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RESEARCHES REGARDING IMPROVEMENT OF THE FATIGUE LIMIT BY HEAT TREATMENTS OF THE AL-ALLOYS FOR AERONAUTICS INDUSTRY

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ABSTRACT

The laboratory experiments were made on the two aluminium alloyed qualities used for aeronautical industry. The structure and mechanical characteristics were analyzed and the gotten results were compared using those two types of the thermal treatments. Also, the conventional thermal treatment was used, consisting of the solution quenching and artificial heat ageing, mode in more working condition. A significantly improvement of the mechanical characteristics was ascertained to the thermical treated test-specimen.

KEYWORDS: thermomechanical treatment, aluminium alloy.

Introduction

The special aluminium alloys are complex systems where the alloying elements: Mg, Si, Cu, Mn, Zn set up solid solution with aluminium, thus improving, the plasticity characteristics.

When the content of the alloying elements is low, the gotten solid solution is stable at any temperature, and the growth of the mechanical characteristics is moderated one.

At higher percentage of the alloying elements, the gotten solid solutions are metastable at the environmental temperature and, consequently, the alloys might be structural hardened by some components precipitation from the solid solution, that determinate an important increase of the alloy strength but with some decrease of the plasticity.[1]

This structural hardening could be achieved by some thermal treatment, applied only to certain alloys which are grouped in aluminium alloys *hardened by thermal treatment*, known as duralumin; The alloying elements are forming the resoluble compounds at heating, for example: $CuAl_2$, Al_2CuMg, Mg_2Si as well as non-soluble compounds Fe, and Mn as: $(Mn,Fe)Al_6$, Al_7Cu_2Fe.

In annealing condition the duralumin consists of the solid solution and secondary precipitated compounds. Heated at about 500^0C, $CuAl_2$ and Mg_2Si are dissolved in Al while Mn and Fe compounds are not.

By quenching, from this temperature, the alloy will consist of suprasaturated solid solution and Fe and Mn compounds. As result, the thermal treatment, typical to Al complex alloy are the hardening (quenching) in solution and the heat (artificial) ageing.

By heat ageing, the compound precipitation of the solid solution is achieved, determining an hardening of the alloy, a growth of the strength characteristics, respectively, with a slight plasticity dropping. The temperature range, both, for quenching and heat ageing, is large enough, in accordomewith the alloy type (alloys elements) and the characteristics that should be gotten. Thus, for aluminium alloys processed by plastic deformation, the temperature range for solution quenching is 450 – 540^0C and for heat ageing is between 90 – 160^0C. [2]

2.Materials and working conditions

The experiments have been made on Al-Zn-Mg-Cu aluminium alloys, for aeronautics having chemical composition shown in table 1.

Table 1. *Chemical composition of Al-Zn-Mg-Cu alloys (%)*

Cu	Zn	Pb	Fe	Mn	Si	Mg
1.219	2.470	0.0025	0.290	0.470	0.310	2.06

During the laboratory experiments more thermal treatments ranges have been used as quenching in solution and heat ageing with different parameters (temperature and holding time) in accordance with table 2 and figure 1.

Table 2. *Experimental conditions of the thermal treatments*

No.	Heating temperature (^{0}C)	Time (hours)	Cooling	Artificial ageing temperature (^{0}C)	Time (hours)	Hardness HB
1	500	0,5	water	120	12	81
2	500	1	water	120	12	85
3	500	2	water	120	12	102
4	500	4	water	120	12	112
5	500	2	water	160	12	98
6	500	2	water	200	12	80
7	500	2	water	120	6	81
8	500	2	water	120	8	89

