Exploring the World of Aluminium Alloys

Aluminium is by far the youngest metal used for industrial applications, having first been produced on an industrial scale only a little more than 100 years ago. Indeed, today it is impossible to think of a world without aluminium. Its use ranges from the building industry to aeronautics, from microchips to space shuttles, from aircrafts to cars, from overhead conductors to packaging, and from cans to cookware. Which mechanical and physical characteristics make aluminium the metal of the future?

Lightness
Volume being equal, aluminium weighs only one-third of steel. Thanks to this lightness it is possible to save a significant amount of weight in almost any kind of mechanical application. All vehicles (cars, trucks, trains, bikes and motorbikes, planes and ships) use more and more aluminium alloys in order to reduce their weight thereby reducing CO_2 emissions.

Life
Since aluminium quickly develops an impenetrable oxide film on exposed surfaces, it is extremely resistant to atmospheric corrosion, even in a marine environment. For this reason, it does not require any protective coating. The greatest use of aluminium is for residential and commercial door and window frames.

Conductivity
Aluminium's specific electrical conductivity makes it absolutely necessary for electronics and electrical applications. Aluminium cables conduct nearly twice the electricity of copper cables of the same weight. High thermal conductivity makes aluminium most suitable for heating and cooling applications. Aluminium and copper are the two most utilized metals as electrical conductors. The present table compares a summary of their characteristics.

AL AND CU CONDUCTORS ELECTRICALLY EQUIVALENT

Sizes ratio	Mass ratio
$\frac{\text{Al size}}{\text{Cu size}} = 1.6$	$\frac{\text{Al conductor mass}}{\text{Cu conductor mass}} = 0.5$
$\frac{\text{Al Ø conductor}}{\text{Cu Ø conductor}} = \sqrt{1.6} = 1.3$	

1 kg of Aluminium can replace 2 kg of Cu

Copper and Aluminium Comparisons

The above comparison shows mainly that:
>> Although aluminium electrical resistivity (2.8 µOhm/cm) is 1.6 times higher than that of copper, an aluminium conductor will need to have a diameter 1.3 times larger than a copper conductor in order to have the same cable resistance per unit length.
>> The density of Copper (8.9 Kg / cm^3) is 3.3 times higher than that of aluminium (2.7 Kg / cm^3). Therefore, at the same electrical resistance, an aluminium conductor will be twice as light as a copper conductor.

Continuus-Properzi Track & Belt Line and Typical Properzi Ingots/Bundles

Workability
Aluminium can be molded more easily than most other metals utilizing all of the most common processing techniques. It is easily cast, or die-cast, into precise and complex forms. It can be forged, rolled to obtain very thin sheets, extruded into complex shapes or bent.

Versatility
Aluminium alloys can be rigid or flexible, particularly robust or resistant to corrosion. The possibility of alloying aluminium with other metals makes it adaptable to a wide range of exigencies.

Design
Aluminium is a clean material. It has a beautiful appearance and does not need additional embellishment. However, its surface can be treated with a wide range of coatings, from paint to colored anodization.

Recyclability
Aluminium can be easily recycled with an energy cost equal to one-twentieth of the cost necessary for its first cast; almost one-third of the aluminium used today comes from recycled scrap.

These days, one-fourth of Europe's aluminium demand is fulfilled by using second cast metal which, in turn, can be recycled indefinitely.



Typical Aluminium Products

Considering that recycling aluminium means saving 95 % of the energy necessary to produce it from ore, most industrialized countries continue to develop scrap collection systems, which today can recycle up to 70 % of all the aluminium components of cars. Continuus-Properzi is present in this sector with our Track & Belt, thanks to which secondary aluminium ingots are successfully produced in very compact stacks.

