TALAT Lecture 1102

Environmental Factors

16 pages, 14 figures

Basic Level

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Objectives:

- to appreciate the importance of aluminium application technologies
- to aquire a basic knowledge of a major materials industry and the products available to manufacturing industry

More specifically, the objectives are

- to review the environmental factors affecting the aluminium industry and the remedial practices followed
- to describe the concept of a product life cycle and the importance of recycling
- to describe the secondary aluminium industry, its history, processes, products and structure. To outline the methodology used to calculate recycling rates.
- to summarize the scope and size of the European aluminium industry.

Prerequisites: None

Date of Issue: 1994

1102 Environmental Factors

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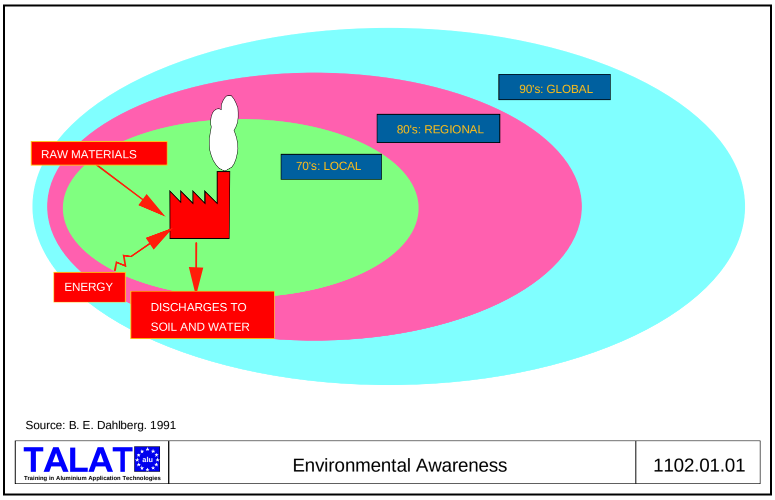
Ecological Concern

Environmental awareness is largely a feature of the last half of this century. Widespread debates were common in the 1960s but most of the problems caused by man's insensitivity to his environment remained unsolved or indeed undiscovered. Smoke and industrial fog was tackled in several countries with dramatic effects (see also **Figure 1102.01.01**).



In the 1970s most attention was focused on the local plant with various industrial cleaning systems being introduced. Inside the factory a great deal was achieved to improve working conditions and in the protection of the workers themselves.

In the '80s these concerns became regional. The acid rain debate for example dates from that decade.

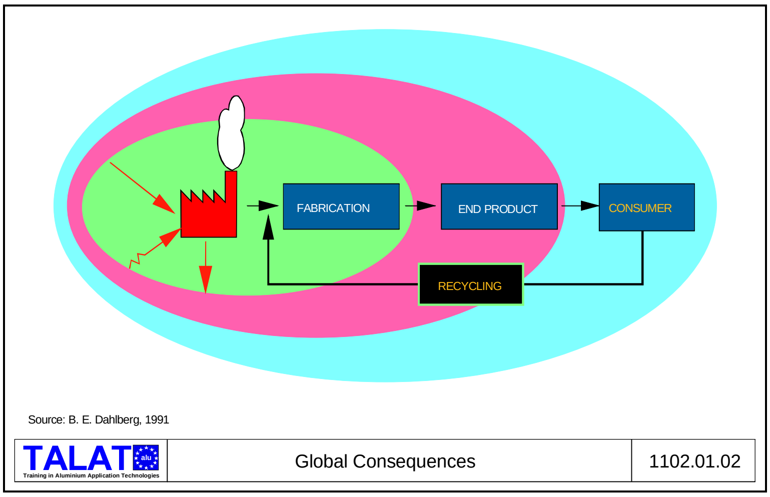
Currently the centre of attention are the global consequences of industrial activity.The destruction of the tropical rain forest, the depletion of the ozone layer and the greenhouse effect are of international concern.

In all these stages of opinion development the aluminium industry has usually kept somewhat ahead of the rest of basic manufacturing industry.

There is increasing concern that we utilise all natural resources in a way to ensure sustainable growth. The reclamation and reuse of materials instead of dumping them has become an attractive, and in some cases an economic option. Waste, both domestic and industrial, is an increasing problem and of great public concern.

