METAL EXTRUSION

Contents

What is Metal Extrusion?

Metal Extrusion is a **metal forming** manufacturing process in which a cylindrical billet inside a closed cavity is forced to flow through a die of a desired cross section. These fixed cross sectional profile extruded parts are called "**Extrudates**" and pushed out using either a mechanical or hydraulic press. The process which was first patented by Joseph Bramah was first used to extrude lead pipes by Thomas Burr.

Most commonly extruded materials are Aluminium, Copper, Steel, Magnesium, and Lead. Plastics and ceramics are also extruded extensively but not discussed in this article.

Figure 1. Aluminium-metal-extrusion

Characteristics of Extrusion

- Able to create complex cross sections and will be uniform over the entire length of the extrudates
- Factors that affect the quality of extrusion are die design, extrusion ratio, billet temperature, lubrication, and extrusion speed
- Similar to any other metal forming processes, it can be performed either hot or cold, although the process generally is carried out at elevated temperatures in order to reduce the extrusion force and improve the ductility of the material
- Low cost due to reduced raw material wastage and high production rate
- Brittle material can be deformed without tear as it only exerts compressive and shear forces in the stock part
- Parts that are formed have excellent surface finish which minimizes post processing machining
- Metal extrusion tends to produce a favourable elongated grain structure in the direction of the material.
- The minimum wall thickness of ~1mm (aluminium) to ~3mm (steel) could be achieved

Types of Extrusion Process

Metal extrusion can be sub divided and grouped into the following categories depending on the direction of extrusion flow, the medium used to apply force, working temperature, etc.

- Direct Extrusion
- Indirect Extrusion
- Hydrostatic Extrusion
- Lateral or Vertical Extrusion
- Hot extrusion
- Cold Extrusion
- Impact Extrusion

Direct Extrusion

D**irect Extrusion,** sometimes called Forward Extrusion is the most common type of extrusion. The process as shown in figure 2 below, begins by loading a heated billet (only for hot extrusion, discussed later) into a press cavity container where a dummy block is placed behind it. Then the mechanical or hydraulic ram presses on the material to push it out through the die. Then, while still hot, the part is stretched to straighten. This process is beautifully animated by Core Materials.

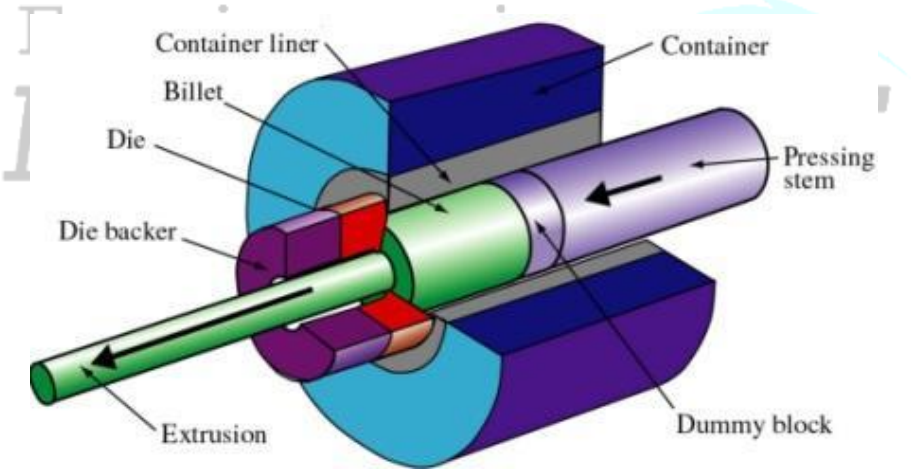

Figure 2 - Direct extrusion (source: Kalpakjian & Schmid)

Under direct extrusion, the high friction caused by steels at higher temperatures is reduced using molten glass as a lubricant while oils with graphite powder are used for lubrication for low temperatures. The dummy block is used to protect the tip of the pressing stem (punch or ram) in hot extrusion. When the punch reaches the end of its stroke, a small portion of the billet called “butt end” cannot be pushed through the die opening.

Advantages of direct extrusion

- No billet modification required
- Can be used for both hot and cold extrusion
- Simple tooling compared to other extrusion process

Disadvantages of direct extrusion

- High force requirement due to friction
- Butt end left inside the cavity
- The force required to push the ram changes as the punch moves

Indirect Extrusion

In **Indirect Extrusion,** the die is located at the end of the hydraulic ram and moves towards the billet inside the cavity to push the material through the die. This is illustrated in figure 2 below.

