THE PROPERTIES HELD BY THE METALS USED IN THE AERONAUTICAL CONSTRUCTIONS

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Abstract: *The aeronautical constructions make use of a series of metals and alloys that are important and that lead to high mechanical endurances, but also to the diminishing of their weight. In the present paper we presented some of their properties.*

Key words: *aluminum, magnesium, titanium, iron, cobalt, nickel, copper, siliceous, lead, tin, germanium.*

1. INTRODUCTION

The aeronautical constructions make use of a series of metals and alloys that are important and that lead to high mechanical indurances, but also to the diminishing of their weight.

The most important materials and alloys used for the making of these constructions are: the aluminium, the aluminium alloys, the magnesium and its alloys, the titanium, the steel, the cobalt, the nickel, the copper, the carbon, the silicium, the lead, the tin and the germanium.

In the present paper we presented some of their properties.

2. THE ALUMINUM

The aluminum is a light metal, with a high plasticity, a low mechanical endurance, with high thermic electrical conductibility, a high degree of corrosion with the air, water and organic acids. Although in manages to crystallize in a cubic system with centered facets, its microstructure is being formed by polyhedrons without macles. The technical aluminum may contain up to 0.5% impurities, mainly Fe and Si coming from the bauxite during the elaboration process. The steel cannot dissipate itself in the aluminum but it forms a Al_3Fe compound. The Al + Al_3Fe eutectoid crystallizes at the edge of the aluminum grains increasing the metal's fragility.

The main disadvantage of the aluminum is linked to its very low endurance to breaking, a reason for which its alloys have a wider range of usage.

Because of its properties, the aluminum is a widely used metal, its industry being one of the most important branches of the non-ferrous metallurgy. Because of its high electrical conductibility it is used in the electro technical industry (cables and electrical devices). It serves to different aluminum-thermic processes in order to obtain certain metals or alloys as well as for the welding of several metallic pieces.

The aluminum foil of approx. ~0,005 mm in thickness is being used for the wrappings. It also represents a very good alloying element [1, 4].

Among the aluminum alloys we mention:

- *the duralumin* (Al, 3-5% Cu, 1% Mg, 0,5-0,8% Mn) with a good mechanical and chemical endurance, used in the aeronautics, in the chemical industry and also for the obtaining of some widely mechanical used pieces;
- *the silumins* (11-14% Si) have a higher hardness and a better mechanical and chemical endurance, being used for the making of the pieces used for the aircraft engines, in the marine etc.

3. THE MAGNESIUM

The magnesium has the smallest specific weight of all the metals used in the making of devices, and its endurance and plasticization are reduced. It crystallizes in a hexagonal system and does not present allotropic transformations. It has a polyhedral structure obtained after a baking and if it is being plastically deformed it presents a polyhedral structure that also has macles. Its low mechanical properties exclude its usage as a material used in constructions. It is used an alloying element and as an deoxidizer for a large number of alloys, in the making of the nodular cast irons, in pyrotechnics and as a basic element for the making of the magnesium alloys [2].

4. THE TITANIUM

The titanium is a metal that is being situated at the crossroads of the light and heavy metals, and it has a technical usage that lately grew in an alert rhythm because of a certain complex of properties like: a relatively small specific mass, a high mechanic resistance, one of the highest relative specific resistances R_m/ρ, where R_m is the breaking resistance and ρ is the specific mass, a good resistance to warmth foil medium temperatures and (up to approx 500ºC) and a high stability to corrosion.

The endurance to corrosion is due to the formation in the presence of the oxygen of a protective foil of Ti oxide (TiO_2) that is very resistant and adherent, and that at a normal temperature cam have a thickness of 20 ... 50 Å and that makes the Ti to overcome the corrosion resistance of the non-oxidable steels of approx. 400 times. Because of these properties it is used in the aircraft construction, helicopters, transportation, chemical devices' building etc.

Its main physical and mechanical properties are presented in table 1. Ti just as Fe has two allotropic forms: Tiα and Tiβ. The Tiα form is stable at low temperatures and it crystallizes in the compact hexagonal system, whereas Tiβ is stable at high temperatures and it crystallizes in a cubic network with a centered volume.

The polymorph transformation takes place at a temperature of 882ºC, in the conditions of a thermic equilibrium and a high purity. In a re-baked state it has a polyhedral structure and after the tempering it presents an acicular structure that is similar to the steel martensite [3].

Table 1 Physical-mechanical properties belonging to the titanium

Property	Measuring unit	Value
Polymorph transformations	-	$\alpha \leftrightarrow \beta$
The polymorph temperature of transformation	ºC	882
The crystalline network of the α stage	-	H.C
The parameter of the α network at 25ºC	Å	a = 2,9504 c = 4,6833
The crystalline network of the β stage	-	C.V.C
The parameter of the β network at 900ºC	Å	a = 3,3065
The specific mass, ρ	kg/m^3	4500
The melting temperature	ºC	1725 ± 10
The specific heat at 20ºC	$J/kg\cdot°C$	473,10
The termical conductibility at 25ºC	$W/m\cdot°C$	171,6
The dilatation coefficient at 25ºC $\cdot\alpha\cdot10^{-6}$	1/grd.	8,5
The electrical endurance at 0ºC	$\Omega\cdot m$	43,5 $\cdot10^{-8}$
The breaking endurance, R_m	daN/mm^2	50 – 70
The flowing limit, $R_{p0,2}$	daN/mm^2	30 – 50
The breaking elongation, A	%	25 – 28

5. THE IRON, THE COBALT AND THE NICKEL

The peripheral electronical configurations of these elements: Fe[Ar]$3d^6 4s^2$, Co[Ar]$3d^7 4s^2$, Ni[Ar]$3d^8 4s^2$ can explain the low oxiding numbers that they represent in comparison with their predecessor Mn. Therefore since the manganese present stable combinations at the oxiding number VII, the iron only reaches the oxiding stage number III. At its turn the cobalt can reach the oxiding stage III but we can encounter it more often in its stage II. The nickel, can rarely form compounds in its stage III, most of them having the oxiding number II and manifesting the tendency to form other compounds with the oxiding number I.

