Aluminium Making & Recycling

Information Sheet

Aluminium is a light weight, silver-grey metal obtained from bauxite ore in a two-stage process.

In the first (chemical) stage, crushed bauxite is mixed with a hot solution of caustic soda which dissolves the alumina (aluminium oxide). Undissolved sand and mud, together with any other impurities, are filtered out and the caustic solution is then cooled to crystallise the dissolved alumina into a white, sandy powder. In the second, (smelting) stage, alumina is dissolved at temperatures of around 900 degrees centigrade. A powerful electric current is passed through the liquid and this splits the aluminium oxide into its two constituents: aluminium and oxygen. Molten aluminium is drawn off and cast into ingots.

Aluminium is the third most abundant element (the first two are oxygen and silicon), and the most abundant metal, in the earth's crust, of which it makes up about eight per cent by mass.

Aluminium is non-magnetic and a good conductor of electricity. It oxidises easily, the layer of oxide on its surface making it highly resistant to corrosion. Because of its corrosion resistance as well as its light weight, aluminium is today widely used in ship-building and aircraft manufacture. It is also used in cables, cars, windows and doors, to make foil, and for domestic applications such as cooking utensils and drinks cans. Aluminium sulphate is used as a coagulant in water treatment, to collect impurities suspended in the water.

When it was first identified at the beginning of the nineteenth century, it was so difficult to extract it was considered a semi-precious metal. The pure metal was not readily available until the middle of the nineteenth century.

In its pure state, aluminium is soft and quite weak, but when alloyed with other elements such as copper or silicon it becomes very strong.

Mining

Bauxite is the principal ore of aluminium. It is formed by the chemical weathering of rocks in tropical climates. Chief producers of bauxite are Australia, Jamaica, Russia, Kazakhstan, Surinam and Brazil. Bauxite is recovered in open cast mines, and the chemical processes which separate the alumina leave in their wake large amounts of residues, known as red mud because of the iron compounds which colour it.

Making one tonne of pure aluminium requires the extraction of four tonnes of bauxite. As with all primary metal extraction and refining processes, production generates significant quantities of solid wastes.

EDDY CURRENT SEPARATION

Although it is not magnetic, a magnetic effect can be induced in aluminium by the application of a strong fluctuating magnetic field.

This causes a small electric current in the aluminium and an associated magnetic field which is opposed to the applied magnetic field, enabling the aluminium to be separated.

Eddy current separation of aluminium cans from steel cans, or from a mixed waste stream, is widely used at waste sorting plants: more than 200 units are already operating in waste processing facilities and incinerators across Europe.

Energy intensive

A lot of energy is needed to produce aluminium: around 146 Megajoules per kilogram (MJ/kg), compared to 32 MJ/kg for steel and 90 MJ/kg for plastics such as polyethylene.

Efficiencies in the industry have reduced energy consumption by around 30 per cent in the last 50 years. However, aluminium production must be located in areas where cheap energy sources, such as hydro-electricity, are available if it is to be economically viable.

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Benefits

There are a number of benefits associated with the substitution of aluminium for other, more traditional materials.

For example, its use for motor vehicle engines and other parts greatly reduces the weight of the car, reducing the vehicle's fuel consumption and therefore its overall environmental impact. On average, around five to ten per cent of a current model might be aluminium. However, there have been some aluminium-intensive experiments by car makers: the aluminium body of the Audi A8 is 40 per cent lighter than the typical steel car body, and because of its rust resistance, it also has a longer life expectancy.

Aluminium is used to make durable, low-maintenance window and door frames for buildings, replacing wood which, while a renewable material, has to be extensively treated with chemicals (such as fungicides) and painted to slow the rotting process.

Table: Aluminium can consumption and recycling in western Europe (1997)

Country	Al can consumption (x million cans)	Recycling rate (per cent)
Austria	315	50
Belgium	150	25
Denmark	-	-
Finland	90	82
France	665	17
Germany	630	86
Greece	890	35
Ireland	220	20
Italy	1,490	41
Netherlands	170	30
Norway+Iceland	40	80
Portugal	220	17
Spain	1,470	20
Sweden	870	91
Switzerland	110	88
Turkey	880	45
UK	4,370	34
Total W Europe	**12,580**	**40**

Aluminium in the waste stream

Aluminium scrap generated in industrial manufacturing processes is always recycled because of its high value. The US aluminium industry claims that Americans have earned around US$9 billion in can recycling since the 1970s.

There is very little aluminium in the household waste stream - less than one per cent of the waste and around two per cent of the recyclables (but around 50 per cent of the value). Almost all of this comes from drinks cans.

A tiny amount comes from aluminium foil, used in the home for cooking and wrapping foods, and by the food industry for lids on dairy products (such as cream and yoghurt), pie cases, and for containers for ready-prepared meals and take-away foods.