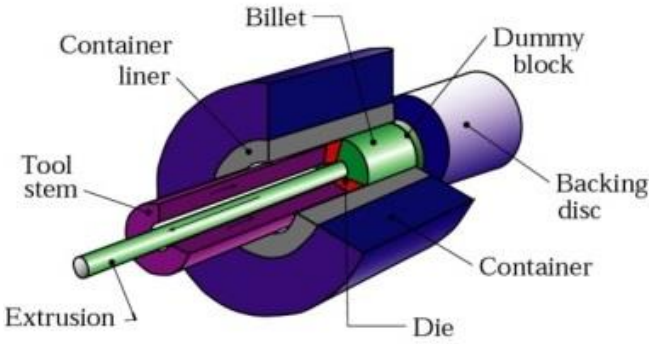

Figure 3 - In-direct extrusion (source: Kalpakjian & Schmid)

This process consumes less power due to the static billet container causing less friction on the billet. However, supporting the extruded part is difficult when the **extrudate** exits the die.

Advantages of indirect extrusion

- Less friction and less power used
- Can be used for both hot and cold extrusion
- Simple tooling compared to other extrusion processes

Disadvantages of indirect extrusion

- Difficult to support the extruded part
- The hollow ram limits the load applied

Hydrostatic extrusion

In **hydrostatic extrusion,** the chamber/ cavity is made smaller than the billet and filled with hydraulic fluid which transfers the force from the ram to the billet as shown in figure 3. Although tri-axial forces are applied by the fluid, the pressure improves billet formability on the billet. Sealing the fluid must be considered at the early stages to avoid any leaking and reduced pressure issues.

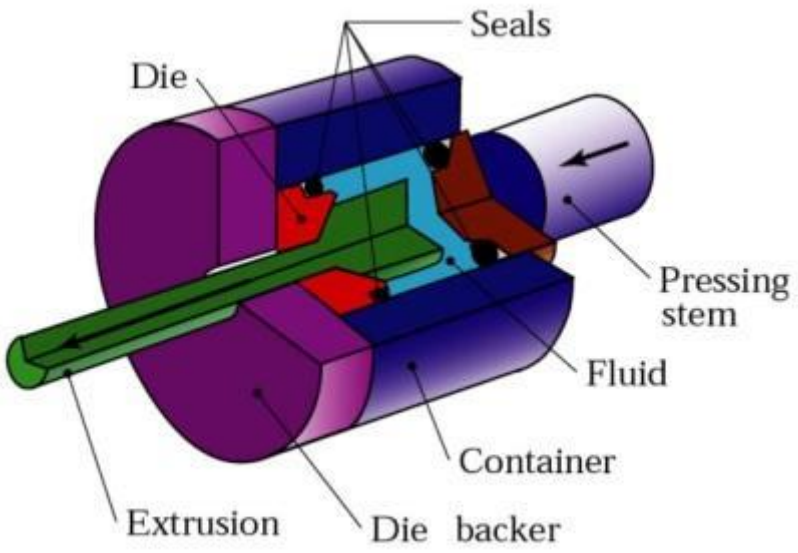

Figure 4 Hydrostatic extrusion process (Kalpakjian & Schmid)

Although the hydraulic fluid eliminates the friction between the wall and the billet by isolating them, due to the specialised equipment requirement, high set up time and low production rate limits its usage in the industry in comparison to other extrusion processes.

Advantages of hydrostatic extrusion

- Low power/force requirement due to no friction
- Fast production rates & high reduction ratios
- Lower billet temperature
- Even flow of material due to the balanced force distribution
- Large billets and large cross sections can be extruded
- No billet residue is left in the container

Disadvantages of hydrostatic extrusion

- Billets needs preparing by tapering one end to match the die entry angle
- Only cold extrusion is possible
- Difficult to contain the high-pressure fluid

Lateral Extrusion

In **Lateral Extrusion** the container is in vertical position as shown in the image and the die is located on the side. This process is suitable for low melting point material.

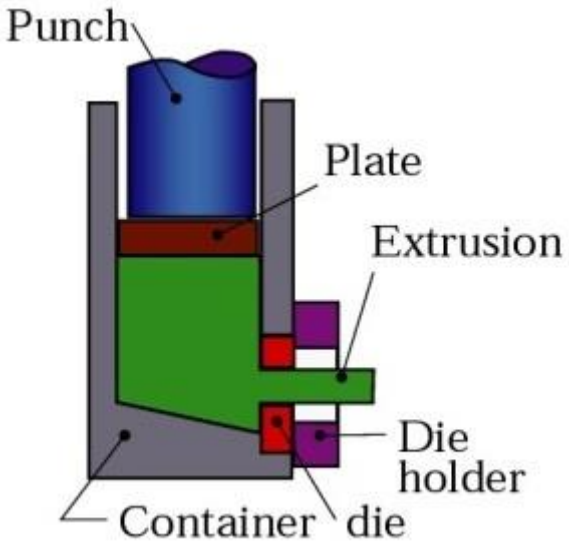

Figure 5 - lateral extrusion process schematic (source: Kalpakjian & Schmid)

Impact Extrusion

Impact extrusion is part of cold extrusion category very similar to In-direct extrusion and limited to softer metal such as Lead, Aluminium and copper. As the schematic illustrates, the punch pushed down at high speed and extreme force on the slug to extrudes backwards. Thickness of the Extrude is a function of the clearance between the punch and the die cavity. The **Extrudates** are slide off the punch by the use of stripper plate.

