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Special Magnesium Alloys: a New Frontier

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When we speak of "*special alloy of magnesium*" as a new frontier, we are in fact, rather than face a new field at all, to trace a critical 90-year history of the magnesium alloys. In these 90 years have in fact explored in a systematic way not all, but a large number of possibilities alligator magnesium metal with elements common both with the most exotic, often fascinating results obtained in terms of mechanical strength, resistance corrosion and lightness.

But often the difficulty of finding some metal elements, or their cost, or their difficulty in handling, or even the difficulty of them to a sufficient degree of purity and, to that degree, to keep the league during its manufacture, have fact is that these leagues, perhaps even in many cases the subject of publications and patents, have ended up in oblivion. Or, in other cases, their application has been limited to particular sectors such as aerospace or defense, so today there are perhaps hints so fast or further discussion in the literature, but lack of practical uses.

It is however also be noted that for a certain period of time, magnesium alloys and in particular the ultra-light alloys ended up in oblivion for the growing competition of composite materials, and other alloys, however, appear that the cause of poor application practice has been driven by strategic reasons, since the fall of the published studies on coincides with the period of the Cold War, as the case of alloys, magnesium-lithium alloys remarkably light ($d = 1.3$ kg/dm^3) and with excellent mechanical properties especially when hot.

This discontinuity in the development are still a recurring in the history of technologies; in different sectors we can observe the same phenomenon in the field of "synthetic biofuels" or in the chemical-pharmacology of natural substances: a period of intensive research and development, a more or less long period of neglect, and thus a rediscovery.

Certainly, the field of magnesium alloys, played a lot against the great reactivity of metal and some of its alloying elements, the cost and difficult availability of some of these, and not a very great interest to go beyond a certain limit in lighten in some mechanical components.

There are other factors that have played against, of course: for example, speaking of lanthanides, until not long ago, their analytical determination was the exclusive domain of a few highly specialized laboratories. And the fact of not being able to assess accurately the composition of an alloy obtained (especially since some of its components tend to get lost in part due to oxidation) did not play very much in favor of its current industrial application.

Today also, we are in, on the one hand, many technological difficulties are overcome, or exceeded, and secondly that it is increasingly felt need to reduce the weight of vehicles and aircraft for reasons of limiting energy consumption and emissions into the atmosphere, and the other to ensure safety and durability of machines. And so many roads traveled in the past and then abandoned for various reasons, can and must be taken in the light of new needs and technologies, of course, redesigned processes and formulations in the light of knowledge and current needs.

In recent times, moreover, there have been new and interesting developments in this field. Among them was the introduction of nanoparticles, such as yttrium oxide and zirconium oxide, in magnesium alloys in order to increase the mechanical strength at elevated temperatures under stress, or drowning in them of ceramic fibers with special processes forming pieces.

It will not be totally unnecessary recap of the alloying elements which, in 90 years, has studied the effect on magnesium: aluminum, manganese, zinc, silicon, copper, nickel, chromium, silver , beryllium, calcium, lithium, cerium and other lanthanides (including in particular lanthanum, neodymium and praseodymium), thorium, yttrium, zirconium, scandium, antimony, bismuth, the tin, lead, and thallium and cadmium. Many others are still studying the effect, at least where they could build up impurities that were to expire on certain properties of alloys obtained and therefore the way to remove or neutralize the negative effect.

If we refer to the automotive industry, for example, and what is reported more frequently in publications on applications of magnesium alloys in this area, you could say that the most common alloying elements are aluminum, manganese, zinc and silicon.

Starting from this consideration, and some people from the context of patents and publications, we may, in a certain way, saying that alloys of magnesium with silver, lithium, scandium, thorium and lanthanides can be defined as "*special alloys*" although this definition is largely debatable and can not define a precise boundary between them and the leagues "*ordinary*".

Some other elements are too soluble and simultaneously too toxic to be used today in a manner consistent with the criteria for protection of workers' health data essential today, especially among those mentioned, cadmium and thallium.

An element such as beryllium, however, in our opinion, for the minimum amount of use (of the order of ppm or less) and the very high boiling temperature (2,961°C) does not constitute a danger in the use in alloys magnesium. It is so toxic and carcinogenic, but if inhaled, while, for example, is not absorbed through the stomach and intestine. It has the important property of inhibiting the possibility of oxidation of magnesium and its alloys both during the casting during the machining, and increase resistance to corrosion.

