THE INFLUENCE OF TEMPERS ON STRUCTURAL PROPERTIES OF ALLICUMGZR ALUMINUM ALLOY

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Abstract (TNR 9, bold, italic): The effects of extrusion processing variables on the structure and properties of an Al-Li-Cu-Mg-Zr alloy (8090 type) have been investigated. A combination of light and transmission electron microscopy have been used to characterise the as extruded microstructures and the precipitation reactions which take place on subsequent heat treatment. The corresponding mechanical properties have been determined by hardness, tensile and fracture toughness test methods. As extruded tensile properties are affected by the processing variables whilst within heat treated material the precipitation processes control the mechanical properties of the alloy. The effects of variation in heat treatment involving natural ageing and stretching on the fracture toughness are discussed in relation to the microstructural changes produced. By suitable process and heat treatment control, good combinations of strength, toughness and ductility can be obtained

Keywords (TNR 9, bold, italic): *Strengthening, precipitation, transmission electron microscopy (TEM), microstructure, electrical conductivity.*

1. INTRODUCTION

Alumintum, the metal wihich is only one hundred years old, has been applied and is still being applled primarly in aircraft (military industry), building construotion, etc., and it is thought that in future it will be one of the most important construotion material. One of reasons is the ratio of hardness to density 16, and in steel 7), good corrosion stability, good eleotrical conductivity.
New generation of high atrength alloys, their research programnes in the world are just made and started, are based on the aluminium-litiumum system, The advantage of these alloys is based on adding lithium to aluminium providing higher density decrease than in cane of any other alloying element. Another advantage is increasing the modul of elasticity. Thus, alloys of this system potentionally provide high level of mechanical properties, good corrosion resistance and good but rare combination of high modul of elasticity and small density. However, Al-Li-X alloys show small plasticity, while retaining hlgh strength, alloying elements ahould be added: Cu, Mg, Zn, Zr, etc. A11 problems concerning new alloys of Al-LI system can be described as:

- discovering of the optimal ratio of good hardness and plasticity,
- dresistance to fracture and stress corrosion,
- weldability problems.

Solving the problem of properties optimization means the application of strengthening process by thermal precipitation, i.e. the nucletion process and role of vacancies in it. By good understanding and regulating this process it is possible to influence on hardness and plasticity of the alloy.

2. EXPERIMENTS AND RESULTS

The investigation in this paper is performed on the alloy AlLi 8090. The regime of direct precipitation is applied. The alloy is subjected to thermal ageing in oil at 175°, 190° and 205° C and precipitation time of 30`-1800`. Direct aim of these investigations is to find out optimal temperature and precipitation time. That is why this paper is aimed to give a certain contribution to this matter, primarily on the basis of experimental results.
Experimental results were used as a base for mathematical model used for achieving process optimization.

By using numerous literature data it could be freely said that till now mathematical models have not been developed in this field wh- ich could, for sure, deseribe qualitatively and quantitavely the strengthening process on alloys of aluminium with lithium. Because of great practical importance and possibility of usage of AlLi alloy, this paper presents the mathematical dependance on temperature and precipitation time.
The first task was to determine the range of temperature and thermal precipitation time in which mathematical modelling will be performed. In order to define this range a great number of papers were consulted /2/, /3/, /4/, /5/, /6/ in which the problem of quality is studied, relate to commercial aluminium alloys. These papers have given the information about priority factors influencing the strengtening by thermal precipitaion pointing out that it is the most interesting to investigate in temperature interval of thermal precipitation of 175°-205°C and precipitation time of 30`-1800`.

3. STRUCTURES

3.1. Mechanism and kinetics of isothermal aging

The precipitation kinetics were obtained for isothermal aging for temperatures of 175°, 190° and 205° C both from the optical and TEM aspects. Due to the interest of the results obtained for the precipitation temperature of 175° C, these special conditions will be given special attention. 175° C at the maximum of the amplification, and the results are given in figures 1 to 2.
A detailed quantitative analysis of the isothermal aggregate sludge was made at a temperature. Based on the quantitative analysis of figures 1 to 2 as well as qualitative tests at isothermal aging at 175°C, δ ', S' and T', precipitations:
The δ' residue is an ellipsoidal and spherical shape with a mean long 57 nm diameter and a mean diameter of 46 nm, with a basis:

- The fraction of the d-phase fraction is 0.97%;
- the number of particles per unit area is 6;
- The average distance between the d 'particles is 416 nm.

The characteristics of the S-sediment are:

- mean needle length 443 nm;
- the average needle width is 28 nm;
- The S-phase fraction of the phase is 3.7%, and
- the number of particles per unit area is 4.