Additionally, a very thin layer of aluminium foil (around five microns) is sandwiched between layers of other materials, such as paper and plastic, to make a laminated

THE RING PULL

First invented in the 1960s in the USA, drinks cans with ring pulls for ease of opening rely on the softness of aluminium. Whether the body (including the base) of the can is steel or aluminium, the top which carries the ring-pull is always made from aluminium. Even all-aluminium cans use a different mix of alloys: the body of the can is an alloy of aluminium, manganese and magnesium, while the top and ring pull (called the stay-on-tab within the industry), are alloyed in different proportions.

packaging material for coffee, long-life milk, juice and other items. The aluminium is used because it forms a very effective barrier.

The aluminium that arises from other sources (such as car parts or old saucepans) is handled by scrap metal dealers.

Re-use & recycling

Very little aluminium is re-used, without re-smelting, but one exception to that is the beer keg.

Aluminium recycling is cost effective simply because of the high energy input needed for the raw material. Using recycled cans to produce new ones allows industry to make up to 20 times more cans for the same amount of energy. In America, aluminium can recycling saved more than 18 million barrels of oil in 1996. Even long distance haulage to recycling facilities - which for many materials obviates the environmental benefits of recycling - is not enough to cancel the relative benefits.

Recycling any material reduces virgin resource consumption. Where that virgin resource is a metal, there is a resulting reduction of mining, with its associated impacts.

A further boost to aluminium recycling (like that for steel) is the guaranteed reprocessing capacity, and a guaranteed market for the re-processed material. Shortage of re-processing capacity and fluctuating end-use markets for other materials, such as paper, limit recycling. While the price paid for collected aluminium does vary, it remains higher than for other materials. In Europe, the aluminium can recycling rate

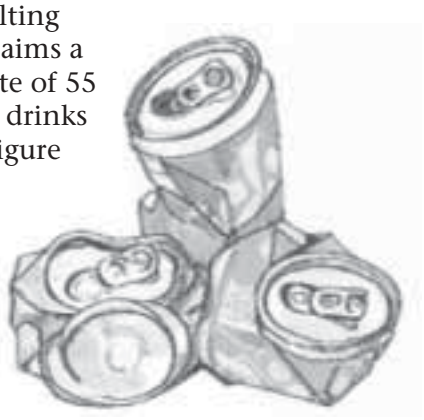
ALUMINIUM DRINKS CANS

In 1997 more than 15 billion aluminium drinks cans were sold in Europe alone, around 50 per cent of the total cans sold.

The first aluminium beverage can in the USA (in 1935) weighed almost 100 grammes (g), almost six times heavier than those used in the present day. When first used for drinks cans, the aluminium was several times lighter than the steel it replaced, and there were major energy savings in distribution. Recent developments in steel technology have greatly reduced the thickness of steel needed to make cans (as well as replacing the lid with aluminium), but there is still a significant weight difference: a 330 ml can in steel weighs around 30 g while the aluminium equivalent weighs around 15 g.

Reverse vending machines were proposed (for instance in Sweden) combined with deposits, as a way to get back more aluminium cans for recycling. An empty can dropped into the slot prompted the machine to pay out a coin or a voucher in return. While the machines attract the return of cans, especially from children, maintaining and servicing the machines is expensive, as are the machines themselves, and the technology has not spread widely.

Depending on the efficiency of the process, up to 90 per cent of the energy used to make a can from virgin material can be saved by recycling. There are some losses in the melting process, and also some limitations caused by the different alloys. Paints and lacquers on the used cans are burned off in the re-melting process. The industry claims a world-wide recycling rate of 55 per cent for aluminium drinks cans. For Europe, that figure is 40 per cent *(see Table opposite)*. In the UK alone, 1.5 billion cans - amounting to 23,900 tonnes - were collected for recycling in 1997.



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THE DANISH BAN

In the late 70s, Denmark introduced a ban on the sale of beer and soft drinks in cans, ostensibly for environmental reasons although many believed it was to protect its national beer industry. By banning one-way cans and requiring refillable bottles, Denmark disadvantaged beer importers from countries like Germany: returning bottles to Germany for washing and refilling was not viable. The fact that Denmark continued to export its own beers in cans was widely resented. The European Commission has challenged Denmark's ban, and the Danish Environmental Protection Agency published a life cycle assessment which defended the current Danish policy.

reached 40 per cent in 1997 (more than 75,000 tonnes of used cans), up from 37 per cent in 1996 and 30 per cent in 1994. The overall rate is expected to exceed 50 per cent by 2000.

Aluminium foil is no harder to recycle, but it is harder to *collect* for recycling as it occurs in smaller quantities. It may also be contaminated with food.

Laminated materials can in principle be recycled but in practice they often are not, because of the high costs involved in separating the different component parts. Despite this non-recyclability, laminated materials need not be detrimental to the environment as they reduce the total amount of materials needed in manufacture (several thin layers each performing different purposes replacing one thick layer), and their light weight reduces transport costs and impacts. Some laminated products do not need refrigeration, saving energy.

Conclusions

Aluminium's light weight and corrosion-resistant qualities make it a useful material in a number of applications. Because of the environmental impacts associated with the acquisition and production of aluminium, recycling it has considerable benefits.

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