RESEARCHES REGARDING THE THERMOMECHANICAL TREATMENTS INFLUENCE ON THE STRUCTURE AND CHARACTERISTICS OF THE ALUMINIUM ALLOYS FOR AERONAUTICS

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ABSTRACT

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

KEYWORDS: thermomechanical treatments, aluminium alloys, mechanical characteristic

1. Introduction

Thermomechanical processing (PTM) of the special aluminium alloys is a too litle studied field, eventhough, from the made experiments, it has been established that it resulted some high characteristics, so that they should be more practically used than conventional methods.

The metallurgical technologies used for special aluminium alloys that, watches the grain size finishing and getting of the average or high strength, are two types:

- technological processing that acts on the crystallin grain-size of some aluminium alloys during first stages of the processing at high temperature by the partial elimination of the structural heterogeneity, by the control of the chemical composition of the casting cycles and homogenizing of these alloys. In the sequel the hot plastic deformation is applied (rolling), finally, a recristallized structure is getting, with fine and uniform grain size;

- technological processing applied on the high strength aluminium alloys particularly used for the aeronautics. They consists of more stages of the plastic deformation and thermal tratments, these constituing the thermomechanical processing (PTM) two types of the thermomechanical processings are applied: intermediar (PTMI) and final (PTMF).

The intermediar thermomechanical processing (PTMI) is used in the world to improve the plasticity, toughness and corrosion strength of the special aluminium alloys without mechanical strength reduction comparatively to the conventional processing.

The final thermomechanical processing (PTMF) is applied to get the final strength characteristics combined with a good plasticity, corrosion strength and fatigue strength.

The thermal treatment characteristics of the aluminium alloys, particularly of those Al-Zn-Mg-Cu system, are: solution quenching and heat (artificial) ageing. Combined in a certain succesion to the plastic deformation the important improvment of the strength characteristics could be gotten. Figure 1 shows some exemples of PTMI combined to the conventional thermal treatment or PTMF. [1].

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.

The laboratory experiments have been made combining thermal treatment specific to such alloys; solution hardening (quenching) and heat (artificial) ageing with deformation degree rolling $\varepsilon = 3 \ldots 50\%$.

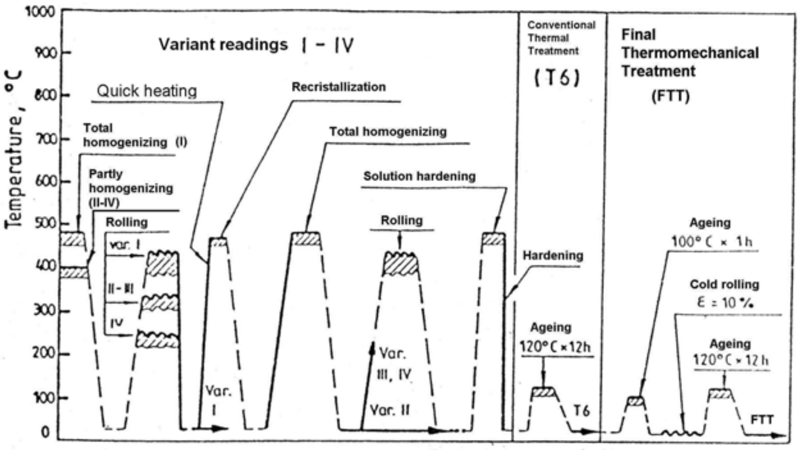


Fig. 1 *Working conditions of PTMI, conventional treatment and PTMF for Al-Zn-Mg-Cu types alloys.*

***Table** 1Chemical 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

3. Experimental results

In the frame of this paperwork two variant experiments have been studied:

a) The influence of the hot plastic deformation degree on the mechanical characteristics.

In this variant way the working conditions of the thermomechanical treatment is shown in figure 2.