Best Available Technology (BAT)

Politics follows opinion, so laws have been proposed giving the producers of materials and products extended responsibilities after they have reached the consumer, and in some cases even after they have been finally discarded (**Figure 1102.01.02**).



The effect of market forces in the environmental field should not be underestimated. Effluents and waste almost always involve the loss of valuable raw materials and energy. Pre-dating the ecology debate by many decades simple self interest achieved real progress.
These rudimentary pressures led to the concept of the ″best available technology″ (BAT) which remains the most effective tool in this environmentally aware age. The best available technology may not suit the idealist. Critics should, however, take into account the costs of remedial or preventive action and the effect on international competitiveness.

Such a concept (BAT) clearly requires an historical perspective when judging the performance of a plant at a specific time. What was the BAT when the plant was built and are more recent innovations of the "bolt on" variety or can they only be applied to a green field site?

Aluminium Industry and the Environment

Whilst this is not the place for detailed consideration of all possible negative, or, indeed, positive ecological effects, it is possible to summarise the position in the main sectors of the aluminium industry.

- Bauxite Mining

The main potential problems with bauxite mining are the effects of deforestation (see **Figure 1102.01.03**).

PROBLEM	EFFECT	B A T
		BAUXITE MINING.
Deforestation	Regional climate changes	Planned reinstatement
Soil erosion	Topsoil loss	---- " ----
		ALUMINA PRODUCTION
SO_2	Acid rain	Exhaust neutralisation
CO_2	Global warming	Improved combustion efficiencies
Dust	Inconvenience	Better handling to minimise Al_2O_3 loss
Red mud	Loss of land use during settling period	"Dry stacking"
	Caustic leach	Improved recovery of process NaOH

TALAT | Ecological Considerations. 1. | 1102.01.03

A commercially viable deposit will take a minimum of five years to work to exhaustion of the ore. Mining begins with the removal and storage of the topsoil and overburden on the first area to be worked. At this initial stage seed is collected from the indigenous plants and trees for the propagation of seedlings.

As soon as mining has progressed sufficiently reinstatement can commence. The vast majority of mining areas, over 90%, are restored to the original land use, i.e mining area reinstatement currently shows 80% restored indigenous forest or scrubland, 11% to agriculture and pasture, 7% to commercial forest and 2% to industrial and recreational use. What use is made of restored areas is usually the prerogative of the host country. Reinstatement will usually be complete within 2 to 3 years of the cessation of mining on the site.

- Alumina Production

The production of alumina from bauxite is a chemical process involving caustic soda and appreciable process heat. The effects of the generation of heat are common to all combustion processes such as electrical power generation from coal or oil and the possible remedies are the same.

The largest amount of heat is used to drive off the chemically combined water in aluminium hydrate at the final stage of producing alumina. Substantial economies have been achieved in modern alumina plants by using fluid bed furnaces instead of the traditional revolving cylindrical kiln.

The red mud residue could provide an ideal material for brick making. Alas most alumina plants are located in areas where the demand for bricks is very limited. Bricks are of course heavy and uneconomical to transport long distances. Dry stacking greatly reduces the area required for storage, minimises the time lag before site restoration and largely eliminates caustic leach.

- Electrolysis

The electrolytic process again gives rise to some of the same problems with the same complete or partial remedies. Fluorides, PAH and dross do require comment (see **Figure 1102.01.04**).

ELECTROLYSIS

PROBLEM	EFFECT	B A T
Fluoride emission	Effect on cattle and vegetation	Containment of cells & dry scrubbing of extracted air to return fluoride to the process
Dust	Inconvenience	Better alumina handling
Polycyclic aromatic hydro carbon (PAH)	Can cause cancer	Fume collection & treatment in carbon plant
CO_2/CO	Global warming	As for alumina
SO_2	Acid rain	---- " ----
Dross	Noxious fumes	High temperature dross treatment (which also recovers extra usable Al)

TALAT Training in Aluminium Application Technologies | Ecological Considerations. 2. | 1102.01.04

The first two need site monitoring before the smelter is built to establish prevailing levels - either from natural causes or the then existing environment. Since the lead time from concept to commissioning can be five to ten years this can be done. Monitoring will be continued for the entire life of the plant.

