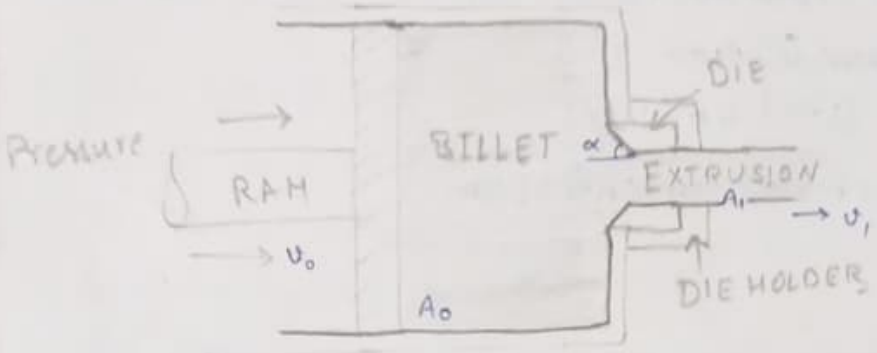
EXTRUSION

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



- Non-ferrous metals and alloy (lead, Cu, Al, Mg etc.) easy to extrude.
- Steel, Stainless-steel & Nickel alloys are difficult to extrude.

reason: (a) St has high yield strength.
(b) St gets easily welded with the walls of the cylinder.

* Molten glass and phosphate coating used to prevent welding.
(Hot process) (Cold process)

Example: Aluminium extrusions are used in commercial and domestic buildings for window and door frame system, prefabricated houses/building structures, roofing and exterior cladding, curtain walling etc.

Commonly extrude material: Metals, Polymers, Ceramic, Concrete.
↓
(Aluminium, Cu, Steel, Mg)

Plastic, Aluminium, Copper and plastic are more suitable for extrusion.

* The products of extrusion are generally called "extrudates".

Advantages of Extrusion

- Any cross-section shape can be easily extruded [Versatile]
- Better grain structure, better accuracy and good surface finish of the components.
- No draft required.
- Huge reduction in cross-sectional area

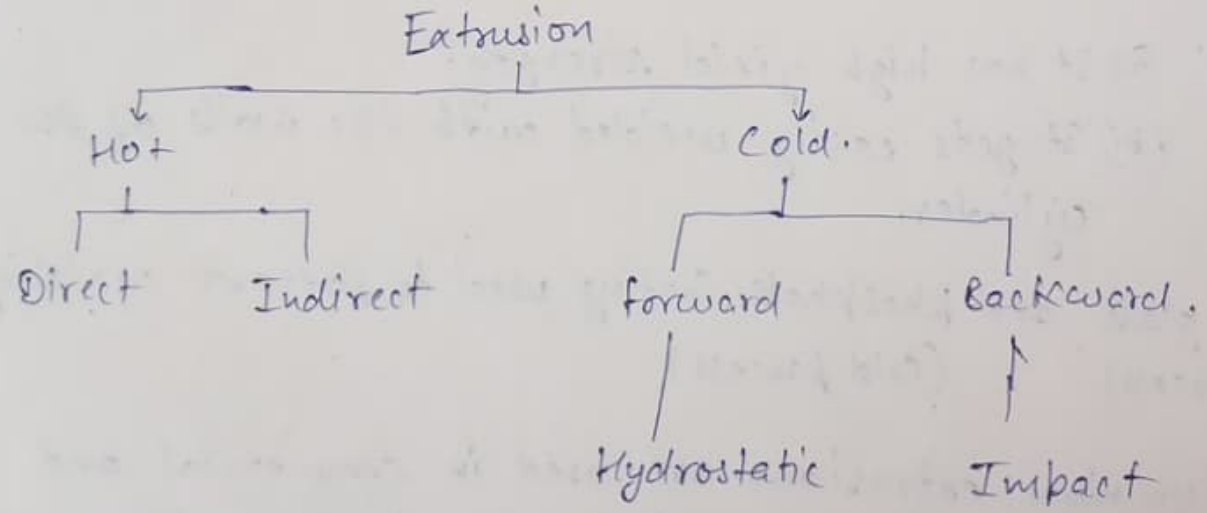
  [for Non-ferrous (Al) 400 : 1
  for ferrous (steel) 40 : 1]

- Less wastage of material in extrusion.
- Low tooling cost.

Limitation:

Cross-sectional area should be uniform along the entire length.

EXTRUSION PROCESS



HOT EXTRUSION PROCESS

- The temperature range for hot extrusion of aluminium is 430-480°C.
- Used to produce curtain rods made of aluminium.
- Design of die is a problem.
- Either direct or Indirect method used.