The characteristics of the T_1 phase, this phase occurs in the form of tiles with a cross section area of 1nm with a mean length of 73 nm and a mean width of 7nm.
The characteristics of the S "precipitate at the grain boundary are plotted as shown in figure 1: the mean length of the needle is 249 nm and the mean needle width is 4 nm.

Figure 1. Microstructure of alloys in isothermal aging on the 175°C, zoom 24000X

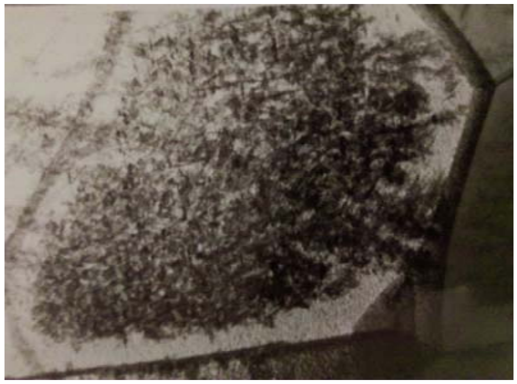

Figure 2. Microstructure of alloys in isothermal aging on the 190°C, zoom 24000X

Table 1. Characteristics of the δ' precipitation

A (nm^2)			d_1(nm)			d_2(nm)			F_{pe}			V_v (%)	N_a	λ (nm)		
min.	**max.**	**mid.**	**min.**	**max.**	**mid.**	**min.**	**max.**	**mid.**	**min.**	**max.**	**mid.**			**min.**	**max.**	**mid.**
0.6	**6**	**2.1**	**30**	**99**	**57**	**26**	**76**	**46**	**0.76**	**1**	**096**	**097**	**6**	**21**	**2045**	**416**

The width of the dislocation loops is 250nm, and the distance between them is from 550-1500nm; The width of the grain boundary is about 250nm.

The aging process of the investigated alloys is complex: nucleation δ' (Al_{3Li}) it starts already during the tempering from the dissolving solvent temperature β` (Al_3Zr) is present even during homogenization.
The application of various research techniques has given different identification of the sediment. The structure of the alloy depends on the properties of the alloy. The goal is achieved by various mechanisms of structure change and obtaining a homogeneous δ` sludge within the grain itself, which will give the optimum characteristics of the tested alloy for aircraft applications.

4. CONCLUSIONS

Based on the obtained results of tests and literary additions, conclusions can be formulated.
1. In the examined systems, there are three qualitatively different moments within the precipitation, of which only one is responsible for the maximum structural strengthening.
The first stage is the stage of the formation of a coherent, middle δ' (Al_3Li) phase, a syllable. or an ellipsoidal form.
The second stage is the growth of needle sediment S` (Al_2CuMg).
In the third stage, besides δ' and S`, the tiles of T_1 (Al_2CuLi) are formed, of certain size and mutual distance, whose presence in certain planes is also witnessed by diffuse distortions of points in the reciprocal space.
Judging from the literary and experimental research carried out in this paper, the first stage is most responsible for the maximum structural reinforcement.
2. An important factor that affects the properties of precipitated reinforced alloys is the dispersion of the sediment. Generally taken high tensile strength can be achieved with finely dispersed taloses. Surely, an important part is the uniformity of the particle size of the sediment. A large difference in the particle size is due to their overlapping or overlapping of the actual stress fields.
Excellent visibility of sediment δ', S` and T_1 'was achieved in the investigated alloys and these are as well known talozes that have decisive influence on hardness, plasticity, nausea and corrosion resistance.
The obtained viscous gels with TEM images are confirmed by diffraction images.
By forming the phase after longer aging times, the stability of the system has been achieved, so it can be safely believed in the high level of asobin of the investigated alloy.
3. The speed of the precipitation reaction can be controlled by the thermal treatment regime.
In the process of homogenization and thermal dissolution, β` (Al_3Zr) dispersoid is formed during the quenching process. After hardening, the alloy is saturated with point defects, so a large number the emptiness is located near the grain boundaries, some are condensed at the grain boundaries, and the other binds the dislocations at room temperature and results in the formation of dislocation loops. The deposition reaction can be shown as:

$$\alpha(solid\ solution) - \delta\ '(Al_3Li) + S`(Al_2CuMg) + T_1\ (Al_2CuLi)$$

δ ′ is separated homogenously in the base during quenching, and in later stages of aging heterogeneously on β` (Al_3Zr) precipitate as well as dislocations.
S` is depositing on dislocations, grain boundaries and grain itself, after longer aging times.
The size and morphology of the sediment depend on the thermal treatment regime. The precipitation is achieved homogeneously in grain and heterogeneous on defects. homogeneous precipitation is a great effect that is reflected directly on the properties of alloys for use in the air industry.

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