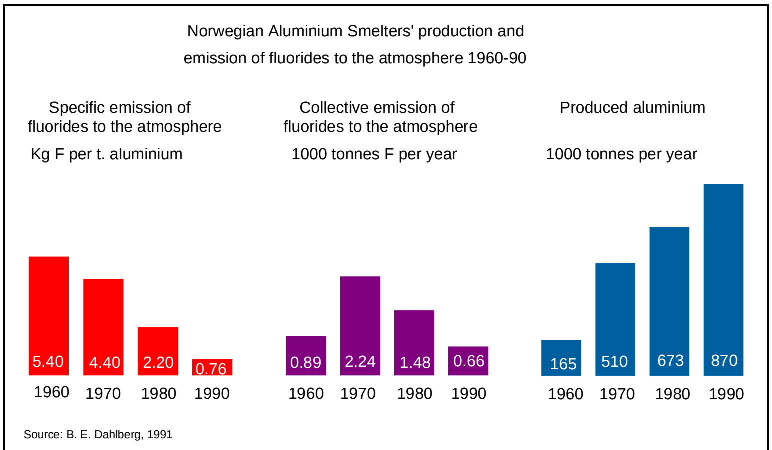
The dry scrubbing process involves the use of fresh alumina being used as the active filter material. It is periodically renewed with the used alumina being fed into the pot lines thus returning the fluoride to the process.

The dross treatment is highly effective. Indeed, merely covering hot dross in airtight conditions will eliminate the very acrid smell.

These problems have different impacts on the working environmental, local community, regionally and globally. For example, the CO_2, CO and SO_2 contribution by the aluminium industry is infinitesimal in global terms but possibly measurable at a local plant level.

A state of the art new plant will beat existing standards and will steadily improve by fine tuning and feasible new BAT application. A further quantum leap in efficiencies and emission control may have to wait until the end of the plant's economic life.

Progress in these areas is measurable and a good example can be found in the reduction of fluoride emissions from Norwegian smelters (**Figure 1102.01.05**).



TALAT | Fluorides to the Atmosphere | 1102.01.05

The specific emission has decreased from 5.4 kg to 0.7 kg per tonne of metal produced. The total emissions are substantially lower today than 30 years ago, even though the production of primary aluminium is five to six times greater.

The main semi-fabrication processes used by the industry are very similar to those used with other metals and thus the problems caused and the effective solutions are similar.

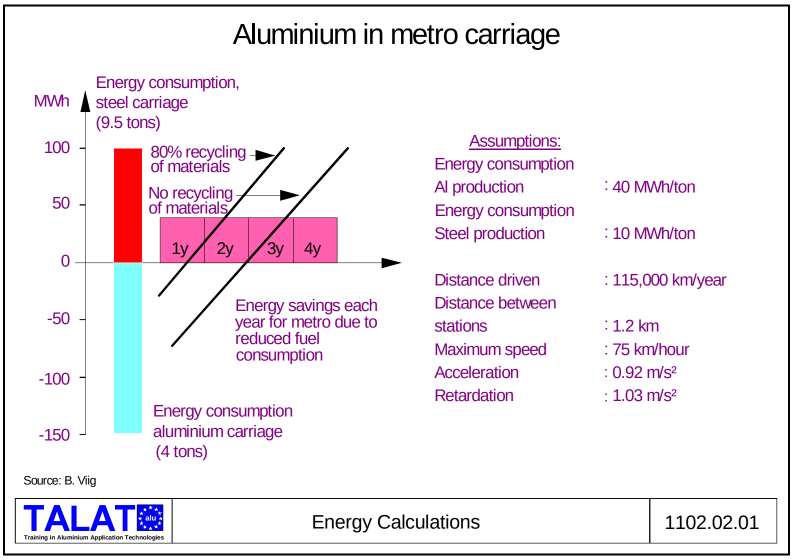
1102.02 Product Life Cycle

- Environment protection by energy saving
- Improvements in production techniques
- Energy content reduction and recycling rate