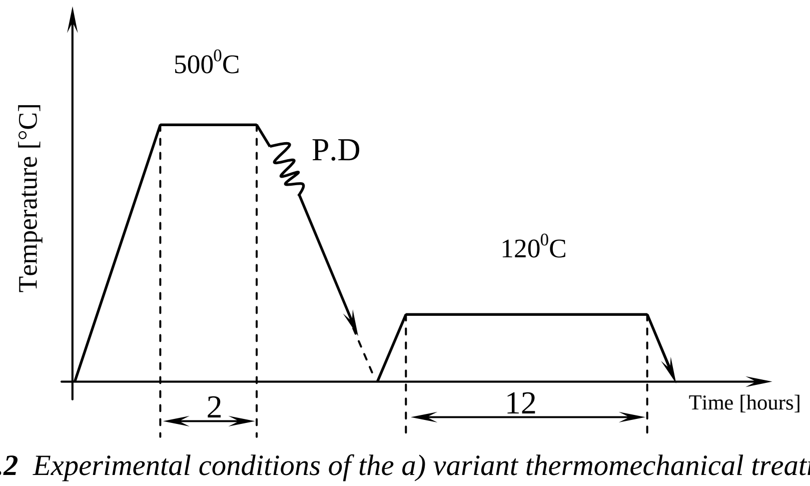


Fig.2 *Experimental conditions of the a) variant thermomechanical treatment*

The operation succesion was the following:

- 2 hours holding at 500^{0}C heating;

- rolling with ε = 3; 8; 13; 40; 50% deformation degree of the pass;

- water cooling at about 80^{0}C;

- finally – an heat ageing was carried out at 120^{0}C for 12 hours.

Therefore, in this case, the quenching in solution was combined with hot plastic deformation into one operation only.

For comparison, a test-specimen was submitted to quenching in solution plus heat ageing, without plastic deformation.

The gotten results are shown in the table 2.

With data of table 2 – the diagrame was drown from figure 3, the variation of the hardness to deformation degree, at rolling.

Table 2. *The experimental working conditions*

No.	Heating temperature (^{0}C)	Time (hours)	Rolling ε (%)	Heat ageing temperature (^{0}C)	Time (hours)	Hardness HB
1	500	2	50	120	12	129
2	500	2	40	120	12	117
3	500	2	13	120	12	114
4	500	2	8	120	12	102
5	500	2	3	120	12	98
6	500	2	0	120	12	85

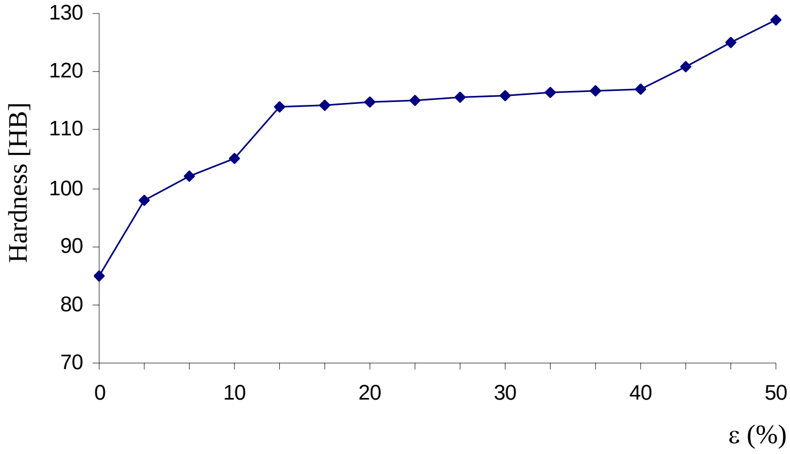


Fig.3 *Hardness variation to hot deformation degree.*

An increase of the hardness to deformation degree is established.

Also, could be remarked that hardness values are higher in case of the carried out plastic deformation against to classic treatment of the quenching in solution, followed by the heat ageing.

b) The influence of the cold deformation and of the heat ageing conditions on the structure and mechanical characteristics.

In this way, a cold plastic deformation have been chosen between two treatments of the heat ageing (fig.4).

