Aluminium Alloy: Introduction to Aluminium and its alloys

Aluminium is the world's most abundant metal and is the third most common element, comprising 8% of the earth's crust. The versatility of aluminium makes it the most widely used metal after steel.
Although aluminium compounds have been used for thousands of years, aluminium metal was first produced around 170 years ago.
In the 100 years since the first industrial quantities of aluminium were produced, worldwide demand for aluminium has grown to around 29 million tons per year. About 22 million tons is new aluminium and 7 million tons is recycled aluminium scrap. The use of recycled aluminium is economically and environmentally compelling. It takes 14,000 kWh to produce 1 tonne of new aluminium. Conversely it takes only 5% of this to remelt and recycle one tonne of aluminium. There is no difference in quality between virgin and recycled aluminium alloys.
Pure aluminium is soft, ductile, corrosion resistant and has a high electrical conductivity. It is widely used for foil and conductor cables, but alloying with other elements is necessary to provide the higher strengths needed for other applications. Aluminium is one of the lightest engineering metals, having a strength to weight ratio superior to steel.
By utilising various combinations of its advantageous properties such as strength, lightness, corrosion resistance, recyclability and formability, aluminium is being employed in an ever-increasing number of applications. This array of products ranges from structural materials through to thin packaging foils.

PROPERTIES

The major advantages of using aluminium are tied directly to its' remarkable properties. Some of these properties are outlined in the following sections.

STRENGTH TO WEIGHT RATIO

Aluminium has a density around one third that of steel and is used advantageously in applications where high strength and low weight are required. This includes vehicles where low mass results in greater load capacity and reduced fuel consumption.

CORROSION RESISTANCE

When the surface of aluminium metal is exposed to air, a protective oxide coating forms almost instantaneously. This oxide layer is corrosion resistant and can be further enhanced with surface treatments such as anodising.

ELECTRICAL AND THERMAL CONDUCTIVITY

Aluminium is an excellent conductor of both heat and electricity. The great advantage of aluminium is that by weight, the conductivity of aluminium is around twice that of copper. This means that aluminium is now the most commonly used material in large power transmission lines.
The best alternatives to copper are aluminium alloys in the 1000 or 6000 series. These can be used for all electrical conduction applications including domestic wiring.
Weight considerations mean that a large proportion of overhead, high voltage power lines now use aluminium rather than copper. They do however, have a low strength and need to be reinforced with a galvanised or aluminium coated high tensile steel wire in each strand.

LIGHT AND HEAT REFLECTIVITY

Aluminium is a good reflector of both visible light and heat making it an ideal material for light fittings, thermal rescue blankets and architectural insulation.

TOXICITY

Aluminium is not only non-toxic but also does not release any odours or taint products with which it is in contact. This makes aluminium suitable for use in packaging for sensitive products such as food or pharmaceuticals where aluminium foil is used.

RECYCLING

The recyclability of aluminium is unparalleled. When recycled there is no degradation in properties when recycled aluminium is compared to virgin aluminium. Furthermore, recycling of aluminium only requires around 5 percent of the input energy required to produce virgin aluminium metal.

The combination of two remarkable properties of aluminium makes the need to recycle the metal obvious. These first of these factors is that there is no difference between virgin and recycled aluminium. The second factor is that recycled aluminium only uses 5% of the energy required to produce virgin material.
Currently around 60% of aluminium metal is recycled at the end of its lifecycle but this percentage can still be vastly improved.

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ALUMINIUM PRODUCTION

Aluminium Production

Aluminium is extracted from the principal ore, bauxite. Significant bauxite deposits are found throughout Australia, the Caribbean, Africa, China and South America. Open cut techniques are commonly used to mine the bauxite.
The bauxite is purified using the Bayer process. This process involves dissolving aluminium trihydrate to leave alumina plus iron and titanium oxides. The iron and titanium oxides are by-products of the process and are often referred to as 'red mud'. Red mud must be disposed of with strong consideration given to environmental concerns.
Approximately two tonnes of bauxite are required to yield one tonne of alumina.

