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Magnesium ad its alloys: a material for the XXI century engineering industry

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Magnesium is not a new metal: its oxide was recognized from the beginning of the eighteenth century and called "*bitter earth"*, but I notice in the form of sulphate ("*English salt*", or "*bitter salt"*, or "*Epsom salt*") from the seventeenth century, obtained from the mineral springs of Epsom, the first, though, that distinguished him sharply from the calcium oxide by the different solubility of its sulfate was the Scottish chemist Joseph Black (Bordeaux 16/4/1728 † Edinburgh 6/12/1799) in 1755. To get it in metallic form, however, it was not until 1808, when the English chemist Sir Humphrey Davy (Penzance 17/12/1778 † Geneva, 29/5/1829) obtained it by electrolysis, but you have to wait up until 1831 because the French chemist Antoine Alexandre Brutus Bussy (Marseilles, 29/5/1794 † Paris 1/2/1882) prepared as the metal mass compact.

Then spent two centuries in his first identification as galenicals to the extraction of pure metal from its salts: this is due to its low electronegativity (for which high reactivity, strong reducing agent for excellence), which makes its salts are very stable and difficult to break.

This high reactivity is also the basis of difficulties for its use as a pure metal or alligator, machine building, for which, as we shall see, although its use may begin in the aviation industry since the days of World War I, only now it begins to look like metal material serviceable for the manufacture of items of mass consumption.

Still, the magnesium is not a rare metal, constituting as much as 2.3% by weight of the lithosphere, entering the composition of dolomite (double carbonate of calcium and magnesium, with an average content of magnesium by 43%), contained large quantities in salt deposits of Stassfurt, and in the sea water which has an average content of 1.37%. It is therefore the eighth most abundant element in Earth's crust.

For its extraction are used primarily to dolomite and seawater; obtained oxide, the metal is obtained either electrowinning (with a rather complex process), or by silicotermica.

Magnesium metal, with its density of 1.74 kg/dm^3, is the lightest of metals directly employed in construction, it melts at 650°C and has a boiling point of 1,103°C, crystallizes in hexagonal system compact, and this is the main cause of their differences as mechanical properties compared to aluminum, metal chemically very similar, but which crystallizes in face-centered cubic system.

Reviewing briefly the history of the use of magnesium as metal buildings, we found a first patent on an technological alloy of magnesium dating back to 1918, filed by Mr. William R. Veazey of Cleveland (Ohio) of Dow Chemical in Midland (Michigan), who obtained a first magnesium alloy technology alligators copper and manganese for a total of 1%. The lightness and the good behavior of the metal even at higher temperatures aluminum stimulating research, and we had in the years following a series of patents of magnesium alloys also very advanced. Its use in the engineering becomes massive when the planes go by the initial structures of wood, metal ones, especially with the Second World War: in 1943 its production was a well 237,000 tonnes, partly used for preparation of propellants for rockets and incendiary bombs, but mainly used in the aviation industry.

But with the end of hostilities, the complexity of its use made it down quickly production in 1963 fell to 140,000 t.

With the lessening of reasons related to strategic control of the metal and the refinement of technology, its production has reached currently, an increase of 10% per year in 1990 was of 350,000 tonnes, and in 2005 of 500,000 t. Its price is now lower than that of aluminum (however, what must not be neglected, magnesium - as opposed to aluminum - is completely non-toxic, and also its production is "clean").

Whereas steel, aluminum and magnesium, it is that the three that has the highest ratio between strength and weight, and as mentioned, magnesium alloys generally have a better behavior at high temperatures than aluminum, especially when alligator, for example, with the lanthanides.

Magnesium alloys have a specific gravity of between 1.75 and 1.85 kg/dm^3, but special alloys, such as magnesium-lithium, they can come to have a specific gravity equal to 1.3 kg/dm^3.

It is certain that the engineering industry must do more than a step forward compared to current manufacturing processes, leading to a massive use of such alloys, but we think the benefits in terms of saving energy and reducing emissions, which a substantial reduction in vehicle weight can have in the future, and in the aviation industry (where the next ten years will be 25,000 new aircraft produced, partly to replace the existing stock), where the weight reduction of aircraft 1 kg results in a saving in the life of the aircraft, about 1 ton of fuel.