The oxiding stage II is explainable for all the three elements, being reached by the loosing of the electron pair 4*s*. The iron, cobalt and nickel salts in the stage II are very alike. As compared to the cobalt, and even further than the nickel, the releasing of an electron from the 3*d* sublevel determines a special stability for the iron III by the semi completion of the 3*d* orbital. Nickel III is a very strong oxidant agent, the cobalt III only with the exception of some complex combinations, also manifests oxiding properties whereas the iron III is a very weak oxidant.

Following the aluminum, the iron is the most spreaded metal in the lithosphere 4.7%, the cobalt $3{,}7 \cdot 10^{-3}$% and the nickel $1{,}5 \cdot 10^{-2}$%. The main minerals in the order of their importance for the iron are: the hematite - Fe_2O_3, the magnetite - Fe_3O_4, the limonite - FeO(OH), the siderite - $FeCO_3$, the pyrites - FeS_2; for the cobalt: the smaltine - $CoAs_2$, the cobaltine - CoAsS, that accompany the nickel and the copper in their minerals; for the nickel: mixtures of the sulphur Cu – Fe – Ni, the niccolite NiAs.

The most important quantities of iron are to be found as silicates. In their native state small amounts of iron can be found whether of terrestrial or cosmic origin. Most of the times the iron meteorites contain appreciable quantities of iron (5 – 20%) and of cobalt (up to 2%).

These metals manifest superior mechanical properties. They can be laminated and molded in very good conditions. In the state of powder, they become pyrophorous. Unpurified with boron, cobalt, sulphurus or phosphorus they loose their plasticity [4].

A very important characteristic of there metals is the fact that they can form numerous alloys. Therefore, the iron can be alloyed with the most diverse metals (e.g. Ti, Zr, V, Nb, Ta, Mn, Cr, Mo, W, Cu etc.) and with non metals as well (C, Si, B etc.) forming alloys with diverse properties and improving. Among these we can enumerate different types of steels, magnetic or non-magnetic alloys, antacids, that resist to high temperatures or to mechanical tests etc.

The cobalt alloys are being appreciated for their magnetic, refractory and antacid properties.

The nickel is being used both as an element of alloying and as a basic component of several alloys. The presence of nickel improves the alloys' properties because of its tendency of forming solid solutions with other metals and it gives them endurance against corrosion, for mechanical and thermic tests, as well as special magnetic and electric properties.

6. THE COPPER

The copper is a non ferrous metal that has a specific reddish color, which holds a series of properties, like a high plasticity, a high thermic and electrical conductibility and a high endurance to corrosion etc. The technical copper (99...99,9% Cu) always holds a series of residues, some being advantageous Fe, Ni, P, As, Si, Mn, properties that increase the endurance properties, and others S, Se, Bi, O_2, Te, Pb, that lower them and that are considered to be disadvantageous. The most harmful are Bi and Pb, because they form eutectoids that are easily fusible, and that come around the copper grains making it fragile to warmth. The copper presents a polyhydric structure, but if it was hammer-hardened and then re-baked, its structure is formed by polyhedres with macles, the size of the grains varying upon the distortion degree and upon the re-baking temperature. Because of its properties, the copper has a wide usage within the industry: approx. 50% of its production is being used in the electrotechical field and 30 ... 40% in the making of the alloys used in the aeronautical constructions [3, 4].

7. THE CARBON, THE SILICIUM, THE LEAD, THE TIN AND THE GERMANIUM

The carbon (C), the silicium (Si), the germanium (Ge), the tin (Sn) and the lead (Pb) are elements belonging to the main group number IV and have the electronical configuration at a peripheral level ns^2np^2, which means they have 4 electrons on a valence. The level before the last one contains a different number of electrons: 2 electrons for the carbon, 8 for the silicium, and 18 for the rest of the elements.

The first element, the carbon is different from its neighbors but in the same time by the rest of the elements of its group having different chemical characteristics: the carbon and the silicium are non-metals, the tin and the lead are metals, and the germanium is a half-metal.

The elements belonging to this group can make their stable configuration by ionizing or by forming covalent connections.

The ionizing can be made by giving 4 electrons (sometimes 2) when resulting negative quadrivalent ions.

Taking into consideration the electronical configuration, their place in the middle of the periodic table and the small values of their atomic rays, the elements belonging to this group have a reduced tendency of forming monatomic ions E^{4+}, a tendance that still grows with the atomic number Z.

Examining the physical constants of the elements belonging to group number IV we can notice that the ionizing possibilities decrease along with the atomic number and along with the intensification of the shielding phenomenon.

8. CONCLUSIONS

The metallic aluminum and its alloys with the magnesium serve for the construction of the nuclear reactors that work at low temperatures.

The magnesium has the smallest specific weight among all the heavy and light metals used in the construction of devices, and the endurance and plasticity are reduced.

The titanium is a metal that is being situated at the crossroads between the heavy and the light metals and its usage within the technical field has lately increased in a sustained rhythm because of a complex of properties like: small specific relative mass, high mechanical endurance.

The iron, the cobalt and the nickel manifest mechanical properties that are superior. They can be laminated, wire-drawn and moulded in very good conditions.

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