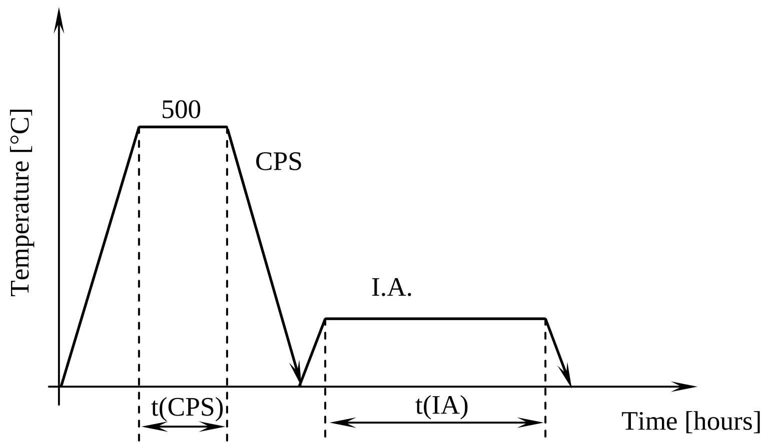


Fig.1 *Variant thermal treatments applied on alloys Al-Mg-Zn-Cu*

3.Experimental results

In the paper framework three variant ways of the thermal treatment have been studied:

a) The influence of the holding time, for quenching in solution, on the hardness.

The following operation have been made:
- heating for 500^{0}C quenching in solution;
- various time of holding (t = 0,5; 1; 2; 4 hours);
- 80^{0}C cooling in water;
- heat (artificial) ageing 12 hours at 120^{0}C.

The gotten results are shown in figure 2.
A light growth of the hardness results to holding time.

b) The influence of the heat (artificial) ageing holding time on the hardness. The following condition had been carried out:
- quenching in solution (500^{0}C, 2 hours holding, cooling in water);
- 120^{0}c heat (artificial ageing; holding time: 6; 8; 12 hours).

The hardness have been measured (fig 3).

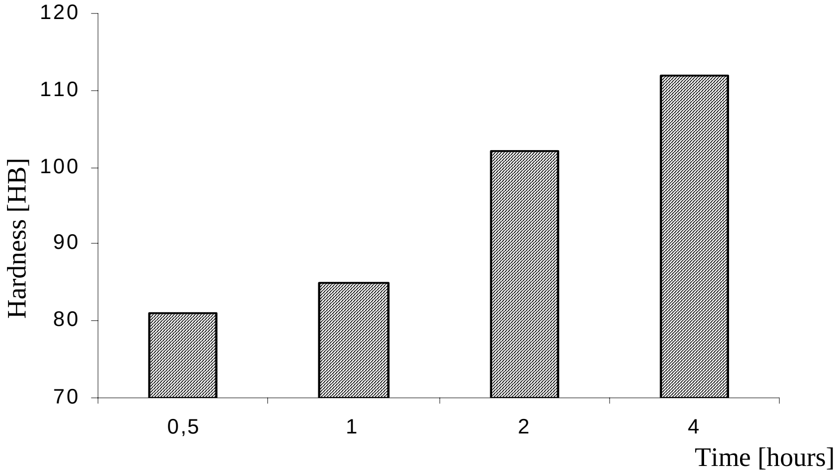


Fig.2 *Hardness variation to the heating time for quenching in solution.*

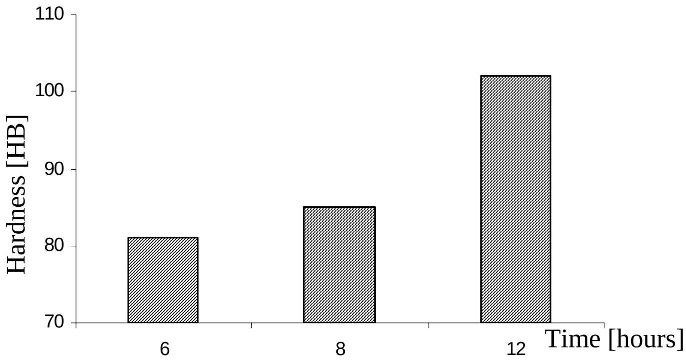


Fig.3 *Hardness variation to the artificial ageing holding time*

A light growth of the hardness with holding time is established (hardness values are very near ones).

c) The influence of the ageing temperature on the hardness, in the following conditions:

- quenching in solution (500^0C, 2 hours, cooling in water);
- artificial ageing, 12 hours, at various temperature: 120^0c; 160^0C; 200^0C.