Environment Protection by Energy Saving

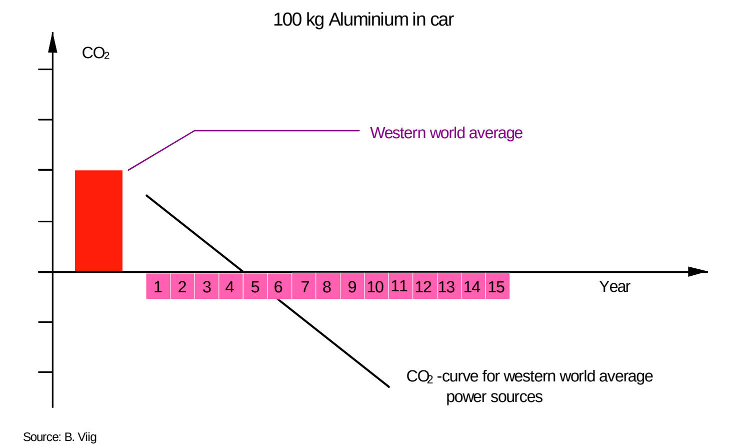
The ecological and environmental story cannot end with the semifabricated product, it must be followed into the life service of the consumer end product. Different products have very different life spans, a beverage can might last six weeks from filling to trash can, an aluminium window perhaps 60 or more years and the aluminium components in an automobile probably 10/12 years.
During the product service life aluminium will provide various savings: energy related if the end product is mobile and maintenance savings in the case of the window - say ten coats of paint and the labour to apply them. In packaging the savings would be in increased shelf life, lower spoilage or some similar measure.

The energy saving by using lightweight aluminium in transport applications can be considerable (see **Figure 1102.02.01**). Total net energy savings over a railcar's service life can exceed 1 million KWh, with the aluminium content then available for recycling. This simplified calculation demonstrates how replacing heavier materials with aluminium in a metro carriage results in reduced energy consumption. After allowing for the energy content of the carriage constructional materials overall savings are achieved in some 3 years.



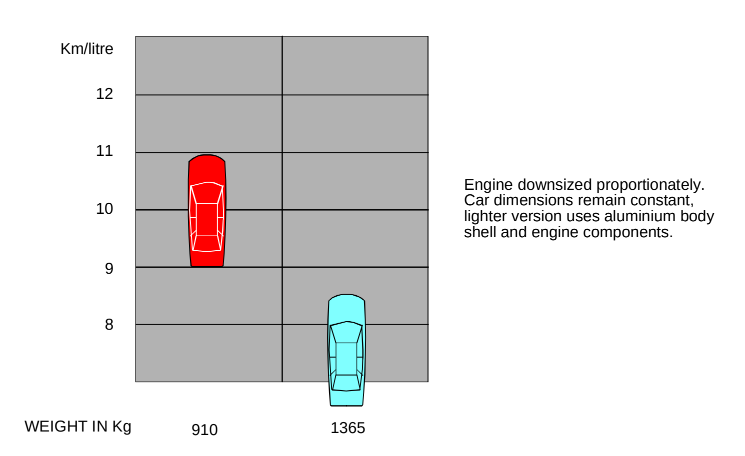
A metro carriage probably has a service life of 30/40 years. Energy savings can of course be roughly equated with reduced pollution as less energy means less fuel burnt in the vehicle's engine, or at the electricity generating station.

This example illustrates the proportionate reduction of emissions as a result of reduced fuel consumption in an automobile, leading to an overall reduction in emissions in only a few years. The additional energy content of the aluminium is based on the western world average (i.e. approximately 60% hydro-power) to provide the CO_2 figure (**Figure 1102.02.02**).



TALAT — CO_2 Calculation Example — 1102.02.02

The energy breakeven point sees the start of a global benefit. The car user makes savings from day 1 of his or her ownership (**Figure 1102.02.03**)! The USA currently requires new cars to exceed 33 miles per gallon, a figure that may be raised to 40. Weight reduction is the most straight forward way of achieving this - unless passengers get much smaller.



TALAT — Lower Weight = Less Fuel Consumption — 1102.02.03

Improvements in Production Techniques

The service life story cannot be complete without mentioning the benefits provided by the steady improvement in production techniques within the semi-fabricated product sector.