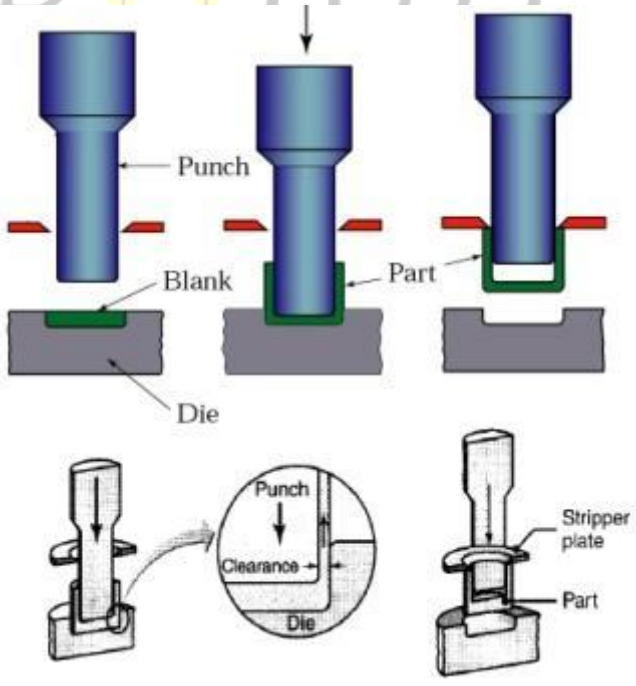

Figure 6 Impact extrusion process (source: Kalpakjian & Schmid)

For impact extrusions a mechanical press is often used, and the part is formed at a high speed and over a relatively short stroke

Since the forces acting on the punch and die are extremely high, tooling must have sufficient impact resistance, fatigue resistance and strength, for extruding metal by impact. Impact extrusion can be divided into the following three types by the flow of the material.

- Forward
- Reverse
- Combination

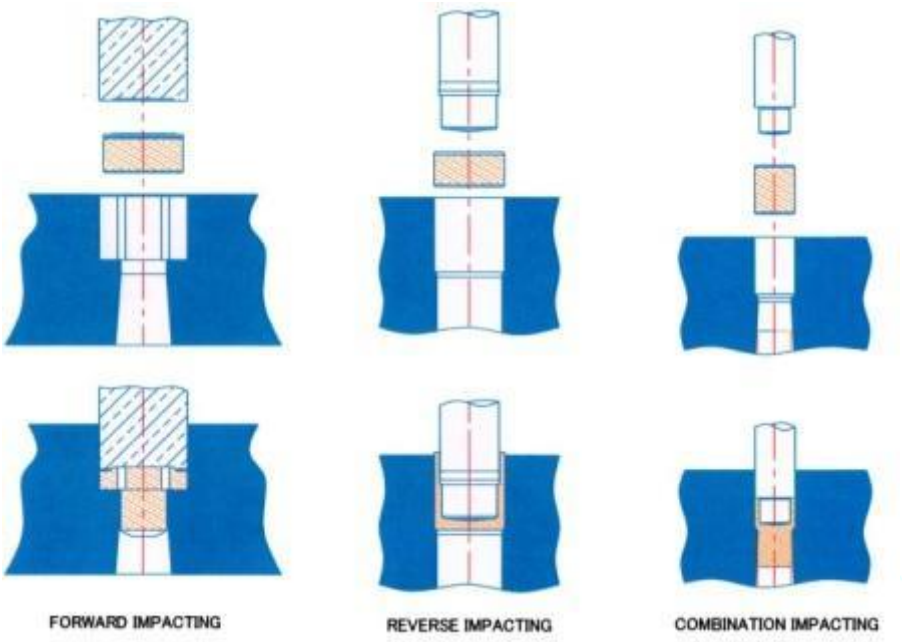

Figure 7 Types of Impact extrusion process (source: Kalpakjian & Schmid)

In **forward impact extrusion**, metal flows in the same direction that the force is delivered while it flows in the opposite direction in **reverse impact extrusion**. As the image shows above, in **combination**, the metal flows in both directions.

Advantages of impact Extrusion

- Raw material savings of up to 90%
- Reduced machining times up to 75%
- Elimination of secondary machining operations
- Reduction in multi-part assemblies
- Improved mechanical properties for material strength and machining due to cold working of the material
- Significantly reduced total part costs up to 50%
- Hollow thin walled tubes, closed on one end, are often produced in manufacturing industry by backward impact extrusion.

Disadvantages of impact extrusion

- Produced as long as the part is symmetrical over the axis by which it is formed
- Many of the parts formed by impacting, in industry, will require further manufacturing processes, such as metal forging, ironing or machining, before completion

Extrusion Defects

Depending on material condition and process variables, extrudates can develop many types of defects that could affect the quality of the end product. These defects can be grouped under the following three defects.

- Surface cracking
- Piping
- Internal cracking

References and recommended reading

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