About 10 % of the aluminium produced worldwide is transformed into aluminium rod and aluminium alloy rod and then into wire to satisfy numerous applications. Aluminium alloys are divided into families as a function of the alloying elements they contain and the use for which they have been developed and industrialized:

- **1XXX Pure Aluminium with Al ≤ 99.00 % – Electrical & Mechanical Applications**
- **2XXX Aluminium alloys containing Cu – Mechanical Applications**
- **3XXX Aluminium alloys containing Mn – Mechanical Applications**
- **4XXX Aluminium alloys containing Si – Welding Applications**
- **5XXX Aluminium alloys containing Mg – Mechanical & Welding Applications**
- **6XXX Aluminium alloys containing Mg and Si – Electrical & Mechanical Applications**
- **7XXX Aluminium alloys containing Zn – Mechanical Applications**
- **8XXX Aluminium alloys containing other elements – Electrical Applications**

The vast majority of the aluminium rod produced (some 80 %–85 %) is used for electrical applications (cables and conductors), while the balance is devoted to the so-called mechanical applications ranging from welding to De-Ox and everything in between.

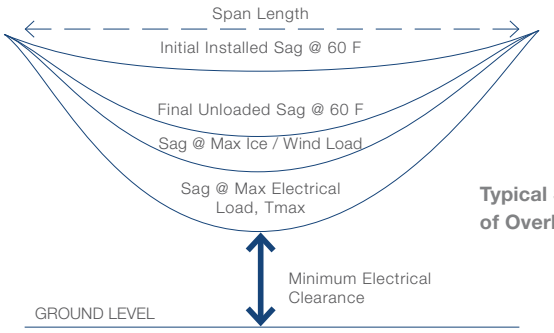
What is becoming more obvious is the global trend of industry to continually increase their efforts to replace copper cables with less expensive, lighter aluminium cables.

Last but not least, the power cable industry serving the electrical energy generation and transmission sector is increasingly pursuing many avenues. Over the years, the industry has worked towards the minimization of power loss associated with power transmission and the optimization of the current carrying capacity per square millimeter of cable and conductors.

For such considerations, the main parameters are the temperature of the conductors and the mechanical stresses of the wire. The new strategies of the wire and cable industry are reflected in the maximization of the transportable power on existing infrastructures or the minimization of the number of pylons necessary to support the lines. The above points have been pursued mainly through three different paths:

a) The development of new alloys reflecting the best compromise between tensile strength and conductivity. This path means the realization of AAAC (All Aluminium Alloys Conductors) which eliminates the heavy steel core from the conductors. When compared to pure aluminium, the wires have acceptable conductivity and almost twice the tensile strength while having only 10 % higher resistivity. Some of the most commonly used alloys are:
AA6101: Rod with conductivity up to 53 % IACS, and UTS (Ultimate Tensile Strength) up to 220 N/mm^2.
AA6201: Rod with conductivity up to 52.0 % IACS, and UTS up to 300 N/mm^2.
AA5005: Rod with conductivity ≥ 53.8 % IACS, and UTS up to 200 N/mm^2.
AA8017: Rod with conductivity between 58.5 % and 60.8 % IACS, and UTS up to 140 N/mm^2.

b) The development of new alloys resulting in SAG resistant conductors; alloys which utilize Mg and Zr.



Typical Sag Development of Overhead Conductors

TAL, ZTAL, XTAL.
These alloys are applied in steel reinforced overhead line conductors, allowing the line capacity to be increased by 50–100 %. Depending on the alloy, the maximum allowable temperatures are between 150 °C and 230 °C. Peak temperatures may vary between 180 °C and 310 °C. These conductors have a limited sag effect compared with others.

c) The use of AA1370 in H8 temper (soft wire) for the manufacture of conductors type ACCC (Aluminium Conductors Composite Core). The conductor consists of a carbon fiber wire with a typical tensile strength of 1,500 N/mm^2, around which the aluminium wires are wound.

Continuus-Properzi, with its experience and know-how, can be a valuable partner for the production of rod and ingot as we stand ready for all the new challenges that this relatively young material will thrust upon us in the future. *by M. Nidasio*