TALAT Lecture 1100.01

Aluminium - A Light Metal

A Brief Introduction to Aluminium

10 pages, 10 figures (also available as overheads)

Basic Level

prepared by Toralf Cock, Skanaluminium, Oslo

Objectives:

This chapter is an introduction to the course on aluminium as a design material. The goal is:

To provide basic information about:

- the history of aluminium
- the principles behind the production of primary metal
- environmental properties
- potential applications
- areas of application

Prerequisites:

The lecture is recommended for those situations, where a brief, general background information about aluminium is needed as an introduction of other subject areas of aluminium application technologies.

This lecture is part of the self-contained course „Aluminium in Product Development“ which is treated under TALAT lectures 2100. It was originally developed by Skanaluminium, Oslo, and is reproduced for TALAT with kind permission of SkanAluminium. The translation from Norwegian into English was funded within the TALAT project.

Date of Issue: 1999

EAA - European Aluminium Association

1100.01 Aluminium - A Light Metal

Production of Primary Metal **2**

Aluminium and the Environment **3**

Potential Applications **4**

Areas of application **7**

The Outlook for Aluminium Structures **8**

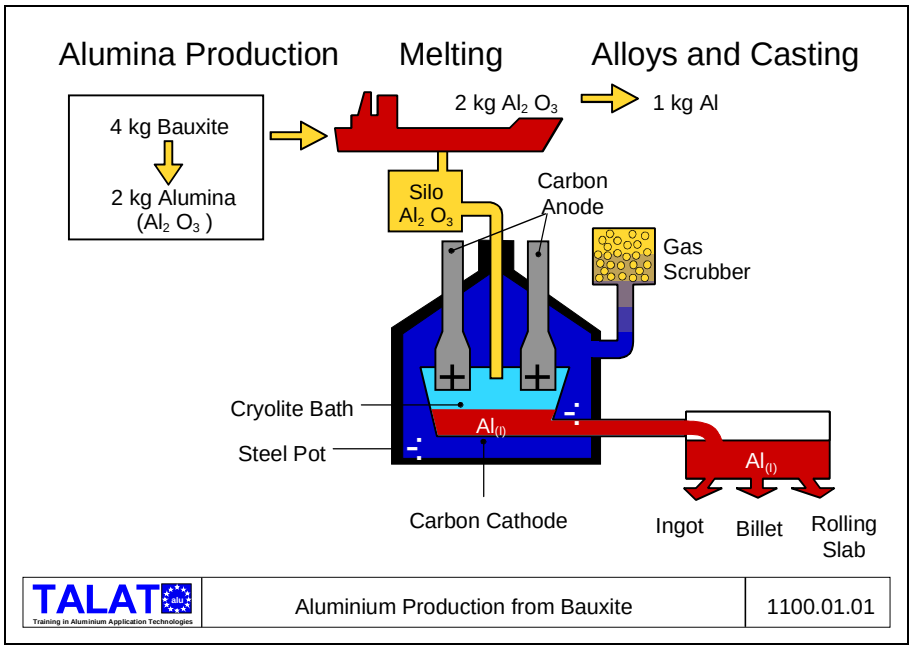
Literature **9**

List of Figures **10**

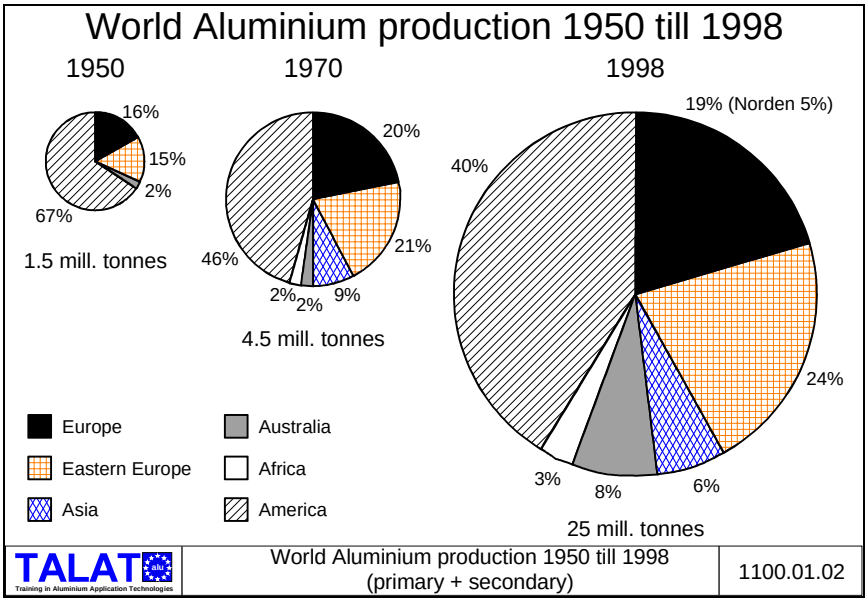
Production of Primary Metal

Aluminium comprises eight per cent of the earth's crust. Since aluminium occurs in extremely stable oxygen compounds, it took quite some time for scientists to figure out how to reduce it into pure metal. That process was first accomplished in 1824 in the laboratory of H.C. Ørsted of Denmark. Some small-scale commercial production was achieved, but even five decades later aluminium remained more costly and coveted than gold.