DIRECT EXTRUSION:

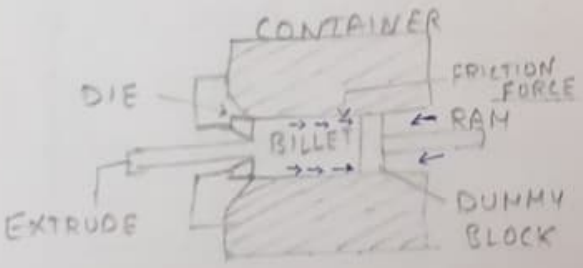
- Similar to forcing toothpaste through the opening of tube.
- The metal billet is placed in a container and driven through the die by the ram.
- The dummy block or pressure plate, is placed at the end of the ram in contact with the billet.
- Friction is at the die and the container wall requires higher pressure.

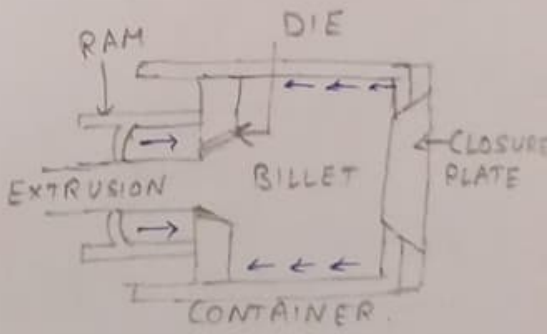
INDIRECT EXTRUSION:

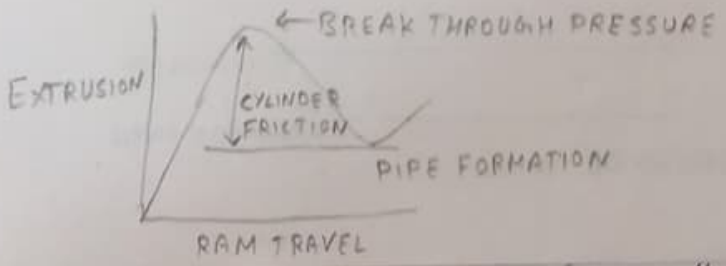
- Punch moves opposite to that of the billet.
- The hollow ram containing the die is kept moving and the the container with the billet is caused to stationary.
- Extrusion pressure for indirect extrusion is lower than that for the direct Extrusion.

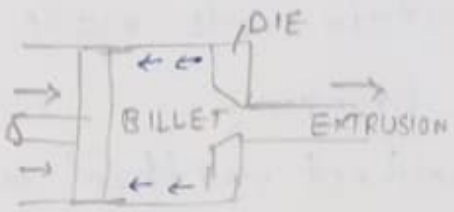
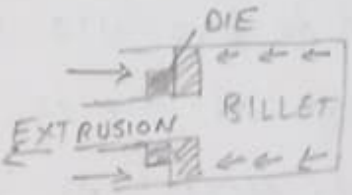
→ Low process waste.

- Required force is lower (25 to 30% less)







Property.	DIRECT EXTRUSION	INDIRECT EXTRUSION
1) Diagram		
2) Direction b/w Extrusion & Ram	Same to force	opposite to force.
3) Die	Stationary	Moving.
4) Billet	Moving	Stationary.
5) Handling	Easy	Difficult.
6) Force	More than indirect	less [25 to 30 %]
7) Friction	Between Billet and container	b/w Die and Extrusion.
8) Nature of friction	opposite to the force / Motion	Support the motion, reduce force.
9) Design & Manufacturing	Easy	Difficult.
10) Amount of Scrap	Higher than indirect	Lesser.

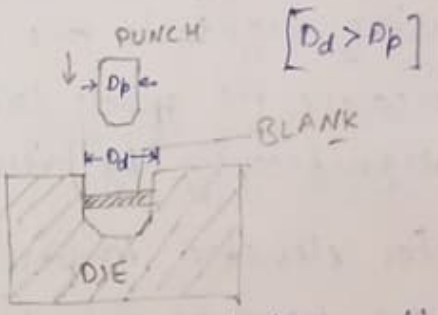
COLD EXTRUSION

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.

- Many ductile metals can be cold extrude into various configuration, with the billet mostly at room temperature.
- Cold extrusion used with low strength metals such as lead, tin, Zinc and aluminium to produce collapsible tubes for toothpaste, medications and other creams; small "cans" for shielding electronic components and larger cans for food and beverages.
- Now-a-days also been used for forming mild steel parts.

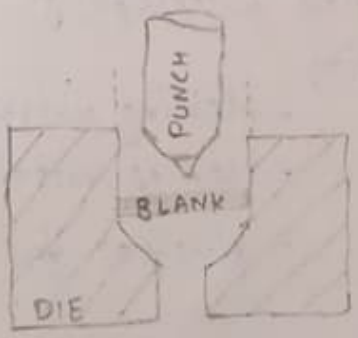
BACKWARD COLD EXTRUSION:

- The metal is extruded through the gap b/w the punch and die opposite to the punch movement.
- For softer materials such as aluminium and its alloys.
- Used for making collapsible tubes, cans for liquids and similar articles.



