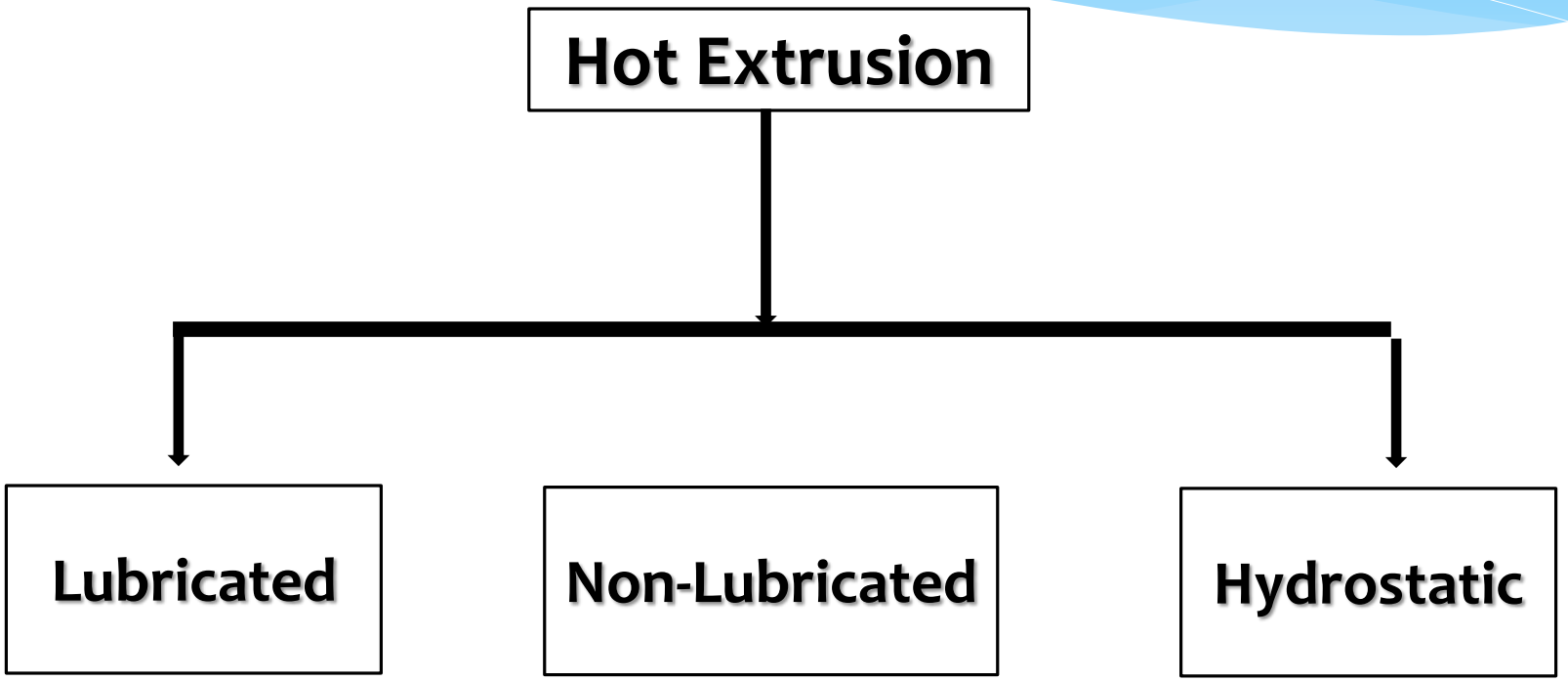


Hot Extrusion

* It is done at fairly high temperatures, approximately 50 to 75% of the melting point of the metal.
* Die life and components are effected due to the high temperatures and pressures, which makes lubrication necessary. Pressures Ranges: 35-700 Mpa.
* Hot extrusion is a hot working process, which means it is done above the material's recrystallization temperature to keep the material workable hardening and to make it easier to push the material.
* The biggest disadvantage of this process is its cost for machinery.

