A RESEARCHES FOR THE DETERMINATION OF THE ATC Si10Mg ALLOY FATIGUE LIFE, FUNCTION OF DIFFERENT APPLIED THERMAL TREATMENT CYCLES

Adrian DIMA[1], Alina Adriana MINEA[1], Iulia-Margareta DIMA[2]

[1] Technical University "Gh. Asachi", Iassy;
[2] Tutora School, Iassy
e-mail: aminea@tuiasi.ro

ABSTRACT

The experimental researches which were made, emphasized the opportunity of applying heat treatment cycles, in order to increase fatigue life of ATC Si 10 Mg alloy. The increase of minimum fatigue resistance is approximately 2,5 when complex heat treatment cycles apply.

KEYWORDS: aluminum alloys, heat treatment cycles, fatigue resistance.

1. Introduction

The aluminum alloys which are suited to plastic deformation processing are much more often studied from the view point of their physico-mechanical and structural properties, on account of their usage in machine elements building.

The casting alloys, especially the complex silico-aluminium-magnesium ones, are used nowadays more and more at the casting of parts which are subjected to variable stresses; this fact leads to the necessity of studying the alloy behavior at fatigue.

1. Experimental

The approach to the experimental researches carried out to establish the fatigue behavior of the discussed alloy, namely the ATC Si 10 Mg one, was meant to determine the fatigue life variation of the casting state- and thermal treated alloy, after different thermal treatment cycles imposed by the research.

The used experimental research methodology is as follows:

i) The determination of the chemical composition of the studied alloy.

ii) The obtaining of NPL-434 Amsler test bars, necessary for studying both the fatigue strength and the fatigue life (constant bending cycle).

iii) The adaptation and the testing of various complex thermal treatment cycles which are in accordance both with the 201/2 - 7 STAS specifications and with the ternary equilibrium diagram of the studied alloy.

iv) The determination of the Wohler fatigue strength curves of the discussed alloy, both in a costing and in a case-hardened and 160°C artificial aged state, time of exposure 7 hours, the purpose is to study the influence of the thermal treatments on the fatigue strength.

As part of the experimental researches, the variation curves have been drawn:

$$\sigma_{-1} = f(\lg N) \qquad (1)$$

Where: σ_{-1}- the fatigue bending strength for the symmetrical alternating cycle (daN/mm^2); N — number of loading cycles.

v) The determination of the fatigue life curves till the failure of the test bars occurs; the fatigue life curves are experimentally determined for all the complex experimental thermal treatments cycles, and are of the type

$$gN=f(t). \qquad (2)$$

Where: N- number of loading cycles till failure; t-time of exposure at constant temperature for artificial aging, hours.

From the specialized literature for plastically deforming hard aluminum alloys, one can see that tolerable strength at alternating stresses ranges from 2 to 2.7 daN/mm^2.

For light non-ferrous alloys, the strength at alterating stresses can be approximated as being:

$$\tau_{-1} = (0.25...0.5)R \qquad (3)$$

As it is known, the metal fatigue strength can be influenced by various factors which may be divided in three major groups.

1. Constructive factors (shape of the work, assembly type, machining accuracy, etc.).

2. Technological factors (material, surface quality, machining, accuracy etc.).

3. Working conditions (type of loading, the asymmetry degree of the cycle, short time overloading Ann-under loading, shocks, loading frequency, working temperature, corrosive action of the working medium).

To determine the fatigue strength, the corrosion strength under stress, and the corrosion durability under constant mechanical stress, only the test bars whose spreading field of both the maximum roughness values and of the ovality of the profiled section is in accordance with the STAS specifications, have been selected.

To carry out this research, the test bars cast in chills under gravimetrical pressure (in conditions similar to the production process) have been used; these test bars have been made in a single melting operation and are responding to the 201/1-71 STAS specifications (Table 1) from the view point of the chemical composition.