The breakthrough came in 1886. Independently of each other, the American scientist C.M. Hall and the French scientist P.L.T. Héroult invented the electrolytic reduction process for producing aluminium. The method is based on alumina derived from bauxite. Although improvements have been made in the process over the past century, the industrial production of aluminium is essentially based on the same process today (see **Figure 1100.01.01**).



In about 1918, the Norwegian scientist C. W. Søderberg invented a continuous electrode, the "Søderberg cell", which is still in use today. Most modern electrolytic reduction plants now use pre-baked electrodes for environmental reasons.
Aluminium production has increased rapidly in recent years, rising from a modest 5,700 tonnes per year at the turn of the century to the current level of about 25 million tonnes annually (see **Figure 1100.01.02)**. Aluminium consumption has increased dramatically during the past 40 years in particular. According to forecasts, growth is expected to continue at a rate of 2-3 per cent per year until the year 2010.



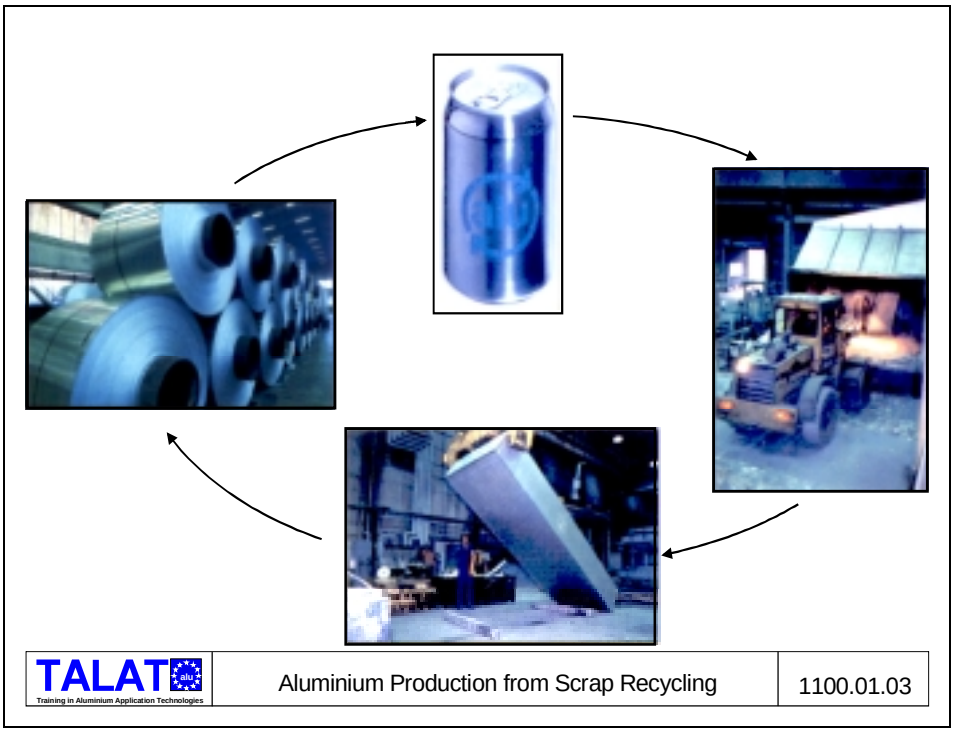
Aluminium and the Environment

The aluminium industry has invested enormous resources in reducing emissions from their production plants. Pollution has been slashed by nearly 80 per cent during the past 20 years, and today's modern electrolytic reduction plants represent minimal environmental problems. We must not forget, however, that there are still plants, especially older ones, which do not satisfy today's environmental standards.

