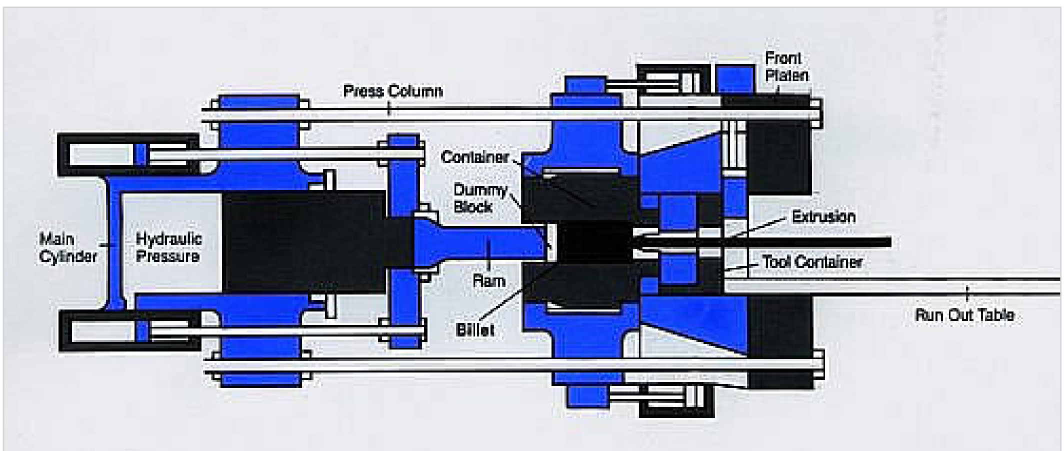
Extrusion Process Overview

The aluminum extrusion process really begins with the design process, for it is the design of the product – based on its intended use – that determines many of the ultimate production parameters. Questions regarding machinability, finishing, and environment of use will lead to the choice of alloy to be extruded. The function of the profile will determine the design of its form and, hence, the design of the die that shapes it.

Once the design questions have been answered, the actual extrusion process begins with billet, the aluminum material from which profiles are extruded. The billet must be softened by heat prior to extrusion. The heated billet is placed into the extrusion press, a powerful hydraulic device wherein a ram pushes a dummy block that forces the softened metal through a precision opening, known as a die, to produce the desired shape.



This is a simple diagram of a typical horizontal hydraulic extrusion press; the direction of extrusion here is from left to right.

That is a simplified description of the process known as direct extrusion, which is the most common method in use today. Indirect extrusion is a similar process, but with some important differences. In the direct extrusion process, the die is stationary and the ram forces the alloy through the opening in the die. In the indirect process, the die is contained within the hollow ram, which moves into the stationary billet from one end, forcing the metal to flow into the ram, acquiring the shape of the die as it does so.

The extrusion process has been likened to squeezing toothpaste out of a tube. When pressure is applied at the closed end, the paste is forced to flow through the open end, accepting the round shape of the opening as it emerges. If the opening is flattened, the paste will emerge as a flat ribbon. Complex shapes can be produced by complex openings. Bakers, for example, use a collection of shaped nozzles to decorate cakes with fancy bands of icing. They're producing extruded shapes.

As suggested by these toothpaste tubes, the shape of the extrusion (profile) is determined by the shape of the opening (die).

Information courtesy of Aluminum Extruders Council.

For more information, go to www.midstal.com or call 920.922.7207.

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You can squeeze aluminum through a shaped opening with the aid of a powerful hydraulic press, producing an incredible variety of useful products with almost any shape imaginable.

These photos show a new length of extrudate, just emerging from the press (left) and the production of a profile in progress (right).

Billet

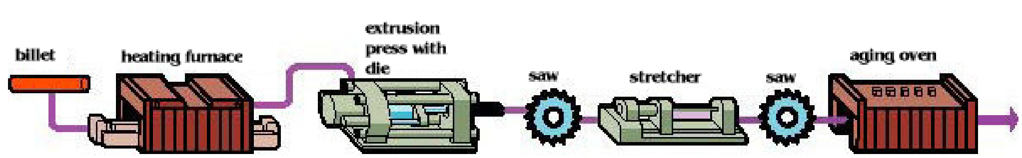
Billet is the starting stock for the extrusion operation. Extrusion billet may be a solid or hollow form, commonly cylindrical, and is the length charged into the extrusion press container. It is usually a cast product but may be a wrought product or powder compact. Often it is cut from a longer length of alloyed aluminum, known as a log.