Table 1

Alloy mark		Chemical composition %				
		Cu	Si	Mg	Mn	Al
ATC Si 10 Mg	STAS	–0.1	9... 11	0.15 ... 0.4	0.2 ... 0.6	6 res
	obtained (819 melting operation)	–0.1	10.6 ... 10.72	0.2 ...0.3	0.25	res

Impurities				
	Fe	Zn	Pb	Ni
STAS	0.7	0.1	0.005	0.1
obtained (819 melting operation)	0.47...0.52	–	–	–

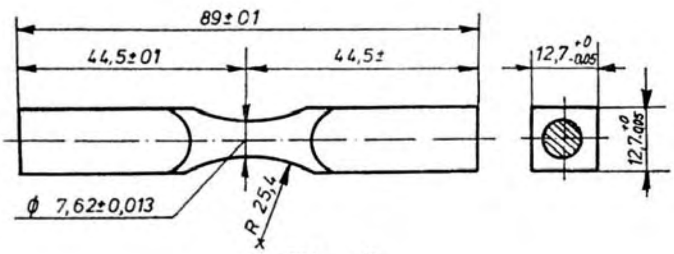

Fig. 1

To study the fatigue life and the fatigue strength variation, some Amsler test bars have been manufactured (Fig. 1.); these test bars have been milled off, machined with profiled tools and finished with coated abrasives fastened on a profiled support. The thermal treatment cycles taken into consideration during experiments (Fig. 2) have been chosen function both of the ternary equilibrium diagram of the studied alloy and of the 201/2-71 STAS specifications. During tests, the so-called "placing in solution" has been used, at the same heating temperature as the same temperatures (520°C) as indicated by standards; the times of exposure temperatures for the artificial aging thermal treatment have been increased (27 cycles of thermal treatments). The high time of exposure is justified considering that as cast parts the precipitates are much more rough then as the plastically deforming alloys; this fact leads to the necessity of a longer time of exposure at the temperature of, "placing in solution" for their dissolution.

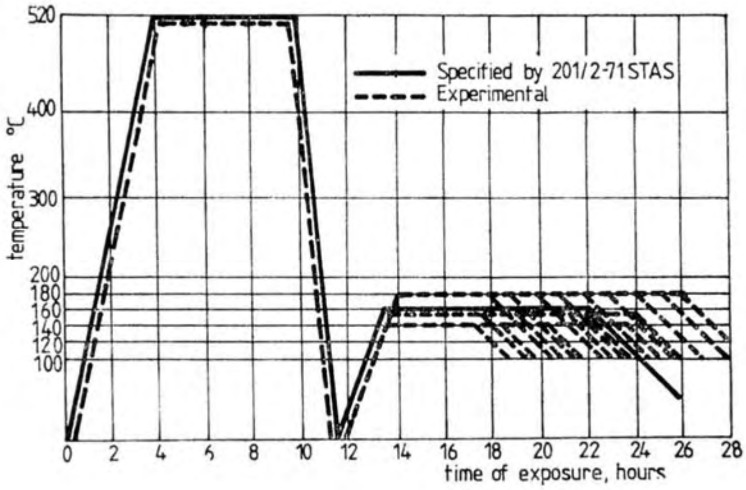

Fig. 2

The hardening thermal treatment has been done immediately after the "placing in solution" in hot water at 80...90°C, a medium which supported an optimal rate of coaling (140°...160°C/s) and, at the same time avoided the coming out of the deformations produced under the action of the hardening thermal stresses.

The constant keeping of the temperature of "placing in solution" of the alloys has been adapted after preliminary experiments of the cycles of thermal treatment indicated in 201/2—71 STAS; as the result of these tests, the optimal values for the mechanical properties in the case of the adaptation of a "placing in solution" at 520°C, for 6 hours, have been obtained.

The whole set of the test bars necessary for experiments have been measured by the methodology of determining both the roughness R_{max} and the ovality Q_r.