The gotten hardness have been recorded in figure 4.

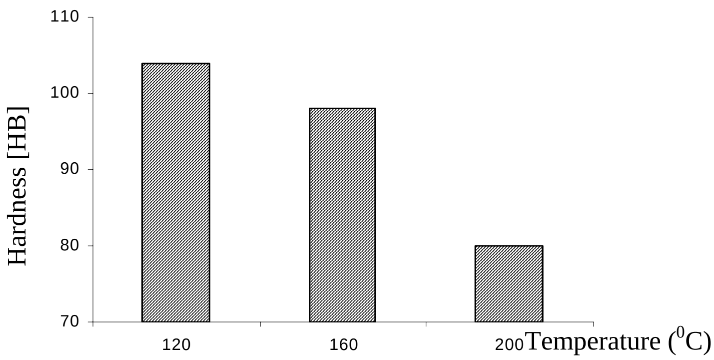
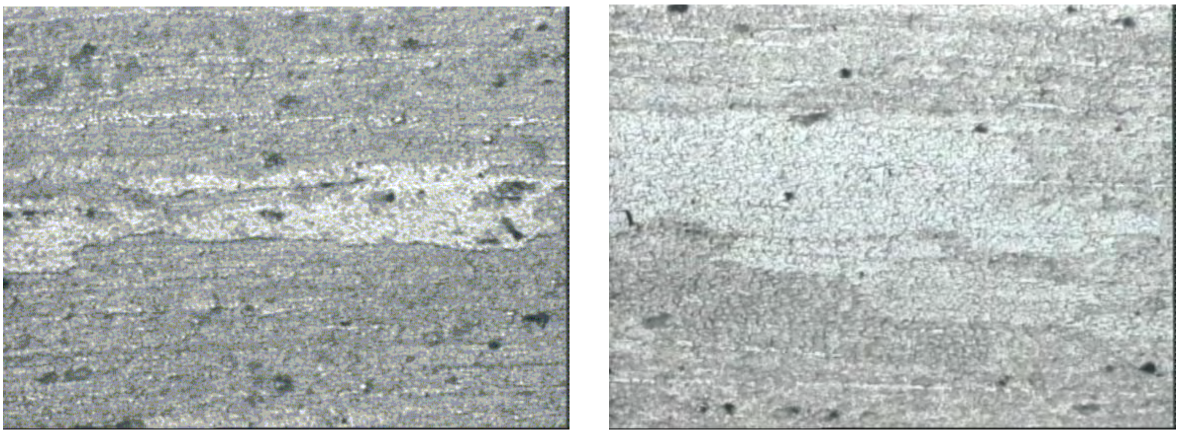


Fig.4 *Hardness variation to ageing temperature.*

A light lowering of the hardness to the growth of the ageing temperature was resulted.

The hardness increase during such treatments a) and b) variant ways is determined by the partly dissolution of the secondary phase precipitates into solid solution, during quenching into solution and, later-on, by the reprecipitation during artificial ageing. By these condition, the getting of certain grain-size and their uniform distribution is watched. The precipitates carrying-out is determining a material hardening.[3]

An increase of the holding temperature could determinate a hardness lowering due to the begining of the coalescence proces of the precipitates (fig.4). These phenomena are, evidently, due to microstructure aspects too, as could be seen in figure 5.



a b

Fig.5 *The microstructure aspect after thermal treatment (magnification x500)*
a) 120^0C ageing temperature; b) 200^0C.

Conclusions

The following conclusions have been resulted from the experiments:
holding time of the quenching in the solution is determining a light growth of the hardness;
heat (artificial) ageing influences the hardness by the heating temperature and holding time;
- for Al-Mg-Zn-Cu type alloys, the treatments of the quenching in solution and artificial ageing are characteristics ones leading to the strength growth, on the one hand, and to the good corrosion and fatigue resistence of the material, on the other hand.

References

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