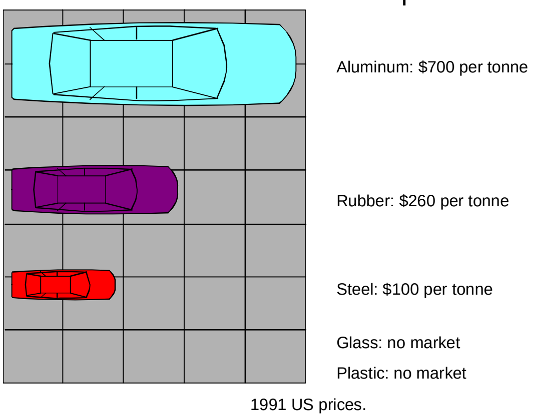
The ability to tighten tolerances, to roll or extrude thinner material and maximise physical properties have lead to "down gauging". For example this has allowed an increase in the number of beverage cans produced from a tonne of metal to increase by some 15% over a relatively short period. Intricate architectural extrusions have shown similar improvement. The gauge of foil has been progressively reduced, without loss of properties, by closer rolling control and minor alloy adjustment.

This type of improvement has been encouraged not only by competition from alternative materials but by competition within the aluminium industry.

Energy Content Reduction and Recycling Rate

No service life history can be complete without consideration of what happens at the end of a product's useful life. With aluminium products the high scrap value plays a deciding role at this point (**Figure 1102.02.04**).

Automotive scrap

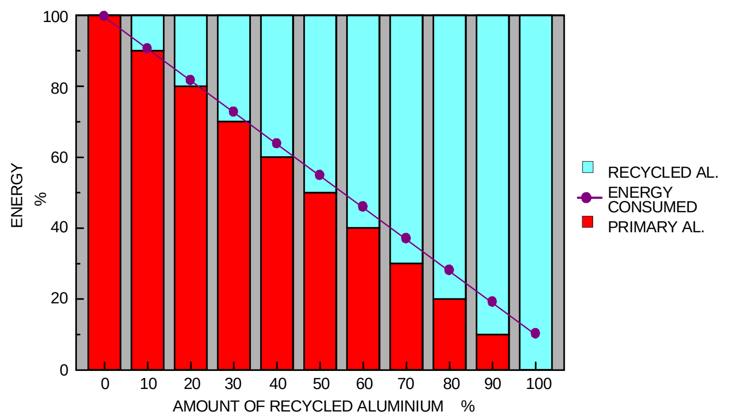


TALAT Value of Recyclable Materials 1102.02.04

Aluminium's potential for recycling is virtually inexhaustible and only some 5 per cent of the energy needed in primary production is required to produce equally usable metal. Hence the relatively high value of aluminium scrap.

If the scrap return rate on a product reaches 90 per cent, the energy required to produce new products would be around 15 per cent of that required for products made entirely from primary metal (**Figure 1102.02.05**). That level of performance has been approached in several countries in the case of cast automobile components.

When energy savings through recycling compound the reductions made by light-weighting, the time to realize net energy savings is substantially reduced. This effect was indicated on the metro carriage example (**Figure 1102.02.01**).



TALAT | Energy Consumption for the Production of Secondary Aluminium Depending on the Recycling Rate | 1102.02.05

The process (new) scrap generated within the aluminium industry from smelting to semi-fabrication has always been recovered 100 per cent and frequently re-processed within the same plant.

A similar recovery is achieved by large users of their process scrap.

1102.03 Secondary Aluminium

- New and old scrap
- Processing of scrap

New and Old Scrap

Aluminium has been recycled since the earliest days of commercial use. A published reference to the economic advantage has been found dated 1903 concerning domestic utensils. A large number of secondary refiners have been established, converting new and old aluminium scrap into foundry ingots (casting alloys), deoxidiser for the steel industry and into wrought alloy slabs and billets.

A wide variety of scrap is processed. New scrap is that surplus material that arises during the manufacture and fabrication of aluminium alloys up to the point where they are sold to the final user. Thus extrusion discards, sheet edge trim, turnings and millings and drosses could all be described as new scrap. On the other hand, old scrap is aluminium material that is recovered when an aluminium article has been produced, used and finally discarded. Such scrap could be a used beverage can, a car cylinder head, window frames from a demolished building or old electrical conductors.