About thorium, when speaking of his chances of being alligators with magnesium - also to stay in toxicology - a move that is critical is that it is a radioactive element. However, it stresses that it is added at levels of 2 ÷ 4%, and that it has, in effect, a half-life of approximately 14'000'000'000 years, so about three times that of uranium - 238: its radioactivity is then that does not change particularly the natural background. What advantages, it significantly increases the hardness of the alloy and its resistance to fatigue at high temperature: so very interesting properties. Its use in this sense goes back to the early '60s of the century just ended, together with lithium, and the first patent that we have found dates back to 1963, the military.

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The silver alloy is an extremely interesting, even if its specific gravity (10.49 kg/dm3) contrasts a little with the goals it sets us using magnesium alloys, the lightness. But it has two interesting properties such as magnesium alloy: namely that increasing the mechanical strength of 50% and more, is to increase remarkably the corrosion resistance: each percentage point of silver added decreases - about - the rate of corrosion league of 30%. In an alloy, for example, in certain conditions, the corrosion rate led to a depletion of 65.8 $mg/cm^2/d$ metal in pure magnesium, and 17.3 $mg/cm^2/d$ metal in an alloy 4% silver. Early studies on date from the '30s of the century just ended, and a first patent on this date to 1936, submitted by Dow Chemical of Midland (Michigan). It is described as a clerk until a maximum concentration of 12%.

When we speak of alloys including magnesium and lithium we enter the domain, if the lithium is added as the massive, of ultra-light alloys, since their density may drop to 1.3 kg/dm^3 or 25% cheaper ordinary magnesium alloys. Generally, speaking of lithium alloy such as magnesium, it is stressed so much that it reduces the density of the alloy, the ductility increases, but also decreases the mechanical properties. Also, the first patent found in this area (year 1948), emphasizes the properties of lithium to reduce the creep temperature of the alloy. Together with the thorium, then, increases the hardness and stability at high temperatures. It is, in these cases, alloys which include varying amounts (usually up to 5%), including aluminum, zinc, zirconium, thorium, silver, and sometimes cadmium. The amount of lithium may be increased to 13.5%, generally between 10 and 13%. It is known that lithium is the lightest of all metals, not only in terms of density (0.53 kg/dm^3, which is about two times lighter than water), but also has the lowest atomic weight (atomic mass 6,9, was third in the periodic table after hydrogen and helium), and therefore has very specific properties. Although a metal - like all the alkali metals - very reactive, and yet less reactive, for example, sodium.

The particular characteristics conferred by the addition of lanthanides in magnesium are observed since the 20 the century just ended. Namely the first patent that speaks of a cerium-magnesium alloy is deposited in 1929 in Germany. In this patent, and in some immediately following, the cerium added in levels that can extend to 12% (from 2%), although the additions are not only cerium, but of misch metal. The goal is always to increase the mechanical properties of magnesium alloys at high temperatures (200÷300°C). But already in those years also focuses attention on the effect of other elements of the lanthanide series: it determines the content of lanthanum dysprosium, samara and in 1949 a patent speaks of magnesium alloys with neodymium, praseodymium and lanthanum, with levels, respectively, of 0.54% and 0.12% of neodymium praseodymium and lanthanum. In this case, we focus on the creep resistance of the alloy obtained up to 315°C. The last few times we return again on these alloys, a Chinese patent last year about a league with tenors of up to 2.6% of cerium and lanthanum, and in 2006 an Australian patent back again on magnesium alloys with neodymium (up to 2.1%), cerium and lanthanum.

Scandium gives the ductility of magnesium alloy, and increases resistance to fatigue, we do not have specific references on this, because, apparently, the difficulty of finding (this is a metal in an almost ubiquitous on the earth's crust, but very small concentrations, except in certain specified minerals) have so far limited the use exclusively to the military area, nor were the aluminum-scandium alloys used in the missile area.

Magnesium alloys with lithium and with certain lanthanides have some difficulty in handling, given the great reactivity of these elements. But the technologies currently available are such as to overcome these problems. So if half a century ago - and beyond - was still a problem with the handling of these alloys, today we might think that the problems of their workers are not much higher than other magnesium alloys, especially in the light of the possibility of develop new alloys - and we saw that we are in a crucial phase of research in this effervescent sense - in front of more stable to oxidation and forming processes such as tixomolding (which excludes the complete liquefaction of the metal), which can be applied to this particular field should certainly be investigated with diligence and attention.

In this brief report is intended only to explain briefly what are the chances of obtaining magnesium alloys also very particular and what benefits you can get with this metal. Clearly a complete discussion would require an entire treatise, but here now is only intended to give a very general overview of the sector, simplifying many aspects, sketching the history of technology and development of these alloys and in particular by making a glimpse of the wide possibilities of application.

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