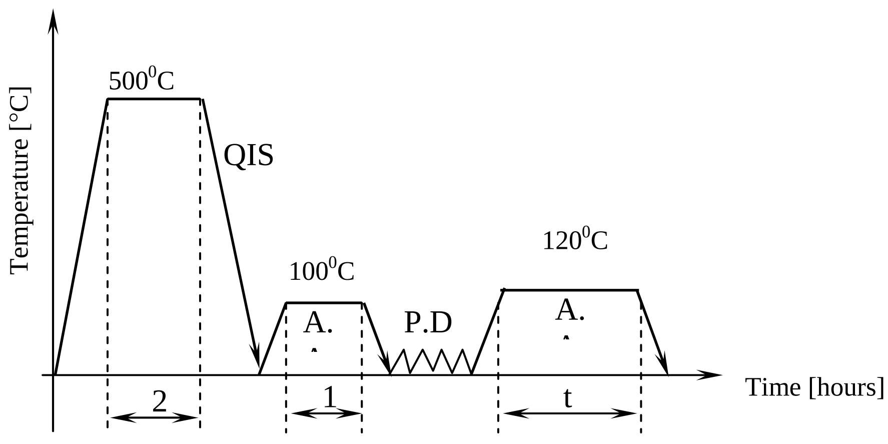


Fig.4 *Conditions of the thermomechanical treatment in b) way*
QIS – quenching in solution ; PD – plastic deformation; AA – artificial ageing;

For comparison, a test-specimen (pieces) was submited to natural ageing (2 days holding at usual temperature).
The gotten results are shown in figure 5.

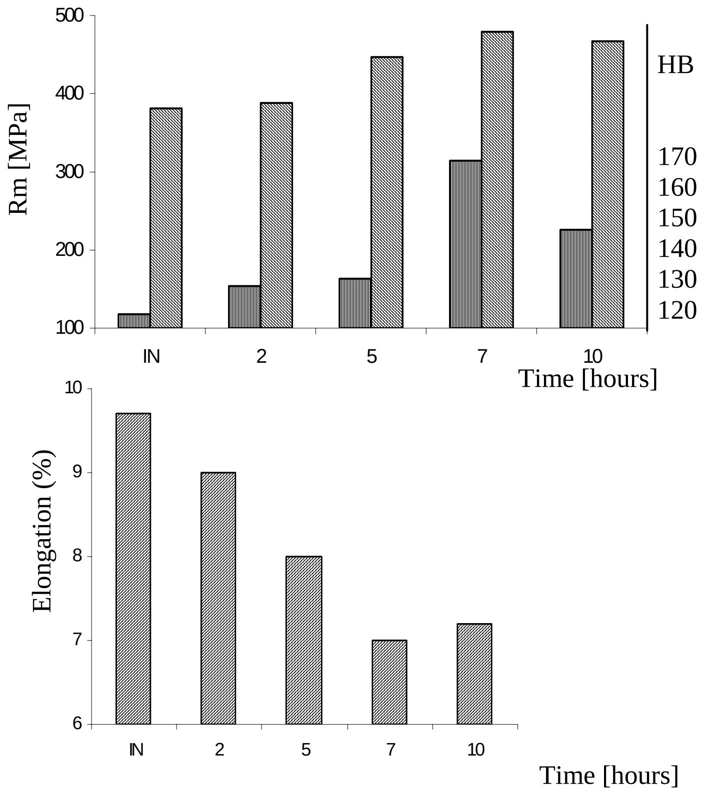


Fig.5 *Variation of the mechanical characteristics to the ageing time.*

From figure 5, could be seen that the strength and hardness grow up, once with ageing time increase (up to 7 hours), after which a hight decrease is recorded. The extension lowers with the ageing time increase.

Comparing the gotten results of the both a) and b) ways could be seen that in case of the plastic deformation, between the two ageings, the hardnesses are much higher than those in case of the hot deformation, followed by the artificial ageing.

In figure 6 the comparatively hardness values are showen, in case of the various thermal and thermomechanical treatment conditions are carried out.