The production of primary aluminium is highly energy-intensive. Roughly 12 - 14 kWh are required to produce one kg of pure aluminium using the electrolytic reduction process. Please note, however, that the metal's melting point (approx. 660 °C) is so low that re-melting requires only about five per cent of the original energy input. This means that efficient aluminium re-cycling is profitable.

Hydroelectric power is used to produce more than 50 per cent of primary aluminium. In actual fact, this is a means of storing and exporting energy to countries where energy production is possible only through the combustion of fossil fuels. This is important in terms of the global environment.

Aluminium lends itself well to recycling and recycled metal currently accounts for about one-third of world aluminium consumption (**Figure 1100.01.03**). Due to growing volumes of used aluminium, increasing environmental awareness and new technologies, we expect the amount of recycled aluminium to increase dramatically in the years to come.



Potential Applications

(Figures 1100.01.04 - 1100.01.06)

The rapid growth in the consumption of aluminium is primarily due to the amazing versatility of the metal:

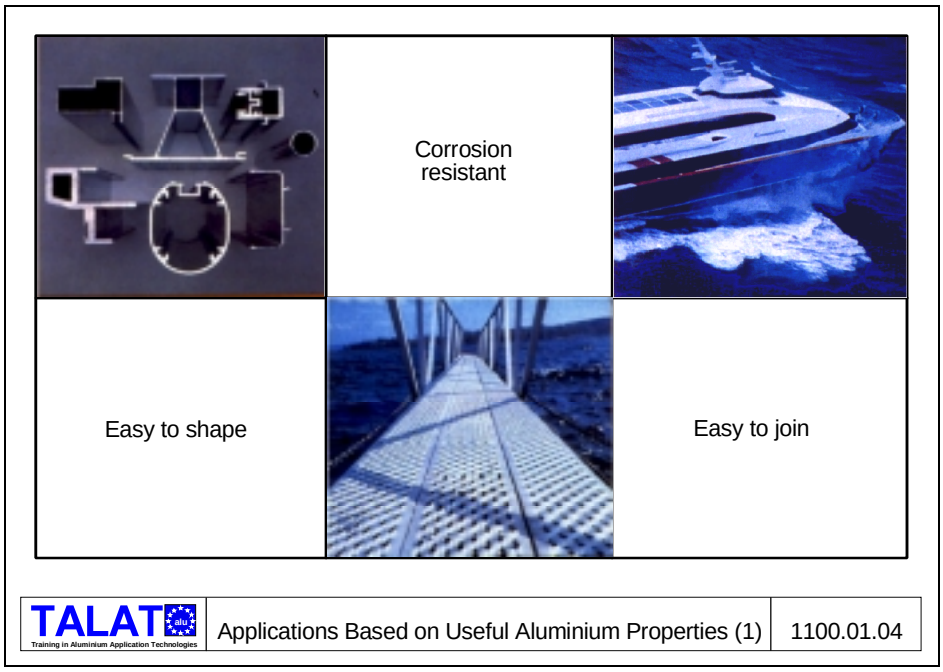
Aluminium is ductile. The metal can be hot rolled or cold rolled down to thicknesses of 6-7 µm (foil). It can be extruded down to wall thicknesses of 0.5 mm. It can also be pressed, drawn, forged, stamped or cast by traditional methods.

Aluminium is corrosion resistant and its surface can be further protected from corrosion by anodising, painting or lacquering.

Aluminium can be **joined** by most well-known joining methods, including welding, soldering, gluing and riveting. Extruding offers special advantages for shape adjustments such as pockets for screws, snap-fit covers, etc.