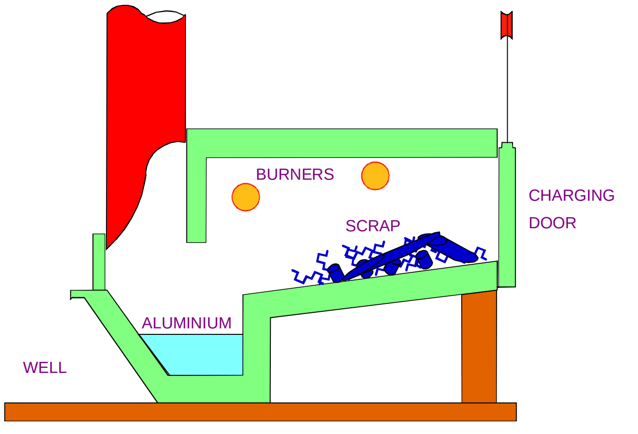
Most new scrap reaching the secondary industry comes directly from the fabricators. It is usually of known quality and composition and often uncoated. It can then be melted down with little preparation, apart perhaps from baling.

Old scrap comes via a very efficient network of metal merchants who have the technology to recover aluminium from motor vehicles, household appliances etc. This is often done using heavy equipment such as shredders together with magnetic separators to remove iron and sink-and-float installations to separate the aluminium from other materials.

Processing of Scrap

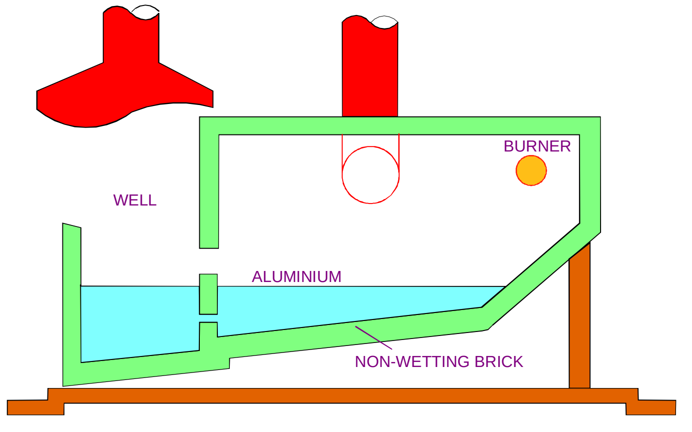
Both types of scrap are processed prior to melting to suit any contamination that may be present. Turnings and millings usually contain oil, water and iron. They are centrifuged and dried to remove the oil and water and then magnetically separated from the iron. Used beverage cans are processed to remove the interior lacquer coating and the outside product display printing inks. This reduces fume emissions and gives pre-heating energy prior to re-melting.

Several melting processes are used depending on the scrap quality (**Figure 1102.03.01**). Clean, uncoated scrap can be melted in a reverberatory furnace (see **Figure 1102.03.02**); finely divided scrap, such as turnings, are ideally melted in a coreless induction furnace; contaminated lower grades of scrap are melted under a flux cover in a rotary furnace (see **Figure 1102.03.03**) and scrap components contaminated with other metals such as steel bolts or studs can be melted in a sloping hearth furnace.

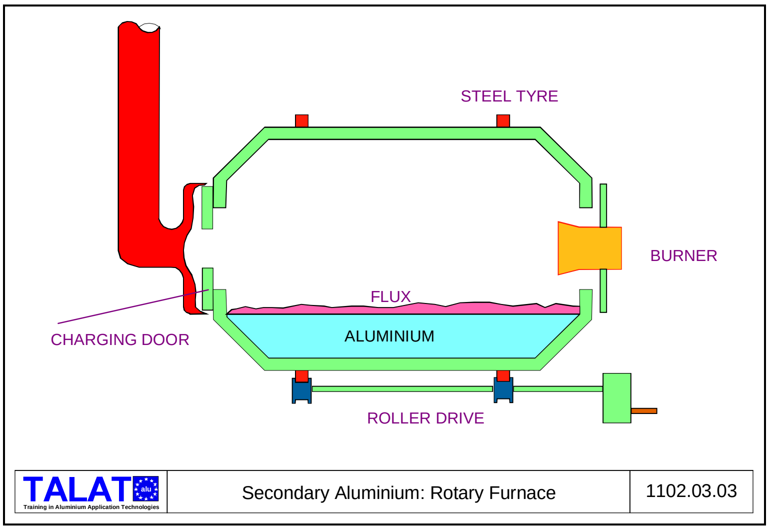


TALAT | Secondary Aluminium: Sloping Hearth Furnace | 1102.03.01

Molten metal fluxing and filtration has been developed to produce aluminium alloys of the desired composition and quality without undue impact on the environment. Most modern secondary aluminium melting furnaces are fitted with fabric filters to ensure that flue gases have a minimal dust content.