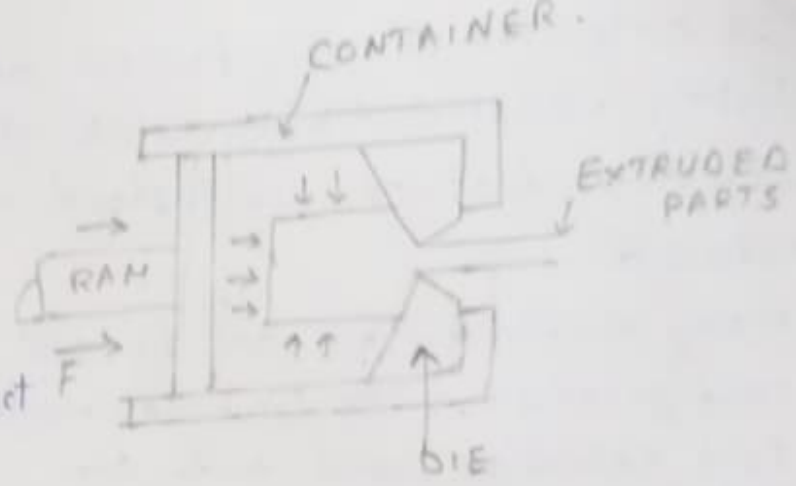
IMPACT EXTRUSION:

- The metal is extruded through the gap b/w the punch and die similar to the punch movement.
- Small Copper tubes & Cartridge cases, toothpaste tubes.



HYDROSTATIC EXTRUSION:

In this process, the pressure required for extrusion is supplied through a fluid medium that surrounds the billet.



- There is no container-wall contact and hence no friction.
- The high pressure in the chamber also transmits some of the fluid to die surfaces, significantly reducing friction and forces.
- The pressure in this process is in the order of 1400 Mpa.
- It is usually carried out at room temperature, typically using vegetable oils as the fluid, particularly castor oil because its good Lubricant and its viscosity is not influenced significantly by pressure.

* for elevated temperature waxes, polymers and glasses are used as the fluid; these materials also serve as thermal insulators and help maintain the billet temp. during extrusion.

- Brittle material like castiron, Stainless steel, Mo, Tn can be extruded successfully.

Application:
- Making wires of less ductile material.
- Making metal clad.
- Nuclear fuel rod for a nuclear reactor.

Roll Number: _____ Batch Time: _____

LUBRICATION FOR EXTRUSION

- For hot extrusion glass is an excellent lubricant with steels, stainless steels and high temperature metals and alloys.
- For cold extrusion, lubrication is critical, especially with steels, because of the possibility of sticking between the workpiece and the tooling if the lubrication breaks down. Most effective lubricant is a phosphate conversion coating on the workpiece.

EXTRUSION DEFECTS:

- Surface cracks due to high temperature, high speed, high friction etc.
- Bamboo defects at low temperature due to sticking of metals in die land.
- Pipe defects or tail pipe or fishtailing, during extrusion surface oxides and impurities are driven towards the centre of the billet, like funnel called pipe.
- Centre Burst or chevron defects are attributed to a state of hydrostatic tensile stress at the centreline in the deformation zone in the die. Tendency increases with increasing die angle and amount of impurities. Tendency decrease with increasing extrusion ratio and friction.

EXTRUSION NOMENCLATURE

EXTRUSION RATIO:

$$E = \frac{\text{Cross sectional Area of the billet } (A_B) \text{ or } (A_0)}{\text{Cross sectional Area of the product } (A_E) \text{ or } (A_f)}$$

REDUCTION

$$R = \frac{A_B - A_E}{A_B} \times 100$$

EXTRUSION LOAD:

$$P = \sigma_0 A_0 \ln\left(\frac{A_0}{A_f}\right)$$

$$= 2 \times \frac{\pi d_0^2}{4} \times \sigma_0 \times \ln\left(\frac{d_0}{d_f}\right) = \frac{\pi d_0^2}{4} \times \sigma_0 \times \ln(R)$$

EXTRUSION STRESS

$$\sigma_E = \frac{P}{A_0} = \sigma_0 \ln\left(\frac{A_0}{A_f}\right) \frac{A_0}{A_0} = 2\sigma_0 \ln\left(\frac{d_0}{d_f}\right) = \sigma_0 \ln(R)$$

DEGREE OF DRAWING / REDUCTION FACTOR

$$D = \frac{A_0 - A_f}{A_0} = \frac{D_0^2 - D_f^2}{D_0^2} = 1 - \left(\frac{D_f}{D_0}\right)^2$$

$$\boxed{D = 1 - \left|\frac{D_F}{D_0}\right|^2}$$

True Strain:

$$\epsilon = \ln\left|\frac{A_0}{A_F}\right|$$

$$\boxed{\epsilon = \ln\left|\frac{1}{1-0}\right|}$$

Maximum Reduction in one single pass.

$\because E_T = 1$

$$\ln\left(\frac{A_0}{A_F}\right) = 1$$

$$\frac{A_0}{A_F} = e^1$$

$$1 - \frac{A_F}{2.73 A_F} = \frac{1.73}{2.73} \times 100 = 63\%$$