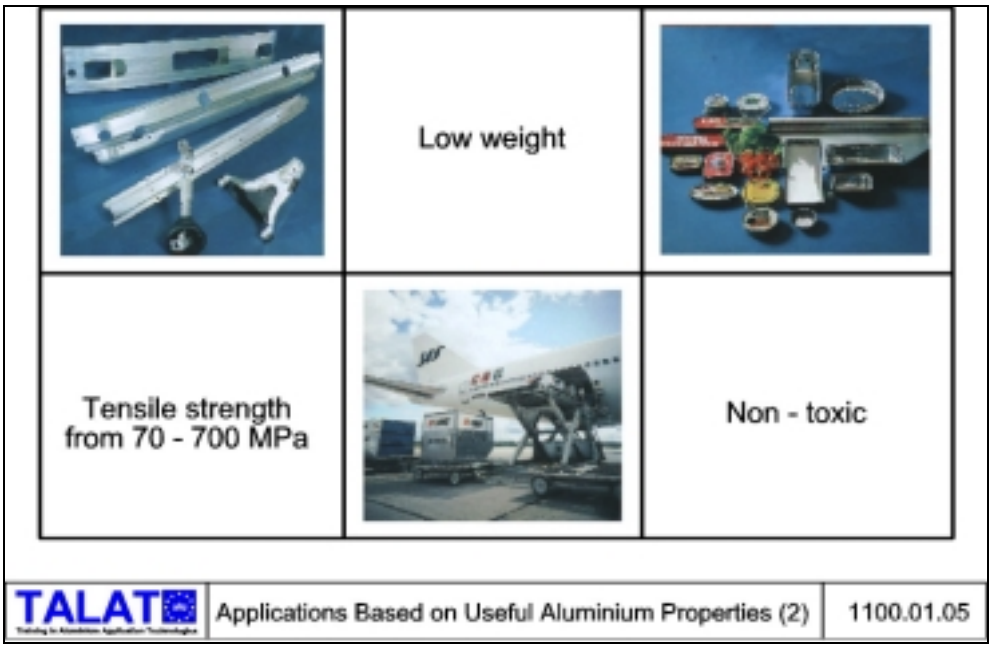
The **tensile strength** of aluminium can be varied from 70 to 700 MPa, depending on the alloying elements added and the process. Its **ductility and strength** can be altered

during the working process to give the material the desired degree of strength. If aluminium is used in structural components that are subject to stress or bending, however, it must be borne in mind that the metal's rigidity (modulus of elasticity) is not altered significantly by alloying or hardening. It will always remain about one-third that of steel (E = 70 GPa).



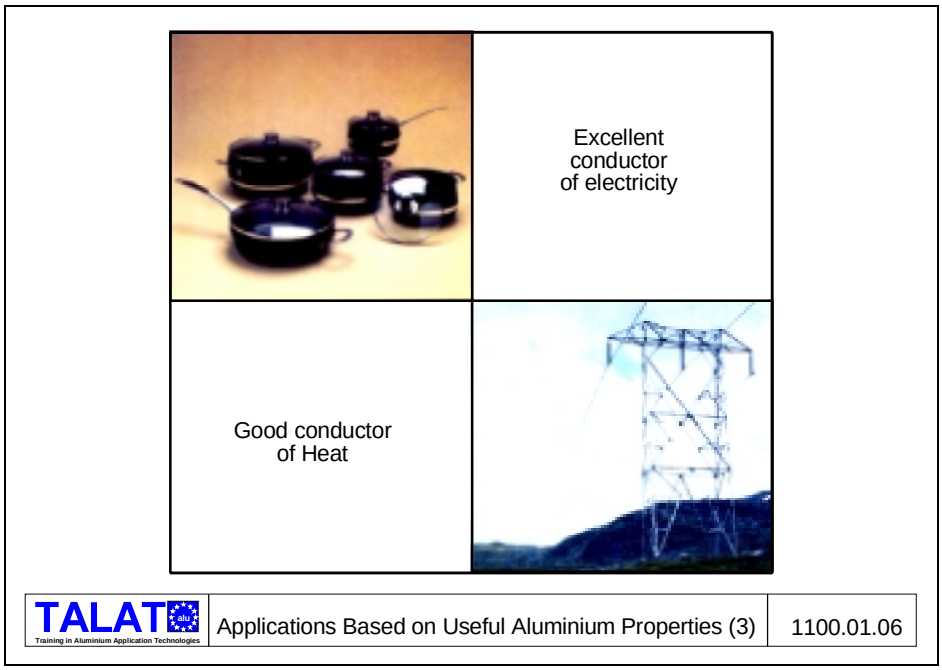
Aluminium is light-weight. Used in vehicles, it reduces deadweight and energy consumption while increasing load capacity. Aluminium has only one-third the density of steel.