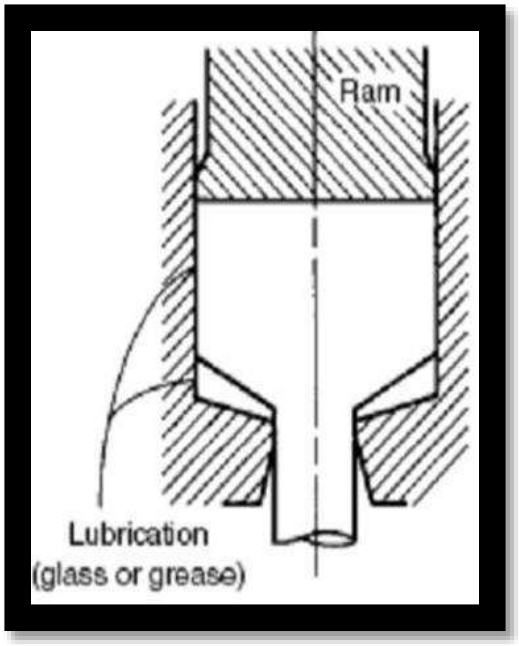


TYPES OF HOT EXTRUSION



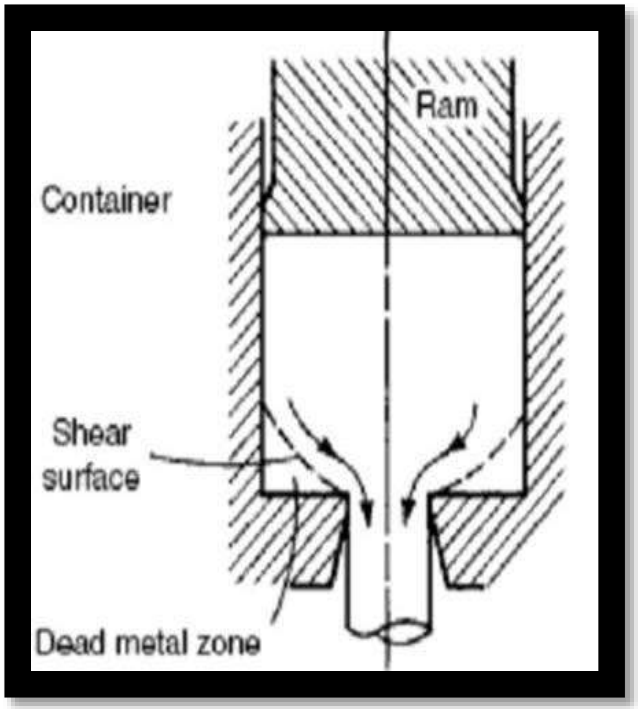
LUBRICATED HOT EXTRUSION

- Before the billet is inserted into the hot extrusion container, a suitable lubricating system is positioned immediately ahead of the die in order to reduce frictional stresses.
- Oil and graphite are used at lower temperature whereas at higher temperatures, glass powder is used.
- Copper alloys, titanium alloys, alloy steels, stainless steels, and tool steels are extruded using lubrication.



