UK Aluminium Industry Fact Sheet 18

Aluminium Rolling

ALFED
ALUMINIUM FEDERATION

+44(0)121 601 6363 www.alfed.org.uk

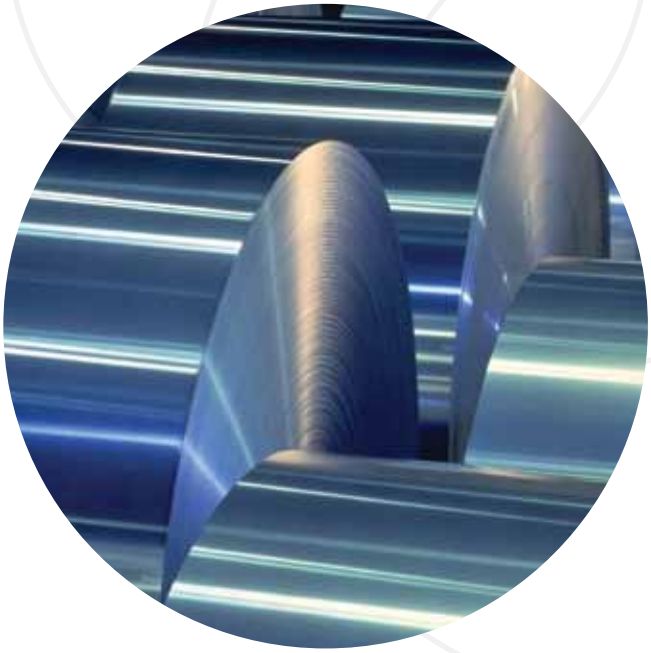
Introduction

Rolling aluminium and its alloys is one of the principle ways of converting cast aluminium slab from the smelters and wrought re-melts into a usable industrial form. By hot rolling, it is possible to reduce a slab of about 600mm thickness down to plate material with thicknesses of 6 - 250 mm and further down as low as 2mm for subsequent cold rolling to sheet with thicknesses as low as 0.2mm. Further rolling can produce the thinnest of foil with a thickness as low as 0.006 mm, approximately one-third the thickness of a human hair!

Common to all rolled aluminium products are the properties of lightness, strength and durability. These three, coupled with other specific properties for particular applications, make rolled aluminium one of the most versatile materials available for the major markets of packaging, transport, and building and construction.

The use of aluminium in place of heavier alternative materials enables significant energy savings to be made over the product's life cycle, for example in transportation and in all areas where products move or are carried.

Metal recovery is another important characteristic, aluminium is easily recycled after use and similar rolled products to those recycled can be produced using only 5% of the energy required to make the initial primary metal. Thus aluminium roofing sheet can be recycled into more roofing sheet and an aluminium beverage can recycled into another aluminium beverage can.



The Process

Conventional Rolling

The starting material for rolled products is rectangular cast slabs weighing up to 30 tonnes each. These slabs are heated to a temperature of around 525°C and then passed repeatedly through a hot rolling mill until either the required plate thickness is obtained or until the metal is thin enough (generally about 3 mm thick), to be coiled ready for cold rolling – the last 3 or 4 hot rolling passes are usually performed sequentially through a 3 or 4 stand "tandem" mill. From this stage onwards, right down to the thinnest of foil thicknesses, the metal is fed in coil form through a series of single or multi-stand cold rolling mills which successively reduce the metal thickness and recoil it after each rolling pass, ready for the next, until the required thickness is obtained. Annealing may be required between passes depending on the final temper (hardness) required.

The rolling of cast aluminium changes its metallic structure and the metal takes on new characteristics and properties. The brittleness of the coarse, as-cast structure is replaced by a stronger and more ductile material, with the degrees of strength and ductility being variable factors that are functions of the amount of rolling (deformation) given to the metal, the rolling temperature, the alloy composition and the use of annealing.

Commercial purity aluminium obtained from the smelting operation has a composition of between 99% and 99.7% aluminium with the remainder made up of other constituents such as iron and silicon.

