Extrusion Processes

Training Objective

After watching the program and reviewing this printed material, the viewer will understand the mechanics of the extrusion processes and the materials involved.

- The extrusion process is demonstrated
- Hot, warm, and cold extrusion processes are explained
- Direct, indirect, combination, and impact extrusion is shown
- Plastic extrusion processes are detailed

The Extrusion Process

Extrusion is a method of forming in which metals or plastics are forced through a die or series of dies, resulting in a specific shape of constant cross section. With the proper tooling, extrusions may be tapered or stepped. Extrusions can be either very thick in cross section or very thin and be either solid or hollow. The extruded stock, which can be 100 feet in length or longer, is then cut to a convenient stock size and used as specific products, assembly components, or as raw stock material for further processing. Extrusion size is expressed as a circle size which relates to the smallest circle diameter which can enclose an extrusion's cross section.

Metal Extrusion

Metal extrusion processes may be performed hot, warm, or cold. Each method has its own unique operating parameters.

Hot Extrusion

Hot Extrusion uses heated feedstock, called a billet, that ranges in temperature from 200° to 2,300° Fahrenheit, or 90° to 1,260° Celsius depending on the material.

Aluminum is the most common hot extruded material, with billet temperatures ranging from 575° to 1,100° Fahrenheit, or 300° to 600° Celsius. Hot extrusion is always performed at temperatures much higher than the recrystallization temperature of the material to be extruded. The heated billet is confined in a container, force is applied and the billet is extruded through a die or dies.

Hot extrusion is used to produce close tolerance dimensions as well as smooth, fine surfaces. Additionally, and depending on the metal used, improved microstructures are obtained. The process is also very economical in that most of the metal extruded is usable.

The primary type of hot extrusion is direct, or forward, extrusion. Direct extrusion is commonly performed in horizontal hydraulic presses. The heated billet is loaded into a thick-walled container from which it is pushed through the extrusion die by a ram. Between the ram and the billet is an intermediate dummy block. Lubrication is used to reduce friction along the billet length and its container. In operation, force increases rapidly as the billet is upset to fill the container, then increases further as breakthrough force before extrusion begins. Upon breakthrough, the force declines as billet length decreases until a minimum force is reached. as the billet thins, the force rapidly rises again to continue metal flow radially toward the die opening.

Hot extrusion presses are rated in force capacity which relates to available ram pressure on the billet. Ram pressure requirements are based upon:

- Billet material and temper
- Cross section dimensions
- Complexity of the extrusion
- Extrusion length and temperature

Another factor in determining ram force requirements is the extrusion ratio. This is determined by dividing the cross sectional area of the container liner by the cross sectional area of the die openings.

Warm and Cold Extrusion Processes

Warm extrusion refers to the extruding of feedstock or billet while it is above room temperature, but well below the recrystallization temperatures used in hot extrusion. Cold extrusion refers to extrusion at room temperatures. Because the feedstock is at lower temperatures, no micro-structural changes occur during processing.

Warm and cold extrusion processes increase the strength and hardness of the finished extrusion. Reduced heat also lowers pollution concerns and eliminates costly high temperature tooling. While virtually all metals may be warm and cold extruded, those having the highest ductility are more suited for processing. Warm and cold extrusion processes are commonly integrated into continuous and semi-continuous manufacturing operations, with the three primary methods including:

- Indirect extrusion
- Combination extrusion
- Impact extrusion

Indirect extrusion, which is also called backward extrusion, is used to produce hollow shapes with the inside diameter defined by the male punch and the outside diameter controlled by the female die.

Combination extrusion combines various types of extruding including direct and indirect methods to produce more complex shapes.

Impact extrusion is similar to the other extrusion methods described, but is a much faster process. Using shorter strokes and shallower dies, punch impact moves the feedstock slug either up, down, or in both directions at once, without being completely confined by either the punch or die walls. Ductile and low melting point metals such as tin, aluminum, zinc, and copper are well suited for impact extruding.

Plastics Extrusion

Plastics extrusion is a continuous process in which thermoplastic feedstock is converted to a molten, viscous fluid and then extruded into various shapes such as bar, rod, tube, and pipe. Plastic extrusion is also used to produce various profiles such as angles and channel shapes as well as mono-filaments and wiring insulation.

The most commonly extruded thermoplastics include nylon, polycarbonate, polyethylene, and polyvinyl chloride. Plastic extrusions are performed in a screw extrusion machine, with the machine's main components including a hopper, externally heated feed barrel, helically fluted extruder screw, and die assembly.

As the feedstock enters the feed barrel it is moved forward by the rotating screw. The feedstock is heated by its frictional movement as it is dragged forward. External heating bands help to bring the material to its final temperature.

Typical extruder screws move the thermoplastic material through four zones:

Feed zone – in which trapped air is forced from the stock. The feed zone has a constant flight depth. The flight depth is the distance between the major diameter at the top of the flight, and minor diameter of the screw at the base of the flight.

Transition zone – in this zone the flight depth decreases, compressing and plasticized the thermoplastic material.

Mixing zone – here the flight depth is constant and there may be a special mixing element to ensure the feedstock is completely plasticized and mixed into a homogenous blend.

Metering zone – the flight depth here is also constant but much smaller than in the mixing zone. This section acts as a pump forcing the material through the extruder die assembly.

The two principal plastic extrusion processes are:

- Profile extrusion
- Blown film extrusion

Profile extrusion is a horizontal process producing long continuous shapes which are cooled in long cooling tanks filled with water after exiting the die assembly. A final cutting operation reduces the extrusion to stock lengths for later use.

Blown film extrusion is a vertical process where molten plastic passes through a die having a 360 degree annular opening. The tubular film produced is then filled with air. As a result, the tube expands out into a bubble having a diameter larger than the diameter of the annular opening of the die. As the tube cools, it is pulled up and flattened as it passes through a series of rolls. These rolls maintain tension on the plastic film as it is eventually wound into a coil for later use.

Review Questions

1. Extrusion size is determined by:
   a. square area
   b. relative size of all flanges
   c. cross section fitting within a circle
   d. diagonal measurement of the extrusion

2. The usual temperature range of aluminum for hot extrusion is:
   a. 575° to 1,100° Fahrenheit, or 300° to 600° Celsius
   b. 200°-2,300° degrees Fahrenheit, or 90° to 1,260° Celsius
   c. slightly above room temperature
   d. 180°-1,650° degrees Fahrenheit, or 80° to 900° Celsius

3. Hot extrusion is economical because:
   a. less expensive tooling is needed
   b. most of the extruded metal is usable
   c. faster operating speeds are used
   d. minimal die wear occurs

4. The extrusion ratio is determined by:
   a. dividing the billet diameter by the area of the finished extrusion
   b. dividing the ram surface area by the die opening area
   c. dividing the cross sectional area of the container liner by the cross-sectional area of the die opening
   d. none of the above

5. Warm and cold extrusion processes are commonly used:
   a. primarily for short run production
   b. for aluminum and lead exclusively
   c. for high speed extruding
   d. for continuous and semi-continuous manufacturing

6. Plastics extrusion is basically:
   a. a cold extrusion process
   b. a continuous extrusion process
   c. an impact extrusion process
   d. an indirect extrusion process

7. Flight depth refers to:
   a. movement of the feed stock
   b. length of the feed screw
   c. the distance between the various zones of the feed screw
   d. distance between the major and minor diameter of the feed screw

8. Blow film extrusion operates:
   a. horizontally
   b. vertically
   c. radially in a vacuum
   d. in rapid pulses

Answer Key

1. c
2. a
3. b
4. c
5. d
6. b
7. d
8. b