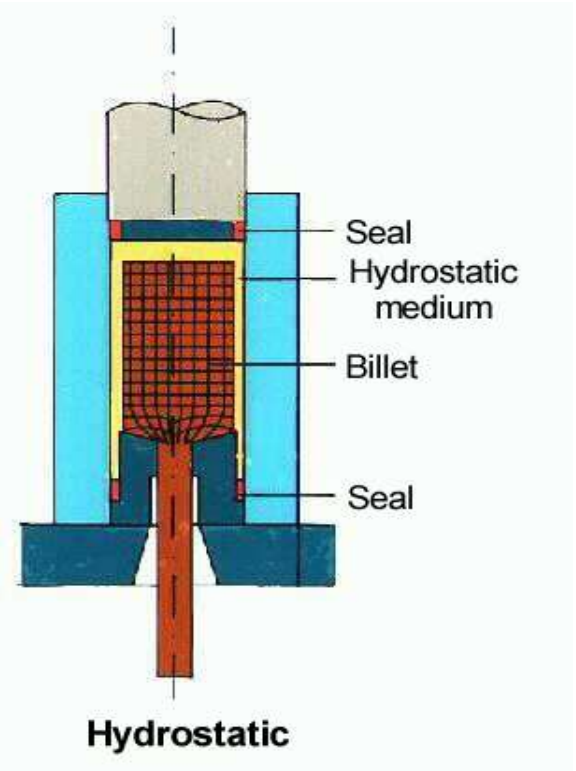
NON-LUBRICATED HOT EXTRUSION

- No lubrication is used on the billet, container, or die for reducing frictional stresses.
- It has the ability to produce very complex sections with excellent surface finishes and low dimensional tolerances.
- Solid and hollow dies with flat shear faces are typically used.



HYDROSTATIC EXTRUSION

- In the hydrostatic extrusion process the billet is completely surrounded by a pressurized liquid, except where the billet contacts the die.
- The rate, with which the billet moves when pressing in the direction of the die, is thus not equal to the ram speed, but is proportional to the displaced hydrostatics medium volume.
- The process must be carried out in a sealed cylinder to contain the hydrostatic medium.
- Pressure = 1400 Mpa (approx.)



Advantages & Limitations

Advantages:

- Elimination of large friction force between the billet and the container wall.
- Possible to use dies with a very low semi cone angle (α-200).
- This process can be done hot, warm, or cold, however the temperature is limited by the stability of the fluid used.

Limitations:

* • Not suitable for hot-working due to pressurized liquid.
* • A practical limit on fluid pressure is around 1.7GPa currently exists because of the strength of the container.
* • The liquid should not solidify at high pressure this limits the obtainable.

HOT EXTRUSION

ADVANTAGES

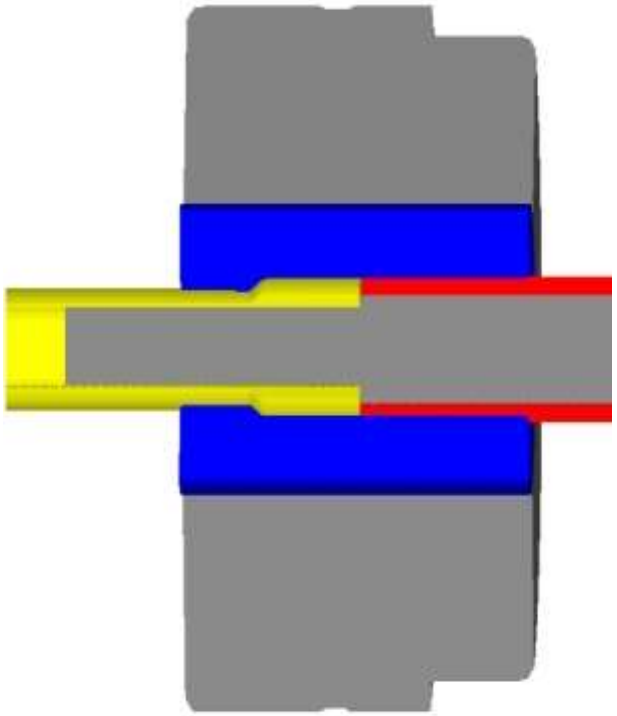
- Complex solid or hollow shapes can be produced.
- Small quantities can be economically produced.
- Delivery times are often far shorter than alternative processes.

DISADVANTAGES

- High equipment set up and maintenance cost.
- Extrusion process for metals is at very high temperatures.
- Die is preheated to increase its life, so there are chances of oxidation of hot billet.
- Process Wastage is higher as compared to rolling.
- Non-homogeneous.