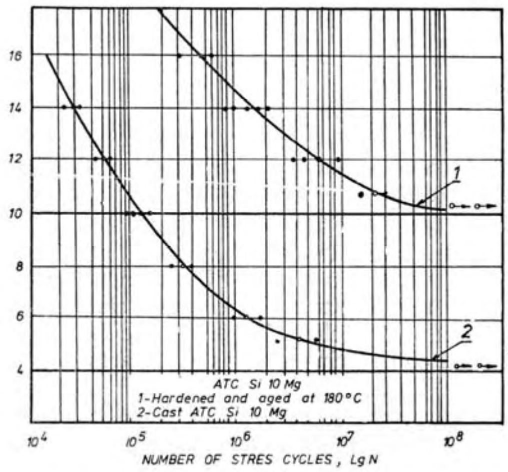

Fig 3

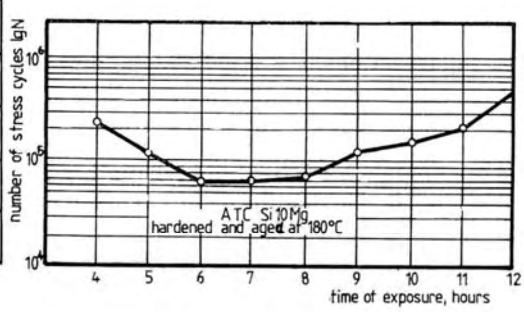

Fig. 4

To determine the Wohler fatigue curves at variable cyclical alternating symmetrical bending loadings, the classic working methodology has been used, by taking a number of 14... 16 samples for each plotted curve. To determine the fatigue strength of the discussed alloy, the number of bending cycles has been reduced to 10^8 cycles.

During the experiments, we have plotted the Wohler-type diagrams for the cast alloy and for the

ATC Si 10 Mg alloy hardened and aged at 180°C, time of exposure 10 hours, with a complete cycle of thermal treatment; the maximal static-mechanical characteristics have been obtained (Fig. 3).

By the comparative study of the obtained diagrams, it has been noticed that by applying the complete thermal treatment cycle, the fatigue strength of the alloy σ_{-1} is increased from 4 daN/mm^2 to 10 daN/mm^2, this is a phenomenon which justifies in excess the necessity of employing thermal treatments to this type of alloys.

For determining the fatigue life variation of the alloy, the semi-logarithmic variation curves of durability up to failure, at a constant strain loading (14 daN/mm^2) for the whole range of thermal treatment cycles tested on the alloy (Fig. 4) have been drawn.

2. Conclusions

From the study of the durability variation curves, function both of temperature and time of exposure during the thermal treatment of artificial aging, it results the following principal aspects.

1. The durability has, for every exposure temperature, a minimal value for reduced times of exposure (6 hours), a fact which is explained by the loss of coherence with the solid solution of the distinct structural phase of the type ; this change leads to the annulling of coherence with the solid solution.

2. The cycles of complex thermal treatment which contain artificial aging at 180°C lead to maximum values of durability.

3. All the cycles of complex thermal treatment lead to durability values considerably higher then the durability of the cast state alloy.

As a conclusion, the experimental determination carried out in this study, pointed out the fact that the application of cycles of complete thermal treatment structural hardening leads, in totality, to an increase both of the fatigue strength and of the durability at a constant strain loading of the studied alloy.

The hardening thermal treatment is, therefore, a very efficient method of increasing the mechanical characteristics of the Romanian-made aluminum alloys.

References

[1]. Speidel M.O., *Conference on Fundamental Aspects of Stress Corrosion Cracking*, State University, Columbus, Ohio State, 11—15, 1967.

[2]. Nadasan S., *Oboseala metalelor.* Ed. tehn., Buc, 1962.

[3]. Dima Ad., *Contributii la studiul micsorarii efectelor coroziunii sub sarcina asupra aliajelor de aluminiu românesti, prin actiunea unui ciclu de tratament termic adecvat*, Teza de doctorat, Institutul Politehnic din Iasi, 1980.