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THE EFFECT OF NATURAL AGEING HEAT TREATMENT ON THE MECHANICAL PROPERTIES OF THE AlZn4.5Mg1 ALLOY

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ABSTRACT

In this paper, the influence of the time of artificial aging on the variation of the values of the mechanical properties of AlZn4.5Mg1 alloy was studied.

By applying the thermal processing variant described in the paper, an increase in the values of the resistance properties was obtained as the natural aging time increases to the value of 1080 hours. Above this value of the natural aging duration the values of the properties of mechanical strength record a decrease.

KEYWORDS: aluminium alloy, heat treatment, natural aging, mechanical characteristics

1. Introduction

Aluminium alloys are widely used in almost all branches of contemporary industry, so implicitly also in aeronautics due to special properties such as: high mechanical strength, low specific weight, chemical stability, etc, good thermal conductivity, good to very good corrosion resistance etc. [1, 2].

The close collaboration between aircraft manufacturers and metallurgical engineers has led to the production of materials with special characteristics.

Aluminium alloys have an elaboration technology with specific peculiarities, which are presented in the profile literature, and, what are determined on the one hand by the variation of their physical-mechanical properties and on the other hand by some conditions that they must meet, either in cast condition, be in deformed plastic state [2, 3].

For a long time, the main materials used in aeronautics were high-strength aluminium alloys of the dural type (Al-Cu-Mg), but their scope was reduced when alloys appeared special aluminium ziral (Al-Zn-Mg-Cu) [3].

The use of Al-Zn-Mg-Cu alloy blanks meant a gain in the weight of aircraft construction. Moreover, due to the high values of the flow limit of the alloy 7075 in the Al-Zn-Mg-Cu system, semi-finished products of this alloy can be used for most building elements loaded with compression loads (upper wing panels, fuselage compression area, poles, struts and ribs) [4].

Special aluminium alloys from Al-Zn-Mg-Cu system, of zicral type, it has special characteristics (such as high mechanical strength) that give it extra interest compared to other aluminium alloys, especially Al-Cu-Mg system alloys, of dural type, considered until recently to be the best performers [2].

The 7xxx series (Al-Zn-Mg-Cu) are aluminium alloys that are mainly used in the aerospace industry due to high-level mechanical properties. These mechanical characteristics are obtained by a control of the process of precipitation hardening [3-5].

Phase transformations in solid state, if allowed in the balance diagram of the alloy, it is an essential condition for achieving a heat treatment by tempering and natural or artificial aging on an aluminium alloy [4, 6, 7].

An alloy of this type is one that can withstand an order-disorder reaction; the hardening process that accompanies this process (similar to hardening by precipitation) is determined by the order-disorder reaction. The conditions for this form of hardening are quite strict, so the most important methods, often used for these alloys, are, they are based on precipitation from a supersaturated solid solution and eutectoid decomposition [7, 8].

In aluminium alloys with structural hardening, the increase in mechanical characteristics is due to complex interactions between the underlying matrix dislocations and precipitate particles occurring in the alloy structure following ageing [9].

The appearance of Guinier-Preston areas or precipitates of compound in the alloy structure determines in their vicinity a series of discontinuities

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of structural, chemical, energetic nature, etc. Depending on the nature of the discontinuities, there may be several mechanisms by which the mobility of these dislocations leading to the production of hardening of aluminium alloys is impaired [10].

2. Experimental conditions

Materials for experimental research are samples of an aluminium alloy of the Al-Zn-Mg-Cu system with the chemical composition shown in Table 1.

The values of the mechanical properties of the alloy studied according to EN 485-2-2007 [180] are shown in Table 2.

Experimental research on the influence of natural aging heat treatment on AlZn4.5Mg1 alloy was conducted according to the scheme in Figure 1.

The adopted research variant aims, for a degree of plastic deformation at hot = 25%, the influence of the maintenance duration at natural aging on the studied mechanical properties.

They were made for conducting experiments of the research variant, samples with dimensions: length = 105 mm; height = 5.7 mm; width = 60 mm.