Cold Extrusion

* Cold extrusion is the process done at room temperature or slightly elevated temperatures.
* This process can be used for materials that can withstand the stresses created by extrusion.
* *Cold extrusion is done at room temperature or near room temperature. The advantages of this over hot extrusion are the lack of oxidation, higher strength due to cold working, closer tolerances, good surface finishing.*
* *Examples of products produced by this process are: collapsible tubes, fire extinguisher cases, and shock absorber cylinders.*



COLD EXTRUSION

ADVANTAGES

- Improved Mechanical properties.
- Good control of dimensional tolerances.
- Improved surface finish.
- No need for heating billet.
- No oxidation takes place.

DISADVANTAGES

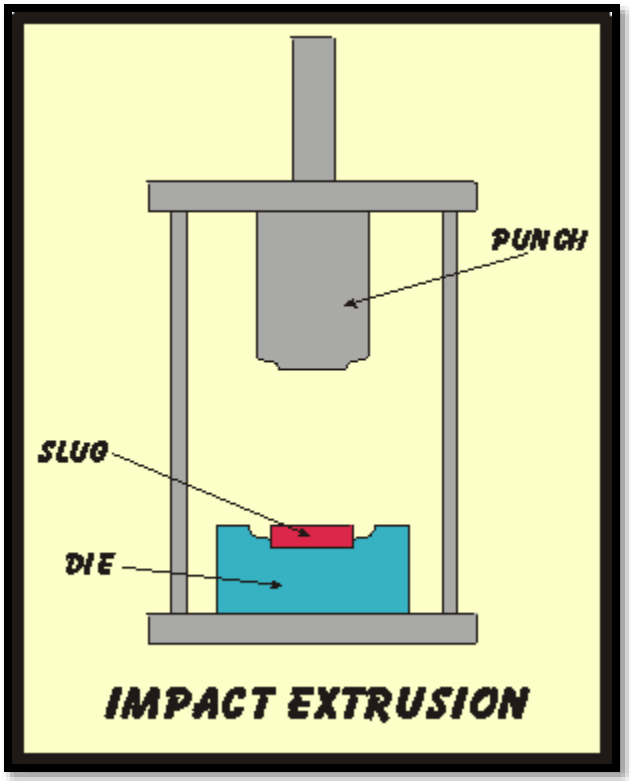
- Tooling cost is high, therefore large production lot size is required.
- Special coating is required to reduce friction and to maintain a lubricant film throughout.
- Limited deformation can be obtained.

Application Of Cold Extrusion

- Cu, Pb, Sn, Al Alloys, Ti, Mo, V, Steel, Zr parts can be extruded.
- Tubes, Gear Blanks, Aluminum Cans, Cylinders, Fire Extinguisher Cases, Shock Absorber Cylinders, and Automotive Pistons are manufactured.

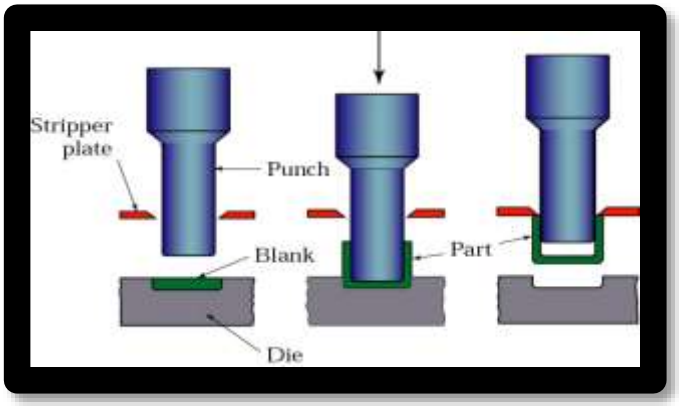
Impact extrusion

- A manufacturing process in which 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.



