Aluminum Overview

Basic aluminum facts and extractive metallurgy

Aluminum is the most abundant mineral in the earth's crust. In nature, however, it typically does not appear in its pure form. There is evidence of its use from as early as 300 B.C., but it was not until 1888 that an economically feasible process was developed for modern, commercial production of aluminum.

Obtaining aluminum

Aluminum is derived from bauxite, a mineral mined from the earth. The bauxite is crushed and sprayed with water; clay and silica are removed as waste by-products. The remaining bauxite is kiln-dried, then mixed with soda ash and crushed lime. The mixture is processed in a digester, then reduced under pressure and sent to a settling tank where additional impurities are removed.

After filtering, cooling, and further processing in a precipitator, the mixture is thickened and filtered once more before being heated in a calcinating kiln. The resultant material is alumina, a powdery chemical combination of oxygen and aluminum.

Smelting

To yield the aluminum alloys in common use today, alumina must go through smelting and alloying processes. An aluminum smelter typically contains a cryolite bath (in which the mineral cryolite is melted using electrical current). Alumina, in powder form, is placed into the cryolite bath, where it is melted and separated from its oxygen component, settling beneath the cryolite. The molten aluminum is siphoned from the bottom of the smelter and placed in a crucible, then formed into ingot or transferred to an alloying furnace.

Alloying

For production of primary aluminum alloys, the molten aluminum may be transferred from the smelter to the alloying furnace or previously produced aluminum ingot may be melted in the furnace. Alloying metals can then be mixed with the molten aluminum. Alloys are mixed metals that offer a wide array of specific material properties. The characteristics of various finished aluminum products are determined, in part, by their alloy content. For instance, copper as an alloying element tends to yield excellent machinability; manganese offers good corrosion resistance; magnesium is very good for welding applications; zinc can result in very high strength; magnesium and silicon together make for a very popular alloy class that is heat treatable and offers good overall characteristics.

Information courtesy of Aluminum Extruders Council

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(Alloying continued)
The molten metal mixture is then cast – using the direct chill process – into a solid log. Logs may be cut to obtain a more manageable billet. It is typically from billet that extruded aluminum shapes – commonly known in the industry as aluminum profiles – are made.

Key characteristics

Aluminum in general (and extruded aluminum profiles in particular) offers a number of advantages over other materials (and other forming processes). Some other materials may offer some of the beneficial characteristics of aluminum profiles, but aluminum can offer a complete range of benefits at once. Aluminum extrusion is a versatile metal-forming process that enables designers, engineers, and manufacturers to take full advantage of a wide array of physical characteristics:

Aluminum is lightweight. Aluminum weighs less by volume than most other metals. In fact, it is about one-third the weight of iron, steel, copper, or brass. Lightweight aluminum is easier to handle, less expensive to ship, and is an attractive material for applications in fields such as aerospace, high-rise construction, and automotive design.

Aluminum is strong. Profiles can be made as strong as needed for most applications. Cold-weather applications are particularly well-served by aluminum because, as temperatures fall, aluminum actually becomes stronger!

Aluminum exhibits high strength-to-weight ratio. Aluminum offers a unique combination of light weight and high strength. Without aluminum, space travel might never have been realized. Engineers are discovering that bridge decks constructed from extruded aluminum can bear heavier live loads, in part because the aluminum bridge deck itself weighs so much less than a conventional steel deck.

Aluminum resists corrosion. Aluminum offers excellent corrosion resistance; it does not rust. Aluminum is protected by its own naturally occurring oxide film, a protection that can be further enhanced by anodizing or other finishing techniques.

Aluminum is an excellent thermal conductor. Based on weight and overall cost, aluminum conducts heat (and cold) better than other common metals. These factors make aluminum ideal for applications requiring heat exchangers, especially because extrusion, as a metal-forming process, is well-suited to produce shapes that make optimal use of thermal conduction properties.

Aluminum does not emit sparks. Because aluminum is nonsparking, it is appropriate for applications involving explosive materials or taking place in highly flammable environments.

Aluminum conducts electricity. Bulk power transmissions generally take place via aluminum because, pound-for-pound, aluminum is twice as conductive as copper.

Aluminum is nonmagnetic. Because aluminum does not acquire a magnetic charge, it is useful for high-voltage applications, as well as for electronics, especially where magnetic fields come into play or where sensitive magnetic devices are employed.

Aluminum is resilient. Aluminum combines strength with flexibility and can flex under loads or spring back from the shock of impact.

