



UK Aluminium Industry Fact Sheet 17

Primary Aluminium Production

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Introduction

In the earth's crust, aluminium is the third most common element after oxygen and silicon and is the most common metallic element. Aluminium in fact accounts for 8% of the earth's crust. The aluminium occurs as very stable chemical compounds known as aluminosilicates and the extraction of metallic aluminium is a very complex series of industrial processes.

The ore most commonly used for the extraction process is bauxite, which is impure since it contains appreciable amounts of iron compounds which give bauxite its characteristic red colour, together with silica and titanium dioxide. The bauxite is processed to alumina – aluminium oxide – using the Bayer process. The aluminium oxide is then processed to aluminium, the metal, in a primary smelter.

In the UK, the aluminium story begins at the primary smelter stage, since all of the alumina used is imported. Most of the bauxite used to make aluminium in UK originates from countries such as Jamaica, West Africa, Australia and South America.

The Process

Generally bauxite is mined in areas where it is very close to the surface so that open cast mining can be used. The top soil taken off from the site is used in adjacent areas where older mining sites are being restored. The current mine rehabilitation practices aim to meet both environmental and commercial objectives which reflect the long-term interests of both the local and the national communities in the mining country. The restored mining areas are reseeded with the same type of flora that was originally present. This recognition of environmental responsibility has won the aluminium industry awards from the United Nations Environmental Programme (UNEP).

The bauxite is mined in the form of granules and does not need crushing before being treated. The bauxite is digested at high temperature and pressure with caustic soda to dissolve the aluminium, leaving iron, silicon and titanium compounds undissolved. The residues are filtered and washed to leave a liquor that contains only aluminium in the caustic solution. The aluminium is precipitated out as a hydrate, filtered, washed and calcined to produce the alumina, aluminium oxide.



The excess caustic is removed from the residues and can be reused in the process. The residue, known as red mud, is returned to the mining areas that are being restored.

In round figures, about four tonnes of bauxite are used to make two tonnes of alumina, which in turn produce one tonne of aluminium.

In a primary smelter, aluminium is produced by an electrolytic process. The finely powdered alumina is dissolved in a molten bath of cryolite (Na_3AlF_6) at a temperature of about 950°C . The cryolite forms the electrolyte of the cell, and the consumable anode and the permanent cathode are both made from carbon. The cells run at low voltage but very high amperage, typically in the UK over 200,000 amps.

Each cell in a primary smelter produces about 1.6 tonnes of molten aluminium each day, so that a typical 125,000 tonne per annum smelter would have of the order of 300 cells, known as pots. The molten aluminium produced at the cathode is siphoned from the pot periodically and sent to a cast house to be alloyed and cast into ingots for remelting, extrusion billet or rolling slab. Because large amounts of electrical energy are used in the electrolytic process, the primary aluminium smelting industry has developed worldwide in areas adjacent to a sufficient supply of electrical energy.

Over 50% of the western world's primary aluminium is produced from electricity generated by hydro electric power. This power generation

is very efficient, generating electricity without any evolution of greenhouse gases.

As the reduction cells operate at high temperatures, volatile fluoride compounds are generated from the cryolite. These emissions are collected by efficient hooding and extraction from each individual cell. Emissions are then passed to a scrubbing system where in excess of 98% of the fluorides are collected prior to discharge of the cleaned air to the atmosphere. The collected fluorides are recycled to the process. Extensive monitoring of the emissions from the plant is carried out to ensure compliance with all regulatory standards.

To demonstrate that there is no impact on the surrounding environment, primary smelters measure atmospheric fluoride concentrations as well as monitoring vegetation and livestock. The out-plant environmental monitoring programme complements comprehensive industrial hygiene measures within the plant to safeguard the health of the workforce.

The modern primary aluminium smelters use of the order of 14 kWh of electricity to produce each kilogramme of aluminium. Better cell design and use of microprocessors and computer controlled pot lines, have ensured that this energy consumption is continually being improved. The recycling of aluminium once produced, takes place for an energy consumption of only 5% of that required to produce the aluminium originally in the primary smelter.

In addition to the need for electrical energy, primary smelters are normally located with access to deep water ports, which allow the transportation of the raw materials to the smelter and the dispatch of the smelter products to the world markets.

The Product

The purity of the aluminium produced in a cell depends on many factors including the age of the cell. The cell can last for up to six years before it is relined. Generally, the aluminium produced is 99.7% purity or better, with small amounts of silicon, iron and other trace elements which were present in the alumina and the raw materials used.

The metal can be cast into ingots, or larger blocks known as sows, which are destined for remelting. More usually the molten aluminium from the cells is transferred to a holding furnace, typically with a capacity of up to 50 tonnes of metal. There it is alloyed with a variety of elements such as iron,

silicon, magnesium and copper. The alloy is then cast into extrusion billet or rolling slab using a semi-continuous process known as direct chill (DC) casting. These products can be sent directly to the extrusion presses and rolling mills for fabrication into semi-finished products, such as extrusions and sheet, plate and foil.

The Structure of the UK Industry

The investment in a primary smelter is very large indeed and therefore only the major aluminium companies can afford such investments. The products of a primary smelter may be used downstream within the same company or may be sold, as ingots, billets and rolling slab, on the world market.

The UK has one large, 180 000 tonne, primary smelter at Lynemouth and a smaller smelter, 43 000 tonnes, in the Scottish Highlands. The Highland smelter was built early in the last century and was completely refurbished in the early 1980's and uses power generated by its own hydro electric power station. In 2009 the Highland hydro power station modernisation project commenced with all the original DC machines being replaced with AC generators. The Lynemouth smelter was built in the 1970s and owns its own coal-fired power station.

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