Aluminium is non-toxic and can therefore be used for food storage and preparation.



Aluminium is a good conductor of heat. This property is exploited in products such as cooking utensils and heat-exchange systems.

Aluminium is an excellent conductor of electricity, twice as good as copper per weight unit. This has made aluminium the most commonly used material in major power transmission lines.



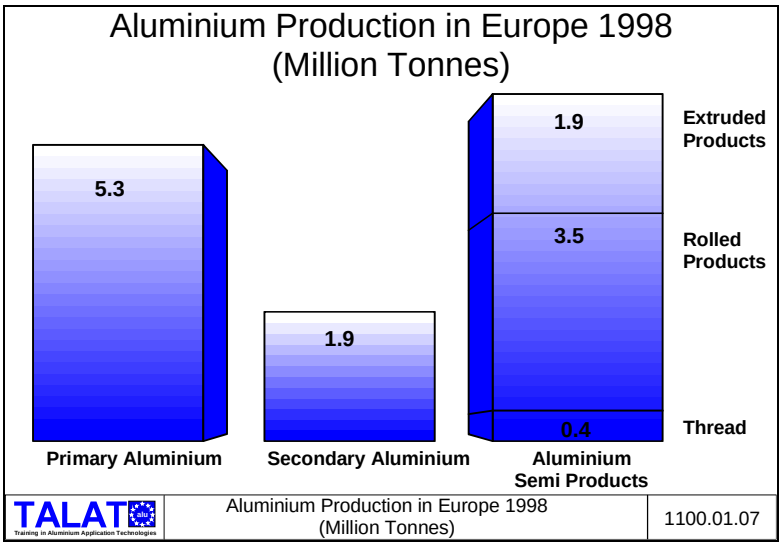
There is no doubt that aluminium is a material which offers a wealth of possibilities. It is nevertheless important to point out that **skill and experience** are required to take maximum advantage of the possibilities inherent in the material.