Aluminum is reflective. Highly reflective aluminum can be used to shield products or areas from light, radio waves, or infrared radiation.

Aluminum is not combustible. Aluminum does not burn and, even at extremely high temperatures, does not produce toxic fumes.

Aluminum is suited to extreme cold. The strength of aluminum actually increases under very cold temperatures, making it especially useful for cryogenic applications and in the extreme cold of outer space, as well as for aircraft and for construction in high latitudes.

Aluminum can be recycled. Aluminum retains a high scrap value. It can be recycled indefinitely without losing any of its superior characteristics, making it especially appealing according to both environmental and economic criteria.

Aluminum accepts a variety of common finishes. Aluminum can be finished with liquid paint (including acrylics, alkyds, polyesters, and others), powder coatings, anodizing, or electroplating.

Aluminum profiles are seamless. Complex shapes can be realized in one-piece extruded aluminum sections without having to effect mechanical joining methods. The resultant profile typically is stronger than a comparable assemblage, less likely to leak or loosen over time.

Aluminum profiles can be joined in many ways. Extruded aluminum sections can be joined by all major methods in use today, including welding, soldering, or brazing, as well as though use of adhesives, clips, bolts, rivets, or other fasteners. Integral joining methods may be especially useful for certain designs.

Aluminum profiles are economical. Extrusion tooling is relatively inexpensive and may not require long lead times. Even short-run prototypes often can be produced at moderate cost.

Pricing

Aluminum is a commodity and, as such, its value is determined by a variety of market factors. Those who buy or trade aluminum understand that its price is subject to periodic fluctuation, due in part to supply and demand, as well as to other factors, such as the actions of commodity market speculators. Those who buy aluminum products, including extrusions, should understand that the price of the metal may be only a portion of the finished or fabricated product's cost to the end user because of all the value-added services performed throughout the manufacturing process. Furthermore, the price of aluminum at the time of purchasing the finished product may not reflect the price of aluminum at the time of its procurement to manufacture that product.

A frequently used benchmark for aluminum pricing is the high grade aluminum contract traded on the London Metal Exchange (LME). The LME quotes daily prices for commercially pure (approximately 99.7 percent) aluminum; the price is published periodically in various journals (such as the *Wall Street Journal*) in U.S. dollars per metric tonne. To convert the posted LME price into a price per pound, divide by 2,204.6. Prices can also be found in American Metal Market (AMM), published daily, and Platt's Metals Week (published weekly).

To this price a Midwest Premium is generally added as a universal surcharge to all North American purchases. Such charges are determined by current market conditions.

In addition, an alloying premium is added to convert the "pure" aluminum quoted on the LME into a standard alloy in log or billet form (the starting material for extrusion operations); the diameter or length of the billet (or log) may effect the cost. Nonstandard alloys carry additional upcharges.

Recycling

Recycling is seen as a closed loop that carries a material – say aluminum – from point-of-purchase to the consumer (end user), from the consumer – once the product is discarded – to collection, sortation and processing (which may include separation from contaminant materials, melting and manufacturing activities), on to fabrication, and ultimately back to a consumer. It is not enough for the material to be recyclable; the material must eventually find its way back to a viable end use.

Recycling is important for many reasons. With many landfills closing due to lack of additional capacity, it is necessary to reduce the solid waste stream; recycling diverts significant amounts of material for reuse. Businesses are driven by economic factors; recycling saves money because the raw material recaptured by recycling costs less than that derived through mining. Energy conservation has become a necessity for both economic and environmental reasons; aluminum recycling saves 95 percent of the energy required to produce aluminum from raw materials. Conserving natural resources is important; because it takes four pounds of bauxite ore to produce one pound of aluminum, every pound of recycled aluminum saves four pounds of ore.

Historically, aluminum has proven to be one of the most important materials in successful recycling programs. Aluminum offers high scrap value, widespread consumer acceptance, and aluminum recycling enjoys significant industry support.

All forms of aluminum can be recycled, from aluminum foil to automobile hoods and, of course, aluminum extrusions. Storm doors, window frames, and aluminum ladders are among the more common household extrusions that can be recycled, but large items such as rail cars and trailers can yield an especially impressive financial return when harvested for scrap. As a case in point, the chief executive of a prominent primary metals producer recently cited the fact that, when hundreds of all-aluminum railcars had been returned to the company in 1993 at the end of their 25-year lease, the value of the recycled metal was equal to 90 percent of the original manufacturing cost!

Aluminum can be recycled and reused over and over without losing any of its characteristic attributes – there is no loss of quality in using recycled aluminum.