Magnesium also has another advantage “environmental” important: the ability to absorb vibrations, and thereby reduce the noise produced by moving mechanical parts. But this also implies a longer life of the machines themselves.

So not only today we are witnessing a rapid growth in the technology of this metal, but it has features that make it easy to predict the exponential growth of its use already in the near future. Growth that could even be accelerated by the global crisis today, as it is in times of great crises that we witnessed the most rapid changes in production structure, technology, but also of social structures (three factors intimately interconnected).

When it happened, in recent months to talk about uses of magnesium and its alloys in the production, the objections that I have often heard from colleagues were those pertaining to its easy susceptibility to corrosion and its high reactivity, which complicates the production processes.

It would take too long to dwell in detail, here, on what are the phenomena of corrosion under which the parties made of magnesium and the mechanisms involved.

But suffice to say that magnesium, such as aluminum, is forming in air a passive film with complex structure but consists predominantly of magnesium oxide and hydroxide, and magnesium oxide, aluminum oxide contrary, no is amphoteric, so that, while the passivation film formed on the magnesium becomes unstable only in acidic environment, one which is formed on aluminum is subject to instability is markedly acid and markedly alkaline environment too. In practice, a good piece in magnesium, is at least as resistant to corrosion that an artifact in other light alloys, and certainly more resistant to corrosion of a product made from an ordinary steel.

The negative experiences of the past were in fact derived from the presence of impurities in the metal (primarily iron, copper, nickel and cobalt, which must be contained within certain limits - or blocked by appropriate alloying), or defects resulting from the merger, such as oxide inclusions.

The modern production process, using very pure primary alloys, castings made in atmospheres which are now protected to guarantee maximum protection against oxidation of the atmosphere (magnesium, in addition to reacting with oxygen is combined with high temperatures with nitrogen), advanced casting and the relatively recent introduction of the technique of tixomolding - which allows the metal to form without going through its complete liquefaction - have canceled nearly all the old problems, and an artifact made of magnesium alloy may have a corrosion resistance at least equal to that of an artifact made of aluminum alloys.

Add to that the possibility of surface treatment, electroplating, or with special painting operations, which, if operated on land free from defects, which are those now obtainable, may give results concerning the corrosion resistance once unthinkable.

About the problematic nature of working, in part we have already seen how they have been overcome. But even the most common machining with chip removal can be done with a minimum of precautions, in complete safety.

For example, the magnesium, which is added a small amount of beryllium as alloy, both during the merger, and afterwards, during operation, form a layer of surface passivation of exceptional stability, which is less than the traditional danger of particles minute of magnesium (or baths of molten magnesium) to flare. The talk about "beryllium" may generate toxicological concerns, but here we speak of a metal added in small amounts and dissolved in a stable manner in the league. Therefore, no more worrying in any of the nickel content stainless steel, and note that nickel is not only known to a toxic metal in ionic form, but also that it is around 10 ppm to inhibit any fermentation (and thus many enzymatic processes, the determines its toxicity also environmental).

Without going into too much further in this report which will only introduce the topic and show what may be the development prospects of applications in the mechanical field of magnesium and its alloys, in closing we wish to mention another important aspect.

The low fatigue resistance of many metals is associated with the presence of microdefects in the crystal structure of alloys with segregation of phases between grains and granules are not very cohesive, inclusion of oxides and other impurities, or gaps between the same for workers by deformation - or casting - inadequate.

The opportunity to work with high-purity magnesium alloys and maintain this purity during operation (which, speaking of casting processes, magnesium dissolves the iron crucibles, molds and other devices to a minor extent, in contrast to aluminum) and coupling of this technology in tixomolding that will take a very particular and homogeneous metallographic structure of the alloy, it causes the artifacts in magnesium alloys can achieve a much higher fatigue strength than many other light alloys, with not only increase the durability of manufactured goods and machinery, but also with considerable increase in safety and security of persons.

Anyway, the durability is another important factor in energy saving and environmental protection, the higher the duration of a product, the lower the environmental impact of its cycle of "birth and death" and for self-elongation of its useful life in itself a saving of energy.

All these perspectives are so seductive for the technology, which should have us well to intensify our efforts to overcome all those difficulties of organizing production and economic investment that now separate us from a more extensive use of magnesium in automotive production, machines , as well as other objects of daily use.

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