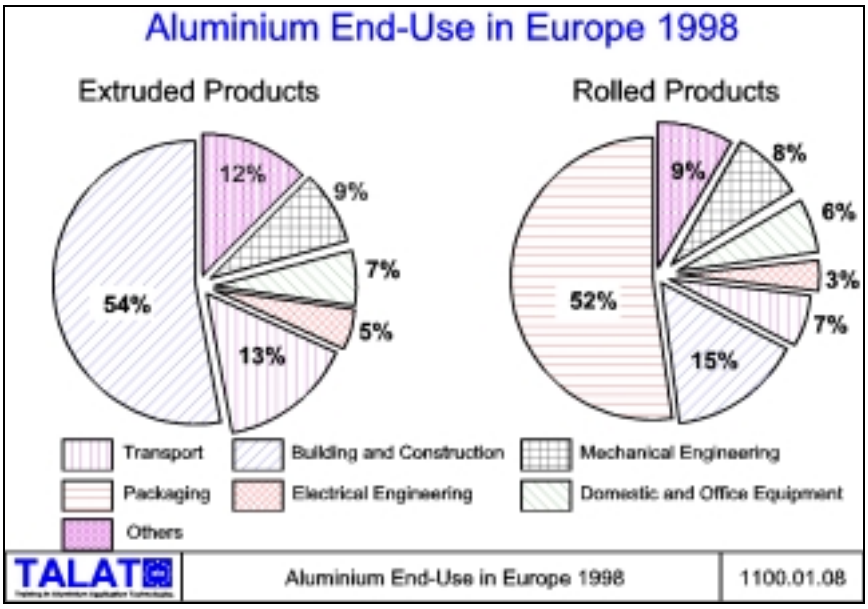
Areas of application

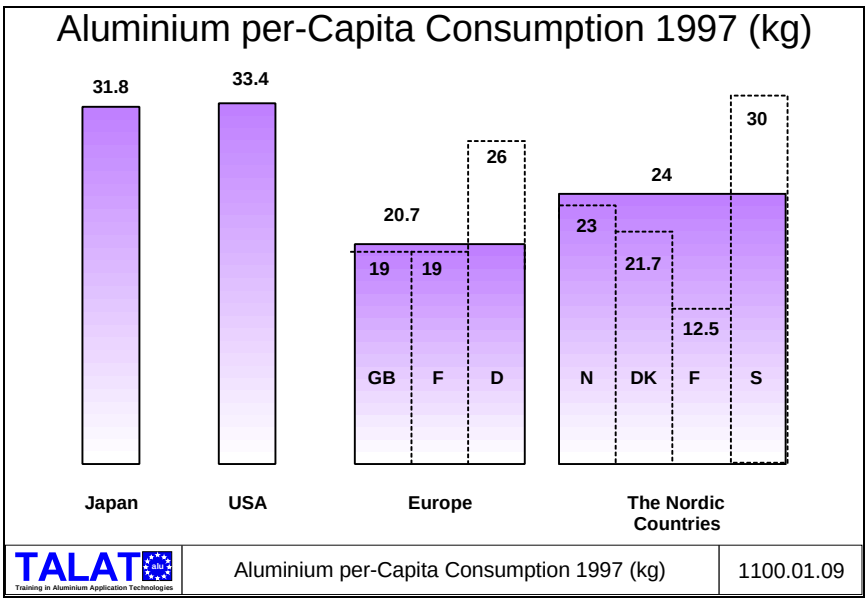
A total of 5.8 million tonnes of semi-finished aluminium products were manufactured in Europe in 1998.

As the illustration (**Figure 1100.01.07**) shows, rolled products clearly accounted for the largest sector, while extruded products took a good second place. The next figure (**Figure 1100.01.08)** shows how aluminium is divided among various areas of application in Europe.

The per capita consumption of aluminium varies considerably from country to country (see **Figure 1100.01.09).** US tops the statistics with 33.4 kg. The European average is 20.7 kg, but this figure conceals significant differences, e.g., 19 kg in the United Kingdom or in France to 26 kg in Germany.







The Outlook for Aluminium Structures

The picture (**Figure 1100.01.10**) offers a prime example of how aluminium has been used on a "flotel", an accommodation platform for an oil drilling rig in the North Sea. The supporting structure is built up of welded aluminium extrusions. Special fireproof aluminium panels have also been used. The structure is a good example of what can be achieved with aluminium when the material is used correctly.

More knowledge of aluminium technology will give the designers of tomorrow a chance to take advantage of the full range of aluminium's properties when developing new products.

- Low weight and high strength
- Good anti-corrosion properties in saline environments
- High fire resistance

TALAT Training in Aluminium Application Technologies	Example: Properties of Aluminium for Offshore Applications	1100.01.10

Literature

Metals Handbook, 9th ed.,vol 2, 4, 9, 10, 11, 13, 15; 10th. ed. vol. 2, 4, American Society for Metals, Metals Park, Ohio 44073.

„*Aluminium-Taschenbuch*“, Aluminium-Verlag, Düsseldorf, 1983.ISBN 3-87017-169-3.

Thundal, Björn, “ *Aluminium*“, kap.1 - 6, Almqvist & Wiksell, 1991, ISBN 91-21-58813-9.

MNC handbok nr.12, *"Aluminium, Konstruktions- och materiallära"*, Metallnormcentralen och SIS, 1989. ISBN 91-7162-143-1.

List of Figures

Figure No.	Figure Title (Overhead)
1100.01.01	Aluminium Production from Bauxite
1100.01.02	World Aluminium Production 1950 till 1998
1100.01.03	Aluminium Production from Scrap Recycling
1100.01.04	Applications Based on Useful Aluminium Properties (1)
1100.01.05	Applications Based on Useful Aluminium Properties (2)
1100.01.06	Applications Based on Useful Aluminium Properties (3)
1100.01.07	Aluminium Production in Europe 1998 (Million Tonnes)
1100.01.08	Aluminium End-Use in Europe 1998
1100.01.09	Aluminium Per-Capita Consumption 1997 (kg)
1100.01.10	Example: Properties of Aluminium for Offshore Applications