Such metal when rolled is relatively soft and ductile. However by adding controlled quantities of other elements such as manganese, magnesium, zinc, copper and silicon to a melt of commercially pure aluminium, it is possible to prepare alloys that have a wide range of different properties and strength characteristics. Many alloys have been formulated specifically for rolling to plate, sheet and foil.

Also, by special refining of the metal during the smelting operation, it is possible to obtain aluminium having a purity of up to 99.99% which can be used for special products such as reflector sheet and in electrical applications.

Strip Casting

These are special processes which eliminate the need for hot rolling and its' associated high capital costs.

Twin-roll casting (TRC)

Molten metal is fed into a converging cavity set by two internally cooled, counter-rotating rolls. The process relies on the heat transfer between the solidifying (& compressed) melt and the roll surfaces to solidify the aluminium which results in very high cooling rates. Because of this, conventional twin roll casters have a limited alloy/ product range - short freezing range alloys for fin, foil & building sheet.

Twin-belt casting (TBC)

Molten metal is fed into a nearly parallel cavity comprised of two, internally cooled, counter-rotating belts. The heat transfer is much lower than for TRC. Twin belt casters can be used for container stock, foil, fin, building products, and some medium strength alloys. It is now possible, with updated technology, to produce automotive stock in 5XXX and 6XXX series alloys.

Today strip casting represents a significant and increasing part of overall aluminium sheet production (>1Millon Tonnes/yr).

No single strip casting technology has yet been developed sufficiently well that it can meet all the property requirements for the full range of aluminium rolled products.

Significant opportunities for important technical developments in the strip casting of aluminium alloys remain.

The Product

Rolled aluminium can be divided into four principal products:-

Plate: a flat material, either hot or cold rolled, over 6 mm thickness.

Shate: a flat material, either hot or cold rolled, between 4 & 6 mm thickness.

Sheet: a flat, cold rolled material, over 0.2mm but not exceeding 4mm (6mm) in thickness; coiled sheet is known as strip and generally does not exceed 3mm in thickness.

Foil: a cold rolled material 0.2mm thick or less.

Rolled aluminium is widely used in many industries including:

Aircraft: Structural members, cladding and many fitments.

Aerospace: Satellites, space laboratory structures and cladding.

Marine: Superstructures, hulls, interior fitments.

Rail: Structures, coach panelling, tankers and freight wagons.

Road: Car chassis & body panels, Buses, truck bodies, tippers, tankers, radiators, trim, traffic signs and lighting columns.

Building: Insulation, roofing, cladding and guttering.

Engineering: Welded structures, tooling plate, cladding and panelling, and heat exchangers.

Electrical: Transformer windings, busbars, cable sheathing, and switchgear.

Chemical: Process plant, vessels and chemical carriers.

Food: Handling and processing equipment, and hollowware.

Packaging: Cans, bottle caps, beer barrels, wrapping, packs and containers for a wide range of food and non-food products.

Printing: Lithographic plates

Rolled aluminium for general engineering specifications is supplied to BS EN 485 Parts 1-4 – plate, sheet and strip. Aerospace materials are covered by the "L" series of British Standards and by the BS EN Aerospace Series.

Much of the UK market for rolled aluminium, except for a number of speciality products such as can stock, lithographic sheet and packaging foil, can be supplied to manufacturers through members of the Aluminium Stockholders Association. This important distribution network is of major importance, particularly as the mills seek further and further scales of economy in production by rolling bigger and bigger ingots. Supplying the UK market with its aluminium requirements is increasingly becoming a partnership approach, with the stockist providing the important "Just-in-Time" link in the chain to ensure manufacturers get the aluminium they need in whatever form, exactly when they need it, with minimum stocks.