Alloys are metals composed of more than one metallic element. Aluminum extrusion alloys contain small amounts (usually less than five percent) of elements such as copper, manganese, silicon, magnesium, or zinc. These alloying elements enhance the natural properties of aluminum and influence the extrusion process.

Billet length varies according to a number of factors, including the desired length of the finished profile, the extrusion ratio, the length of the runout, and the requirements of the extrusion press. Standard lengths may run from about 26 inches (660 mm) up to 72 inches (1,830 mm). The outside diameter may range from 3 inches (76 mm) to 33 inches (838 mm); 6-inch (155 mm) to 9-inch (228 mm) diameters are the most common. The modification methods applied to heat- and nonheat-treatable alloys are listed in the Temper Designation System below.

Direct Extrusion Operation

This diagram shows the basic steps involved in extruding an aluminum profile.



Once the shape of the final product has been identified, the proper alloy selected, and the die prepared, to make ready for the actual extrusion process, the billet and extrusion tools are preheated. During extrusion, the billet is still solid, but has been softened in a heating furnace. The melting point of aluminum varies with the purity of the metal, but is approximately 1,220° Fahrenheit (660° Centigrade).

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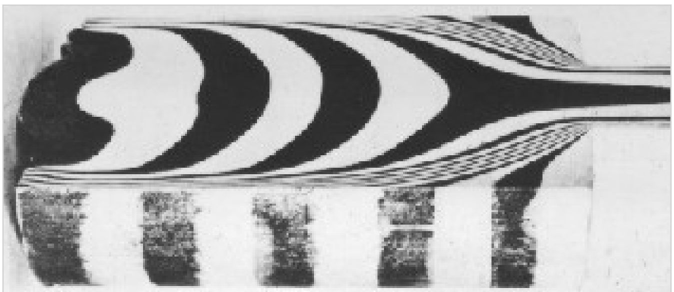
Extrusion operations typically take place with billet heated to temperatures in excess of 700°F (375°C), and – depending upon the alloy being extruded – as high as 930°F (500°C).

The actual extrusion process begins when the ram starts applying pressure to the billet within the container. Various hydraulic press designs are capable of exerting anywhere from 100 tons to 15,000 tons of pressure. This pressure capacity of a press determines how large an extrusion it can produce. The extrusion size is measured by its longest cross-sectional dimension, sometimes referred to as its fit within a circumscribing circle diameter (CCD).

As pressure is first applied, the billet is crushed against the die, becoming shorter and wider until its expansion is restricted by full contact with the container walls. Then, as the pressure increases, the soft (but still solid) metal has no place else to go and begins to squeeze out through the shaped orifice of the die to emerge on the other side as a fully formed profile.

About 10 percent of the billet, including its outer skin, is left behind in the container. The completed extrusion is cut off at the die and the remainder of the metal is removed to be recycled. After it leaves the die, the still-hot extrusion may be quenched, mechanically treated, and aged.



As heated aluminum is forced out of the container and through the die, the core of the billet flows more rapidly than the periphery, as illustrated by the dark banding in this photograph. The periphery, which is left behind as residue, is recycled for future use.

Extrusion rates vary, depending on the alloy used and the shape of the die. A hard alloy, given a complex shape, may emerge from the press as slowly as one or two feet per minute; a soft alloy taking on a simple shape may be extruded at a rate of 180 feet per minute, or even faster.

Depending on billet size and die opening, a continuous extrusion as much as 200 feet long may be produced with each stroke of the press. The newly-formed extrusion is supported on a runout conveyor as it leaves the press. Depending on the alloy, the extrusion is cooled after emerging from the die, either naturally or through the use of air or water quenches. This is a critical step to ensure sufficient metallurgical properties after aging. The extrusion is then transferred to a cooling table.

Stretching

A stretcher and/or straightener may be employed, after the profile has been quenched (cooled) to straighten the extrusion and correct any twisting that may have occurred subsequent to extrusion. (The stretcher may also be used to impart cold work to the extrusion.) Conveyors feed the work to the saw.

