Aluminum

General information

Overview

Aluminum alloys are the most important of the light alloys (the others being titanium and magnesium), second only to steel in the volume of its use. They can be split into cast and wrought alloys; these in turn are split into different series depending on composition.

Strengths

Versatile - wide range of uses, low density, high strength, good thermal, and electrical conductivity, highly reflective surface, no brittleness at low temperatures (except pure Al), range of surface treatments available, and they are easy to weld and cast. Whilst they are fairly low cost, they are still twice as expensive as most steels. Wrought alloys generally have better ductility and strength than cast alloys.

Limitations

Low fatigue endurance relative to their tensile strength. Low elastic modulus (1/3 that of steel), limited high temperature capability (120-200°C / 250-390 °F), not suitable for use in certain environments (e.g. coal mines, due to sparking possibility).

Typical uses

Aerospace, aircraft applications, domestic electrical appliances, weapons industry, transport applications, forged missile and aircraft fittings, machinery, engine blocks, gas meters, gear blocks, gear cases, fuel pumps, instrument cases, intake manifolds, clutch housings, oil pans, outboard motor propellers, pistons, cylinder liners.

Composition overview

Compositional summary

Al with varying additions of Cu, Mg, Si, Fe, Mn, Zn. Less common additions include Cr, Ti, Li, Ni

Material family	Metal (non-ferrous)
Base material	Al (Aluminum)

Effect of composition

Corrosion resistance is generally lower as alloy additions increase.

Processing properties

Feedstocks & production

The feedstock is bauxite (hydrated Al2O3). Alumina (Al2O3) is extracted from bauxite via the Bayer process. It is then electrolytically reduced in molten cryolite (Na3AlF6). Aluminum ions are reduced to metallic aluminum at the cathode whilst oxygen collects at the anode. Alloying elements are added by inoculation.

Available forms

Sheet, plate, foil, ingot, extrusion, tube, rod, bar, wire, forgings, powder, sand, permanent mold, pressure die, investment and plaster castings.

Forming

It can be cast using permanent mold, pressure die, and sand casting. Cold or hot-rolling, extrusion, forging, and drawing into tube shapes.

Machining

Generally excellent machinability. Can be machined rapidly and economically. Alloys are generally easier to machine than pure aluminum.

Heat treatment

Annealing softens alloys hardened by cold work. Stabilizing relieves internal stress. Hardening occurs via solution treatment, quenching, and aging.

Joining

Can be joined by a wide variety of methods, including fusion and resistance welding, brazing, soldering, and adhesive bonding. Weldability is reasonable but welding is made more difficult by oxide films - the surface must be prepared so that the resistance of the contact is constant.

Surface treatment

Chemical etching produces matte finish, alkaline etching is used to reduce surface scratching, anodizing increases the corrosion resistance of the alloy, electroplating is difficult as aluminum has a high affinity for oxygen. Other surface treatments: painting, powder-coating, wet barrel finishing , barrel burnishing, deburring, polishing (rarely required) and buffing, satin finishing, chemical brightening, chemical conversion coatings, porcelain enameling (only for certain alloys), immersion plating and shot-peening. Electroless-plating can be used when electroplating is not practical, but it is more expensive.

Notes

Reference sources

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