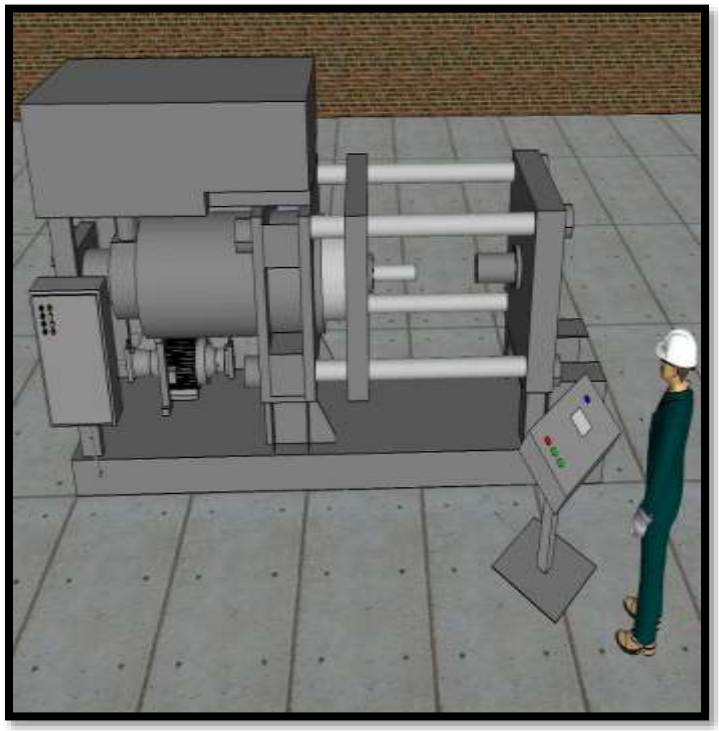
Applications

- Although the process is generally performed cold, considerable heating results from the high speed deformation.
- A short lengths of hollow shapes, such as collapsible toothpaste tubes or spray cans.
- Requires soft materials such as Al, Pb, Cu or Sn.



Horizontal extrusion process

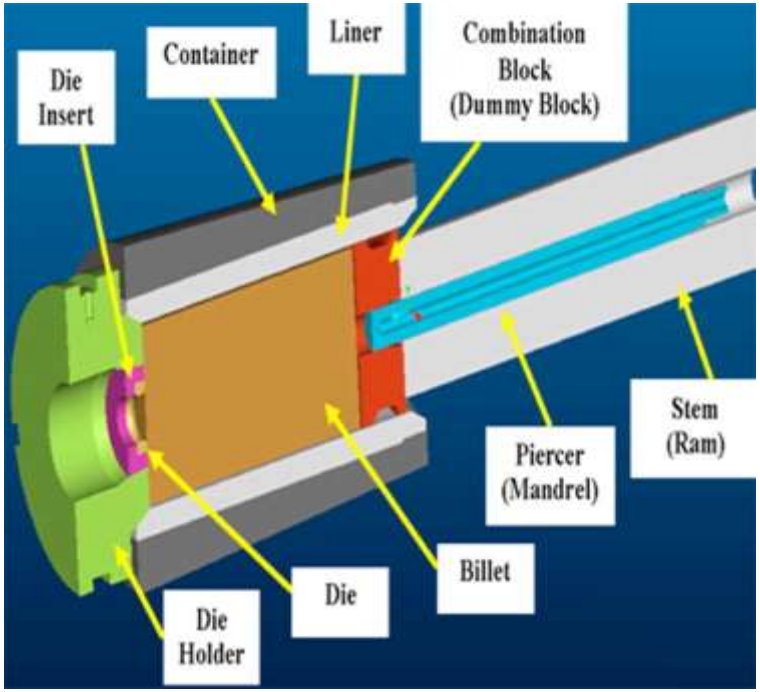
- The layout of operating machine is horizontal and movement of billet as well as of ram is horizontal in direction.
- 15-50 MN capacity.
- It is mostly used for commercial extrusion of bars and shapes.