Table 1. *Chemical composition of the alloy under investigation*

Element / Aloy	Zn	Mg	Cu	Si	Fe	Cr	Mn	Al
AlZn4.5Mg1	4.5	1.4	0.2	0.35	0.4	0.35	0.5	rest

Table 2. *Alloy properties according to EN 485-2-2007*

Proprieties / Aloy	Rm, [MPa]	$Rp_{0,2}$ [MPa]	A_5 [%]	HB
AlZn4.5Mg1	350	280	10	104

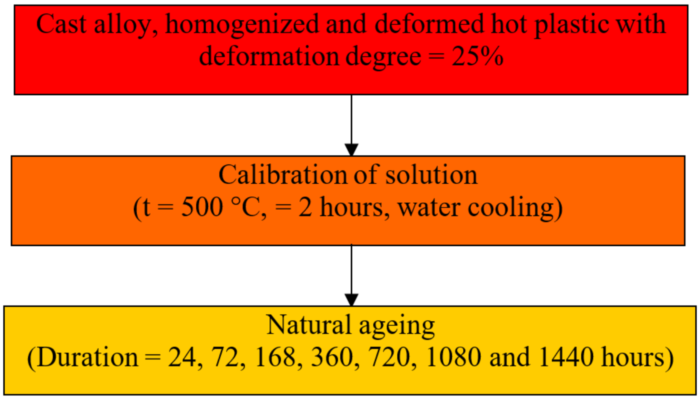

Fig. 1. *Schema de procesare termică adoptată*

3. Results of experimental research

After performing the heat treatment variant and performing the tests for finding out the values of the researched mechanical properties, the diagrams of variation of the mechanical characteristics studied according to the natural aging time according to Figures 2, were drawn up, 3, 4 and 5.

Figure 2 shows the variation in mechanical strength values (Rm) with natural aging time. Figure 3 shows variation in flow resistance values ($Rp_{0,2}$) of the alloy studied according to natural aging time. Figure 4 illustrates the variation in Brinell (HB) hardness with the natural ageing time at which the alloy under study was subjected. Figure 5 shows the variation in the elongation values at breakage (A5) with the natural ageing time at which the alloy under study was subjected.