Smelting
The extraction of aluminium from alumina is achieved using an electrolytic process. A cell or pot is used that consists of a carbon lined steel shell. This shell forms a cathode. A consumable carbon anode is suspended in liquid cryolite (sodium aluminium fluoride) held within the pot at 950°C. Alumina is dissolved in the cryolite by passing low voltages at high amperages through the pot. This results in pure aluminium being deposited at the cathode.

ENVIRONMENTAL CONSIDERATIONS

The aluminium industry is very conscious of the environmental impact of its activities. The mining and smelting of aluminium, plus the disposal of red mud can have a major environmental impact if not done properly.
The industry is proud of its efforts and achievements in rehabilitating open cut mine sites and the restoring flora and fauna to these sites. Such efforts have been rewarded with awards from the United Nations Environment Programme and red mud disposal areas are now being successfully revegetated.
Environmental requirements are met on pot line emissions through the use of specialist scrubbing system.

APPLICATIONS

The properties of the various aluminium alloys has resulted in aluminium being used in industries as diverse as transport, food preparation, energy generation, packaging, architecture, and electrical transmission applications.
Depending upon the application, aluminium can be used to replace other materials like copper, steel, zinc, tin plate, stainless steel, titanium, wood, paper, concrete and composites.
Some examples of the areas where aluminium is used are given in the following sections

Packaging
Corrosion resistance and protection against UV light combined with moisture and odour containment plus the fact that aluminium is non-toxic and will not leach or taint the products has resulted in the widespread use of aluminium foils and sheet in food packaging and protection.
The most common use of aluminium for packaging has been in aluminium beverage cans. Aluminium cans now account for around 15% of the global consumption of aluminium.

Transport
After the very earliest days of manned flight, the excellent strength to weight ratio of aluminium have made it the prime material for the construction of aircraft.
These same properties of aluminium mean various alloys are now also used in passenger and freight rail cars, commercial vehicles, military vehicles, ships & boats, buses & coaches, bicycles and increasingly in motor cars.
The sustainable nature of aluminium with regards to corrosion resistance and recyclability has helped drive the recent increases in demand for aluminium vehicle components.

Marine Applications
Aluminium plate and extrusions are used extensively for the superstructures of ships. The use of these materials allows designers to increase the above waterline size of the vessel without creating stability problems. The weight advantage of aluminium has allowed marine architects to gain better performance from the available power by using aluminium in the hulls of hovercraft, fast multi-hulled catamarans and surface planing vessels.
Lower weight and longer lifecycles have seen aluminium become the established material for helidecks and helideck support structures on offshore oil and gas rigs. The same reasons have resulted in the widespread use of aluminium in oil rig stair towers and telescopic personnel bridges.

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Building and Architecture
Aluminium use in buildings covers a wide range of applications. The applications include roofing, foil insulation, windows, cladding, doors, shop fronts, balustrading, architectural hardware and guttering.
Aluminium is also commonly used as the in the form of treadplate and industrial flooring.

Foils
Aluminium is produced in commercial foils as thin as 0.0065 mm (or 6.5 µm). Material thicker than 0.2mm is called sheet or strip.

Aluminium foil is impervious to light, gases, oils and fats, volatile compounds and water vapour. These properties combined with high formability, heat and cold resistance, non toxicity, strength and reflectivity to heat and light mean aluminium foil is used in many applications. These applications include:
~ Pharmaceutical packaging
~ Food protection and packaging
~ Insulation
~ Electrical shielding
~ Laminates

Other Applications
The above applications account for approximately 85% of the aluminium consumed annually. The remaining 15% is used in a wdie variety of applications including:

~ Ladders
~ High pressure gas cylinders
~ Sporting goods
~ Machined components
~ Road barriers and signs
~ Furniture
~ Lithographic printing plates

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REVISION HISTORY

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