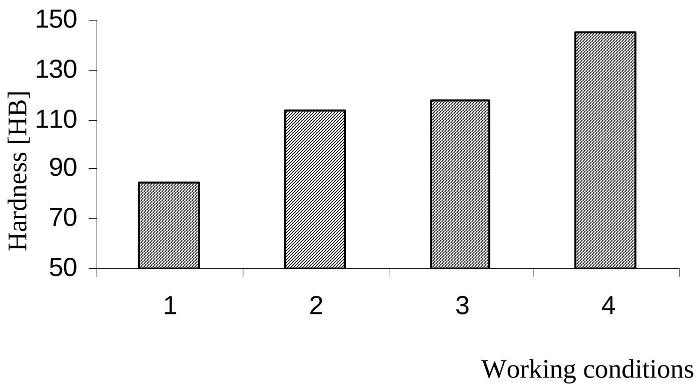
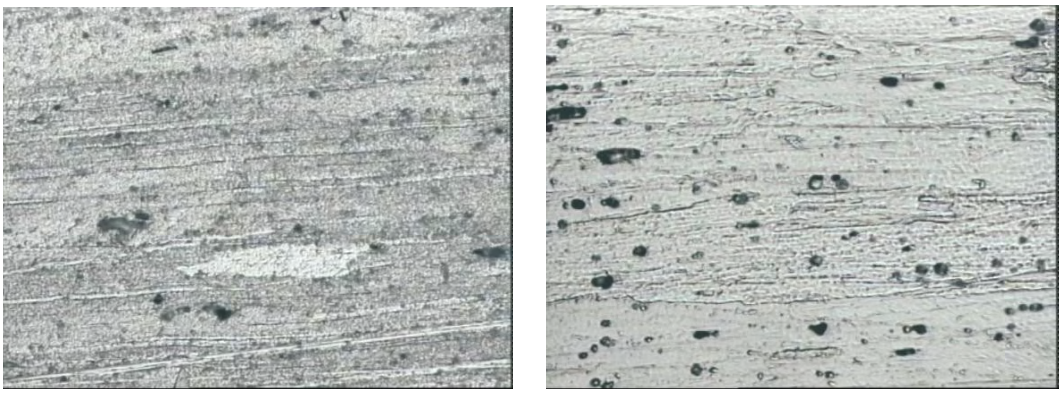


Fig.6 *Hardness variation against to the carried out treatment conditions*
QIS – quenching in solution ; PD – plastic deformation; AA – artificial ageing; NA – natural ageing
1) QIS + AA; 2) QIS + PD + AA; 3) QIS + PD + NA; 4) QIS + NA + PD + AA

Variation way of the mechanical characteristics during these treatments, could be explained, in fact that, during quenching in solution, a partly dissolution of the secondary gases take place in the base solid solution.

By heat (artificial) ageing, a precipitation of the secondary phases take place, that is characterized by a certain scattering degree and range, which is determining a hardening of the alloys[2]. If the process is combined with a cold rolling, a cold strengthening is carried out, due to plastic deformation, which is determining a suplimentary hardening of the alloy. In figure 7 the gotten microstructure of the thermomechanical b) way treatment are shown.



a *b*

Fig.7 *Microstructures of the plastic deformation between two artificial ageing ageing time: a)-2 hours; b)-7 hours*

Could be seen that, once with the increase of the holding time at heat (artificial) ageing, the precipitate quantity of the secondary phase increases too. It explains the hardness variation with a growth up to a certain time (7 hours), after which the hardness lowers, once with the continuosly time increase. There is a holding time, when the precipitates is optimum recorded, from grain-size and scatering point of view.

Over this time, the precipitates coalescence process begin, which is determining a diminution of the strenght characteristics. [3]

4. Conclusions

The laboratory experiments carried out on Al-Mg-Zn-Cu type alloys resulted the following conclusions:

- the hot plastic deformation combined to a quenching in solution and heat (artificial) ageing lead to the sensitive hardness growth;
- cold plastic deformation, between two heat (artificial) ageing determines a more increased growth of the mechanical characteristics (hardness and mechanical strength);
- Al-Mg-Zn-Cu type alloys are sensitive to thermomechanical treatments, resulting high strength characteristics with acceptable plasticity for such materials.

References

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