Cutting

Typically, a finish cut saw is used to cut the profile to the specified commercial length. Circular saws are the most common in use today and are generally similar to a radial arm saw that cuts across the profile at a perpendicular angle to the length of the extrusion. Other saws may swing down onto the profile (like a power miter saw), or may operate more like a table saw, with the circular blade rising up to make the cut, then dropping down below the table for the return pass.

A typical, circular, finish cut saw may be 16 - 20 inches in diameter, with more than a hundred carbide-tipped teeth. Larger saws are used for larger-diameter presses.

Lubricated saws are equipped with delivery systems that feed the lubricant through the teeth of the saw for optimal efficiency and cut surface.

Automatic devices clamp profiles in place for sawing. Saw chips are collected for later recycling.

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Aging

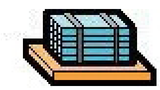
Some extrusion alloys reach their optimal strength through the process of aging, sometimes known as age-hardening. Natural aging occurs at room temperature. Artificial aging takes place through controlled heating in an aging oven and is sometimes referred to as precipitation heat-treating.

When the profile emerges from the press it is in a semi-solid state, but rapidly solidifies as it cools or is quenched (whether by air or water). Non-heat-treatable aluminum alloys (such as those utilizing manganese or magnesium) derive their strength through natural aging and cold working. Heat-treatable alloys (such as those utilizing copper, zinc, and magnesium with silicon) are further strengthened or hardened through controlled thermal treatments that affect the metallurgical structure of the alloys.

Either way, the aging process ensures the uniform precipitation of fine particles through the metal, yielding maximum strength, hardness, and elasticity for the specific extrusion alloy.

Packaging

Aluminum profiles can be packaged in a variety of ways.

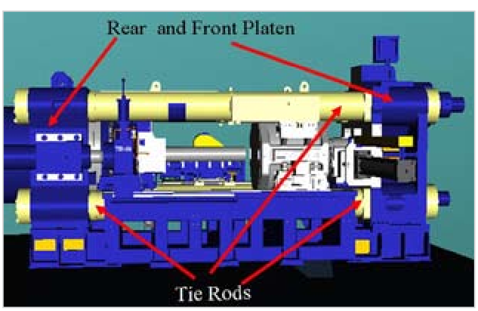


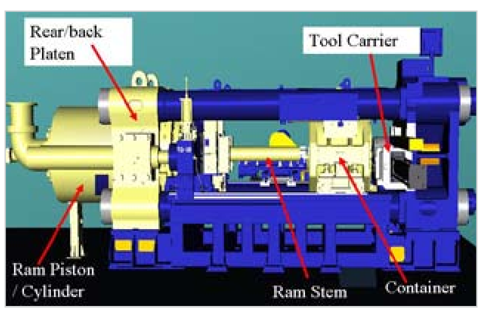
After sufficient aging, whether in an aging oven or at room temperature, the profiles are moved to other areas of the plant for finishing or fabricating, or to be packed and prepared for shipment to the customer.

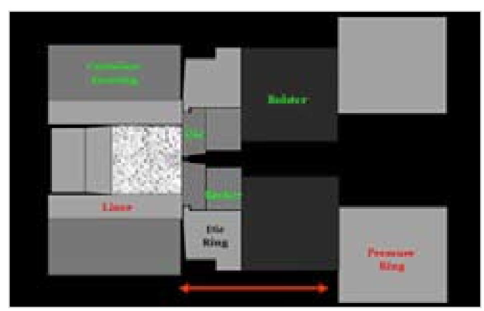
Most extrusion plants are equipped to accommodate any likely packaging requirement. Profiles are palletized in such a way as to be protected from surface damage, twisting, or other hazards. Customers may specify their own packaging requirements, or the type of extruded product may suggest a particular method of packaging for ease of storage or delivery.

Press Components

The front and rear platens are held parallel with one another by the tie rods and nuts. The diagram below (far left) shows a press with four tie rods. It is possible to have presses with only two or three tie rods.







The ram piston/cylinder pushes the ram stem forward, which in turn pushes the billet through the container and then through the die (held in position by the die carrier) that ultimately forms the profile. See labeled illustration above (middle) that identifies the component parts involved in this process.

The diagram above (far right) shows a cross-sectional view of the die, backer, and bolster in the tool carrier.

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