TALAT | Secondary Aluminium: Open Well Reverberatory Furnace | 1102.03.02



1102.04 Secondary Aluminium Industry

- The products
- Structure of the secondary industry
- Recycling rates

The Products

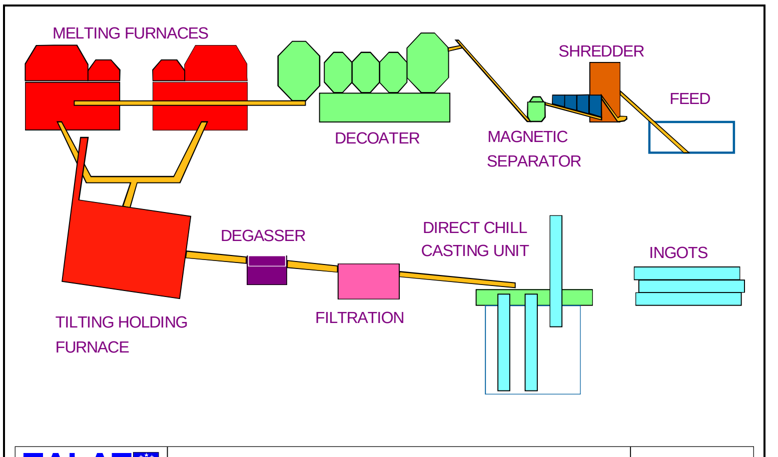
Secondary aluminium refiners convert most of their materials into foundry ingot, generally based on the aluminium-silicon alloy system with additions of other metals such as copper and magnesium. These ingots, to recognised national or international specifications, go into the manufacture of aluminium cast components. Some of this metal is delivered in a molten form by road tanker to large foundry users thus eliminating a further remelting operation.

Deoxidiser for the steel industry is supplied in notched bar or granular forms.

Alloy "hardeners" are also produced. These ingots, with a high known percentage content of alloying metals, are used by other sectors of the aluminium industry such as primary smelters and wrought remelts.

The reprocessing of used beverage cans (UBCs) is a specialist branch of the industry. Here UBCs are dealt with in a dedicated facility and the end product is rolling ingot ready to be reprocessed into can body stock. A modern plant of this kind will treat some

50,000 tonnes of UBCs per year (see **Figure 1102.04.01**); there are between 40 and 50,000 UBCs to the tonne.



Beverage Can Recycling Plant 1102.04.01

Until the can market and the UBC recovery infra-structure has developed to a sufficient size such plants are not a viable proposition. There is at present only one such plant within Western Europe.

Structure of the Secondary Industry

Secondary aluminium refiners may be integrated into major aluminium companies or they may be entrepreneurial, independent companies. Because of the rapidly changing price of aluminium scrap and primary metal and the fluctuating market for foundry alloys, the refiners need to be very flexible in both buying and selling.

Some countries generate more scrap than the national foundry industries can absorb. The secondary refiners in these cases need to sell internationally.

Recycling Rates

It has already been noted that new aluminium scrap, being readily identified and within the control of the industry, has a recycling rate of virtually 100%.
The recycling of old scrap is more interesting and depends on the basis used for calculating the percentage rate for various types of scrap. Should the recovery of aluminium scrap from automobiles be measured against shipments of foundry metal to automobile component suppliers during the current year or, since the average life of a car is 10/12 years, shipments made 10 years ago?

The secondary industry calculates that 63% of available scrap is recovered. Within Europe there are some 200 such companies who in aggregate ship some 1.7 million tonnes of secondary products each year.

Many materials have a very high recycling rate; aluminium printing plates and automobile castings being good examples. The recovery of UBCs varies according to the national recycling infra-structure and within Europe varies from a few per cent to as high as 80%. The UK for example with rapidly growing UBC recovery systems expects to reach 50% by 1996.

The values for other types of packaging are not so good, largely because material such as foil is thinly spread throughout the population.The problem is one of recovery rather than technology.

1102.05 List of Figures