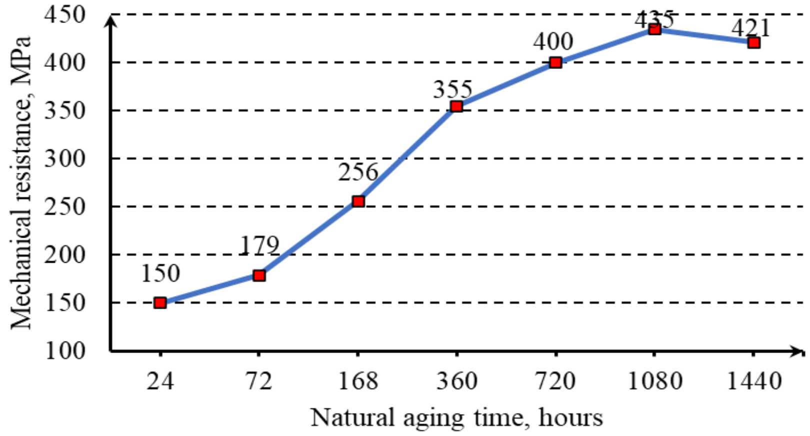

Fig. 2. *Variation of mechanical strength values with natural aging time*

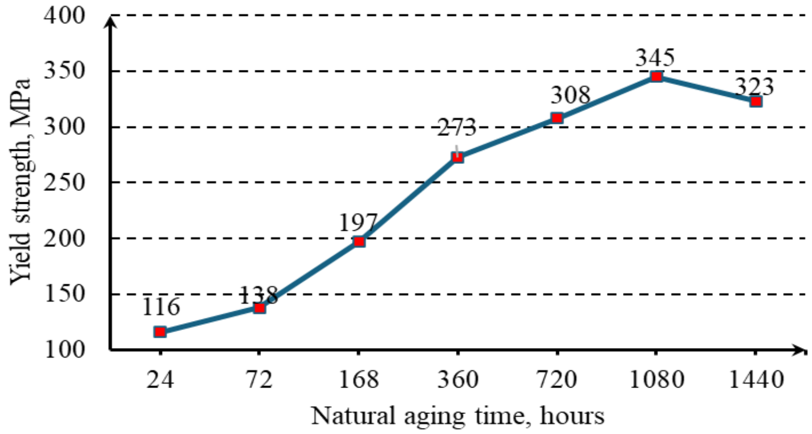

Fig. 3. *Variation in flow resistance values with natural aging time*

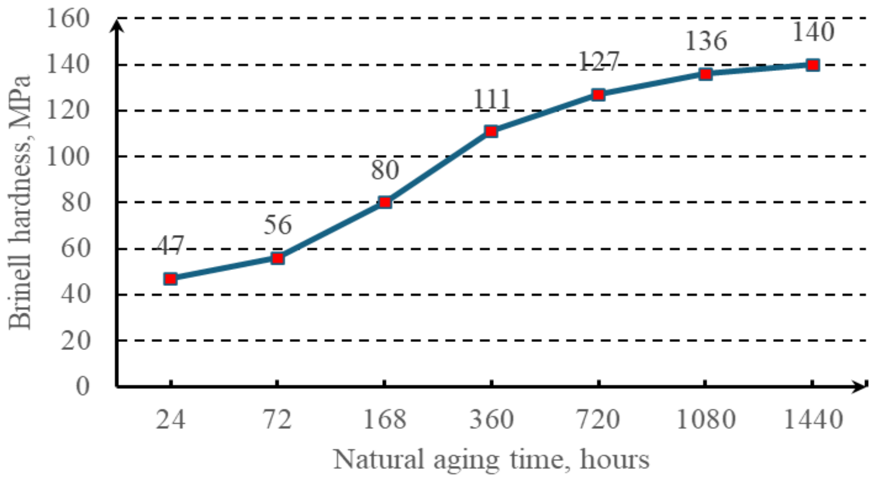

Fig. 4. *Variation of Brinell hardness values with natural aging time*

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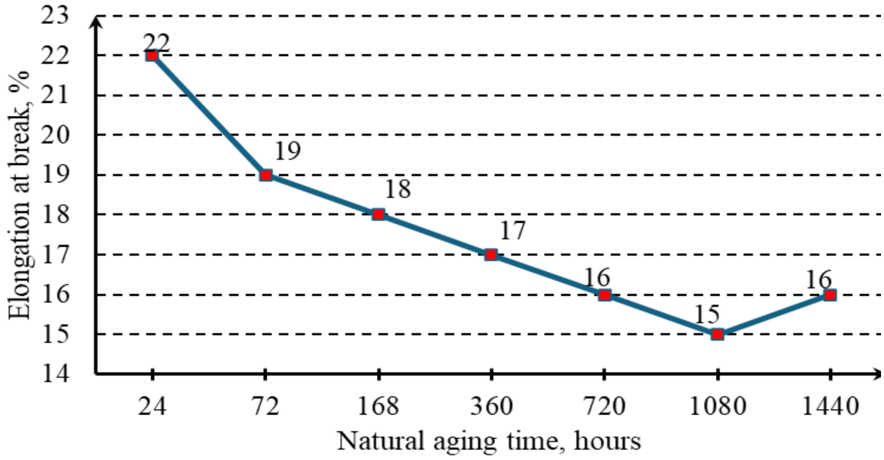

Fig. 5. *Variation of elongation values at breakage with natural aging time*

4. Conclusions

Specific for all three strength properties (Rm, $Rp_{0.2}$ and HB) after the realization of the heat processing variant is that they increase as the natural aging time increases, recording a maximum of 1080-hour aging time values. The further increase in natural aging time causes the values of these three resistance properties to begin to decline for the 1440-hour value of aging time.

As for the elongation at breakage, it is observed from the variation of the recorded values that the elongation decreases as the natural aging time increases.

The graph shows that the elongation records a minimum at the time of 1080 hours, after which a slight increase follows.

For both strength and elongation properties this variation is explained by the fact that the precipitates formed during the natural aging process have reached a critical value of their size, then follows their growth by coalescence.

More specifically, the growth of large ones occurs at the expense of small ones and structurally there is a decrease in the grain limits, which leads to a decrease in mechanical properties of strength, and, at the expense of plasticity.

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