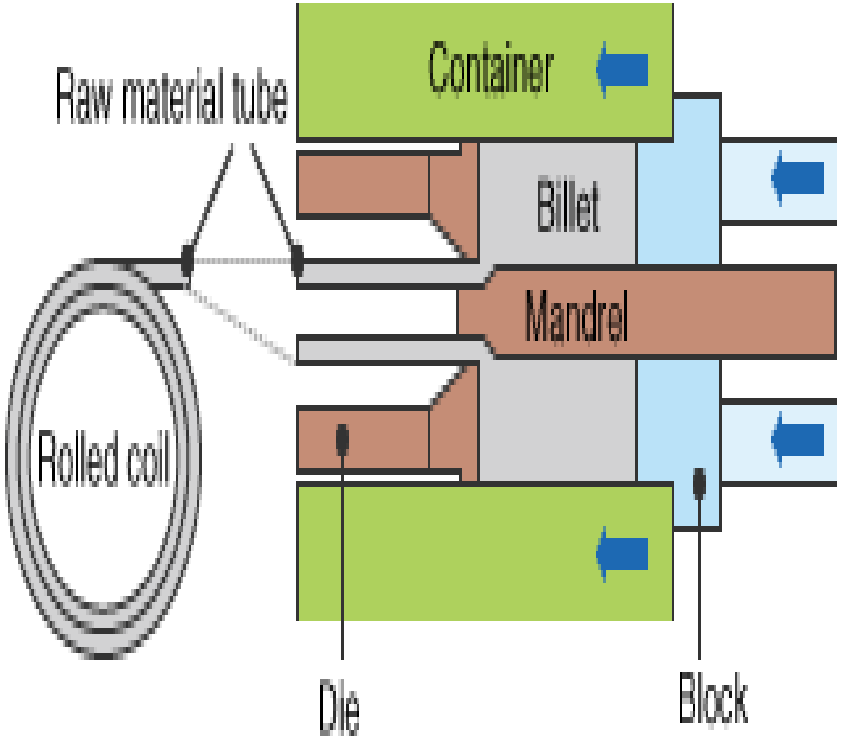


Vertical extrusion process

- The movement of billet and ram is vertical in orientation.
- 3-20 MN capacity.
- Mainly used in the production of thin-wall tubing.

Seamless Extrusion





DIE MATERIALS

- Commonly used materials are Tool Steels and Carbides
- Diamond dies are used for fine wire.
- For improved wear resistance, steel dies may be chromium plated, and carbide dies may be coated with titanium nitride
- For Hot drawing, cast-steel dies are used .
- Dies are made from highly alloy tools steels or ceramics (Si_3N_4).
- Heat treatments such as nitriding are required (several times) to increase hardness (1000-1100 Hvor 65-70 HRC). This improves die life.

LUBRICATION

NEED-

- Proper lubrication is essential in extruding, in order to improve die life, reduce drawing forces and temperature, and improve surface finish.

- **Types of Lubrication-**

a) **Wet** : Dies and Rods are completely immersed in lubricant.

b) **Dry** : Surface of the rod to be drawn is coated with a lubricant.

c) **Coating** : Rod or Wire is coated with a soft metal that acts as a solid lubricant.

d) **Ultrasonic Vibration :** of the dies and mandrels.

FACTORS AFFECTING THE EXTRUSION FORCE

1. Type of extrusion
2. Extrusion ratio
3. Working temperature
4. Deformation
5. Frictional conditions at the die and the container wall

MATHEMATICAL RELATIONS

1. Extrusion ratio, R -

It is defined as the ratio of the initial cross-sectional area , Ao, of the billet to the final cross-sectional area , Af, after extrusion.

R ~ 40:1 for hot extrusion of steels.
R ~ 400:1 for aluminum.

$$R = \frac{A_0}{A_f}$$

2.Fractional reduction in area, r -

$$r = 1 - \frac{A_f}{A_0}$$

$$R = \frac{1}{1 - r}$$

Contd..