Selection of Rolling Alloys

Alloy Designation	Characteristics	Typical Applications
1050A (Former BS designation 1B)	Very good atmospheric corrosion resistance. Very good workability. High thermal and electrical conductivity (preferred alloy 1350). Attractive appearance, high reflectivity. Suitable for decorative anodising. Very good weldability. Low mechanical properties.	Packaging containers, foils, collapsible tubes, radiator tubes, wide jar closures, printing plates. Heat exchanger strip, boiler making. Kitchenware. Chemical and food industry equipment, containers. Automotive trim, light reflectors. Architecture. Vessels, piping.
2014/2014A (Former BS designation H15)	Heat treatable alloy. High mechanical strength, slightly higher than 2011 and 2017A.	Usually in plate form. High strength structural components, military vehicles and bridges. Weapons manufacture, structural applications.
3103/3003 (Former BS designation N3)	Very good resistance to atmospheric corrosion. Very good weldability. Good formability by pressing, drawing and roll forming. Medium strength alloy. Better mechanical properties (in particular at elevated temperatures) than 1xxx-alloys.	Roofing and sidings, acoustic ceilings, corrugated sheets. Chemical and food industries: storage tanks, pipes, metal work. Heat exchangers, air conditioning evaporators, vehicle radiators, freezer linings. Home appliances, cooking utensils, bakery moulds, office equipment. Packaging containers, closures. Cladding alloy.
3004 (No former BS designation)	Al-Mn and Al-Mn-Mg 3000 Series alloys provide a wide range of mechanical properties and very good corrosion resistance, weldability and formability. The strength/formability characteristic is achieved by application of various degrees of strain hardening and by intermediate annealing. Alloy 3004 as well 3104 alloy are the 2 alloy types use for beverage can body stock.	Siding, can stock, packaging, lamp bases. Sheet-metal work, storage tanks, trailer panel sheet.
5251 (Former BS designation N4)	Very good corrosion resistance to seawater, marine and industrial atmosphere. Very good weldability. Good cold formability. Medium high strength alloy with a strength slightly lower than 5052. Medium high fatigue strength.	Boiler making, containers. Nameplates, traffic (road) signs, architectural panelling. Welded tubes, chemical industry, irrigation, desalination units. Pressure vessels. Rivets.
5754 (No former BS designation)	Very good weldability. Very good resistance to corrosion, especially in seawater, marine and industrial atmosphere. Good cold formability. Medium high strength higher than 5052 and 5251. High fatigue strength. Fair machinability.	Welded structures in nuclear, chemical and food industries. Pressure vessels, piping and tubing (for hydraulic application), boiler making. Marine and offshore applications, ship building, boats, office equipment. Facade panels. Appliances, vehicle bodywork. Road poles and structures. Rivets.
5083 (Former BS designation N8)	Very good weldability. Very good corrosion resistance to seawater and marine atmosphere. High strength alloy with a strength slightly higher than 5086. High fatigue strength. Good cold and stretch formability in soft temper in relation to strength. Can be produced in thick plates without internal stress.	Shipbuilding, masts, platforms. Chemical apparatus and storage tanks, cryogenics. Pressure vessels, piping and tubing. Automotive: welded tank trailers and welded dump bodies. Railway: welded tanks and structural components. Military vehicle bodies and equipment: armour plates, collapsible bridges. Machinery: structures, appliances, tools. Building and road construction, poles, pylons, towers, scaffolding.
6082 (Former BS designation H30)	Very good corrosion resistance and weldability (lowered strength values in the welding zone). Good machinability. Good cold formability in T4 temper after a stabilizing heat treatment. Heat treatable medium high strength. Strength somewhat higher than 6061. Medium high fatigue strength.	Heavy duty structures in rail coaches, truck frames, ship building, offshore, bridges, military bridges, bicycles, boilermaking. Machinery: platforms, mining equipment, motorboats. Nuclear technology.
7075 (Former BS designation 2L95)	Heat treatable very high strength alloy with a strength slightly lower than 7010. Very high fatigue strength. Joining preferably by rivets, adhesives or screws. Corrosion protection is recommended also in outdoor atmosphere.	Usually in plate form. Aircraft and military highly stressed structural components. Rolling stock for machine parts and tools (for rubber and plastics). Ski poles, tennis rackets, screws and bolts, nuts. Rivets. Nuclear applications.

Further information about aluminium and aluminium alloys, their production, fabrication and end use can be obtained from:

(1) European Aluminium Association in Brussels
www.eaa.net

(2) International Aluminium Institute in London
www.world-aluminium.org