Extrusion Dies

Extrusion dies can be made to form a virtually limitless array of profiles and sizes.

The cost and lead times for aluminum extrusion tooling are typically less than for the tooling required by vinyl extrusion, die casting, forming, roll forming, impact extrusion, stamping, or pultrusion.

Several factors influence the actual cost and lead time of a specific die. The best combination of product performance, quality, and cost is achieved when the customer, the product designer, the die vendor, and the extruder collaborate to develop the optimum product. Details and design tips for extrusion dies and related tooling are offered in the pages that follow.

Introduction to Extrusion Dies

There are three basic types of extrusion dies: solid dies, semihollow dies, and hollow dies, which produce solid profiles, semihollow profiles and hollow profiles respectively.

Extrusion dies are essentially thick, circular steel disks containing one or more orifices of the desired profile. They are normally constructed from H-13 tool steel and heat-treated to the desired condition.

In a typical extrusion operation, the extrusion die will be placed in the extrusion press along with several supporting tools. These tools, also made from hardened tool steel, are known as backers, bolsters and sub-bolsters. The backer, bolster, and sub-bolster provide support for the die during the extrusion process and contribute to improved tolerance controls and extrusion speeds.
A tool stack for a hollow die is similar to that used for a solid die. A hollow die is a two-piece construction, one piece forming the inside of the hollow profile and the other piece forming the outside of the profile. It likewise requires the use of additional support tools.

**Solid Dies**

Solid dies are used to produce profiles that do not contain any voids. Various styles of solid dies are used, depending on the equipment and manufacturing philosophy of the extruder. Some prefer to use flat-face style dies while others prefer to use recessed pocket or weld-plate style dies. A pocket die has a cavity slightly larger than the profile itself, approximately ½” to ¾” deep. This cavity helps control the metal flow and allows the billets to be welded together to facilitate the use of a puller. Both pocket and weld-plate type dies provide for additional metal flow control, compared to that of the flat-face type die.
More Solid Dies

A weld plate is a steel disk that is placed (often pinned and/or bolted) in front of a solid die. It has an orifice that controls the flow of aluminum to the die orifice. Weld, or feeder plates serve to provide continuous extrusion from one billet to the next, and/or control contour; and/or spread the aluminum.
Contour Feeder Plate

A feeder plate, in this example, is used to control contour for dies that require special dimensional tolerances.

Baffle Feeder

A feeder plate, as shown, is used to weld billets together. The first billet is pushed through the die stack. All subsequent billets weld together, allowing continuous extrusion, which facilitates the use of modern material handling equipment.

Semihollow Feeder (Heat Sink)

A feeder plate, such as this, is used to spread the aluminum to needed areas when the circle size of a profile is larger than 90 percent of the billet diameter.

Spreader Feeder
Hollow Dies

A hollow die produces profiles with one or more voids. The profile could be as simple as a tube with one void or as complex as a profile with many detailed voids.

The most common type of hollow die is the porthole die, which consists of a mandrel and cap section; it may or may not have a backer.

The mandrel, also known as the core, generates the internal features of the profile. The mandrel has two or more ports; the aluminum billet separates into each port and rejoins in the weld chamber prior to entering the bearing area. The ports are separated by webs, also known as legs, which support the core or mandrel section.

The cap, which creates the external features of the profile, is assembled with the mandrel.

The backer, when used, provides critical tool support and is immediately adjacent to, and in direct contact with, the exit side of the cap.
Semihollow Dies

A semihollow die is used to produce profiles having semihollow characteristics as defined in Aluminum Standards and Data (published by The Aluminum Association, Inc.).

Briefly, a semihollow profile partially encloses a void; however, a solid shape also may partially enclose a void, and the distinction may not be obvious. The semihollow classification derives from a mathematical comparison between the area of the partially-enclosed void and the mathematical square of the size of the gap. This ratio ($\frac{\text{Area}}{\text{Gap}^2}$) is called the tongue ratio.

Depending on the tongue ratio semihollow dies can be constructed as flat, recessed pocket, weld-plate, or porthole design. Porthole dies are more prevalent in the production of semihollow profiles.
Some die applications allow for the use of replaceable inserts. These inserts are made from materials such as carbide, ceramic, or various commercial compounds. Typically, replaceable inserts possess greater wear resistance, allowing for longer extrusion runs than possible with H-13 tool steel. They typically can be replaced at a fraction of the cost of a complete non-inserted tool, even though the initial tool costs are higher.
Support Tooling

The support tooling reinforces the extrusion die from the extreme pressure of the extrusion forces. In most cases, a die is supported by a backer, which is supported by a bolster.

**Backer:** A steel disk with the same diameter as the die, but usually two or three times the thickness of the die. The aperture is somewhat larger than the exit side of the die. The backer may be fitted with pins and/or bolts that interlock the backer and the die.

**Bolster:** A steel disk, which is normally the same diameter as the die ring (that holds the die and backer) and thicker than the backer. The aperture is somewhat larger than the backer.
Custom Tooling

A die is only as good as the tooling behind it. If the profile to be extruded has commercial dimensional tolerances, wall thicknesses that are acceptable, and die tongue ratios that do not require much support, then standard tooling most likely is acceptable. On the other hand, if the profile to be extruded has less than standard dimensional tolerances, walls that are thin, and die tongue ratios that need considerable support, or is uniquely shaped, then custom tooling may be recommended. Failure to utilize custom tooling when appropriate could result in excessive die deflection, breakage, and/or an inability to meet tight dimensional tolerances.

Wear of Extrusion Dies

The life cycle of an extrusion die is generally determined by the wear of the bearing. The bearing is the surface of the extruding aperture at right angles to the die face that controls the metal flow and velocity by means of friction. The bearing, therefore, is the primary determinant of control and finish of the profile.

Any deterioration of the bearing—in light of the surface finish required—will lead to premature failure of the die.
Enhancing Die Life

Die life can be extended by various methods. One method is nitriding. Nitriding is a heat-treat process that makes the bearing surface extremely hard. If monitored properly, this process can be repeated several times before a new die needs to be made.

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Note: Above numbers are based on Mill Finish condition and standard Aluminum Association dimensional tolerances. Actual die life will vary, depending on alloy selection, the desired extrusion surface quality, and dimensional tolerancing.