3. Velocity -

Velocity of extruded product = (Ram velocity) x (R)

4. Extrusion force -

$$P = kA_0 \ln \frac{A_0}{A_f}$$

where k = extrusion constant,

EXTRUSION DEFECT

Inhomogeneous deformation -

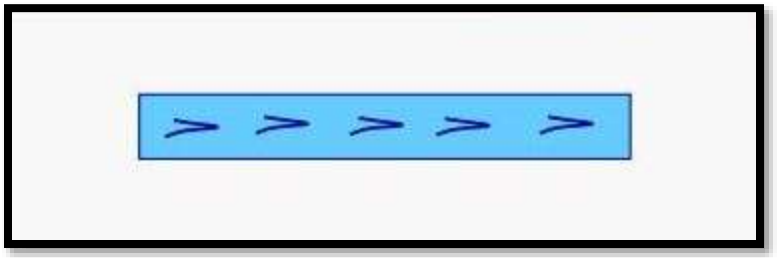
- In direct extrusion, a dead zone along the outer surface of the billet due to the movement of metal in the centre being higher than the periphery.
- After 2/3 of the billet is extruded, the outer surface of the billet (normally with oxidised skin) moves toward the centre and extrudes to the through the die, resulting in internal oxide stringers.

Surface cracking

- It is the ranging from a badly roughened surface to repetitive transverse cracking called fir-tree cracking.
- It is due to longitudinal tensile stresses generated as the extrusion passes through the die.
- In hot extrusion, this form of cracking usually is intergranular and is associated with hot shortness.

Centre burst or chevron cracking

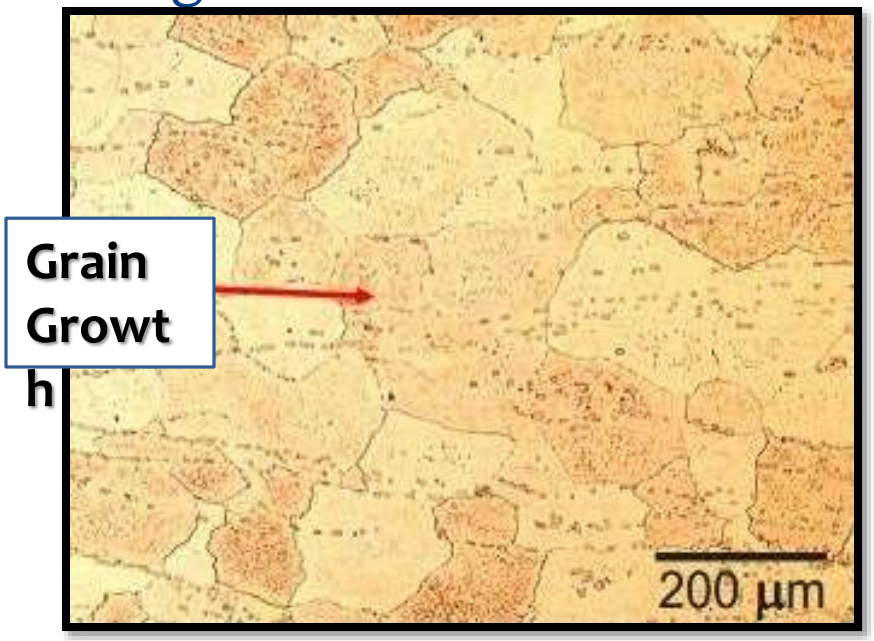
- It can occur at low extrusion ratio due to low frictional conditions on the zone of deformation at the extrusion die.
- High friction(at a the tool-billet interface).
- Low friction centre burst.



Variations in structure and properties

Structure & properties are varied within the extrusions due to non-uniform deformation for example at the front and the back of the extrusion in both longitudinal and transverse directions.

- Regions of exaggerated grain growth, due to high hot working temperature.



Hot shortness

(in aluminium extrusion)

- High temperatures generated cause incipient melting, which causes cracking.