Aluminium Production

HIGHLIGHTS

■ **PROCESSES AND TECHNOLOGY STATUS –** Primary aluminium is produced from aluminium oxide (alumina, Al2O3) which is obtained from bauxite, a widespread mineral. The primary aluminium production from alumina is based on an energy-intensive electrolytic process at a temperature of approximately 960°C, where a high current (200 to 350 kA) is passed through the electrolytic bath to produce aluminium metal. There are basically two different technologies for primary aluminium production, i.e. Prebaked and Søderberg technology. The first one is more efficient and less polluting. The use of the Prebake technology has increased from about 63 % in 1990 to about 90 % in 2010. An aluminium plant consists of many electrolytic cells in series (pot-lines). Secondary aluminium is produced by melting scrap (recycled) metal in a furnace. Production of secondary aluminium consumes less than 5% of the energy needed to produce primary aluminium. It accounts for 33% of today's global supply and is expected to rise to 40% by 2025. In 2010, the global production of primary aluminium was 41.2 million tonnes (Mt), about twice as much as in 1990. China, Canada, Russia, and the United States accounted for 59% of the 2008 global production.

■ **PERFORMANCE AND COSTS –** Today's electricity consumption for primary aluminium production ranges from 13 to 17 kWh/kg, with best performance in advanced large-scale pilot plants of 12.5 kWh/kg The target is to reduce it to 11 kWh/kg in next generation of production cells (theoretical minimum energy use for electrolysis is 6.3 kWh/kg). Aluminium production involves the emission of pollutants in all phases of the process including alumina production and electrolysis. The emissions from the electrolytic cells consist of greenhouse gases such as CO_2 and poly-fluorinated hydrocarbons (PFC), and other pollutants including fluorides, polycyclic aromatic hydrocarbons (PAH), SO_2, dust, metals, NOx, CO. Apart from CO_2, the actual emissions depend on the efficiency in flue-gases treating, which usually ranges from 95% to more than 99%. In 2006, the average direct GHG emissions from aluminium production were about 1.5 tCO_2eq/t Al from alumina production, 2.5 tCO_2eq/t Al from electrolysis (of which 0.7 due to PFCs) and 5.5 tCO_2eq/t Al from electricity generation, thus totalling 9.5 tCO_2eq/t Al. The secondary aluminium produces by far less emissions than primary aluminium, but salt slag (up to 500 t/t Al). A major waste from alumina production is the red mud (600-1500 kg/tAl_2O_3). As far as cost is concerned, the investment cost for new aluminium production facilities is between €4000 and €5000 per tonne of production capacity per year. Due to this high investment cost, an option to increase the capacity is to upgrade and modernise existing plants thus increasing capacity and energy efficiency, rather than building new facilities. The typical cost breakdown of aluminium production is dominated by the cost of electricity and alumina (about 60%), with the electricity share varying significantly among producers. Profitability of the aluminium production depends on market prices, operation costs and the cost of the raw materials. Market prices can vary significantly, e.g. high-grade primary aluminium ingots ranged from $0.75 per pound in 2009 to $1.17 per pound in 2008 (London Metal Exchange average).

■ **POTENTIAL AND BARRIERS –** The main areas of growth for the aluminium market are expected to be in non-OECD countries such as China, Brazil, Middle East and South Africa. New production plants are usually located where the production and electricity costs are expected to be lower. The associated emissions can be significantly reduced if aluminium production is based on electricity from hydro power and other renewable sources rather than from coal-fired power plants. Emerging technologies like inert anodes (carbon free) and new cathode materials (wettable cathode) might succeed in achieving highly efficient electrolysis processes, but still are at a pilot plant level. Increased aluminium recycling will reduce significantly the use of raw materials, energy and emissions for aluminium production.

PROCESS OVERVIEW

Aluminium is the third most common element on the earth. It is obtained from bauxite, a mineral largely available at commercial prices. In 2010, the global production of primary aluminium was 41.2 million tonnes, up from 37.3 million tonnes in 2009 and 39.6 million tonnes in 2008. Four countries (China, Canada, Russia, and the United States) accounted for 59% of the total production in 2008, see Figure 1~~Figure 1~~ [1].

■ Production of Primary Aluminium

Primary aluminium is produced from aluminium oxide, Al_2O_3, also called alumina. Alumina is produced from bauxite. Most primary aluminium production plants do not have an alumina production process on site. The most common process for alumina production is the Bayer process, where bauxite ore is grinded, mixed with caustic soda and heated up to 280°C. The dissolved aluminium hydrate is then precipitated as a solid material at about 55-70°C. The aluminium hydrate crystals can be removed by either filters or thickeners and finally converted to alumina by calcination at a temperature of around 1000°C. The production of one tonne of aluminium requires two tonnes of alumina and about four tonnes of bauxite [2]. The energy use for bauxite mining, raw materials

Please send comments to Eva.Rosenberg@ife.no, Author, and to
Giorgio.Simbolotti@enea.it and Giancarlo Tosato (gct@etsap.org), Project Co-ordinators