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EXPERIMENTAL STUDIES ON STRUCTURE PROFILE OF CAST ALUMINUM ALLOYS

Alina-Adriana MINEA, Adrian DIMA

Technical University "Gh. Asachi" Iasi, Romania;
e-mail: adima@tuiasi.ro

ABSTRACT

This paper presents experimental studies regarding the behavior after heat treatment of two cast aluminum alloy. So, we selected a typical charge for studying the structure profile. The studies that we have done can reveal the advantage of controlling the heating process at heat treatment of aluminum alloys.

Doing the studies that are described in the paper, we have obtained the microstructure profile that can express the importance of the process.

KEYWORDS: aluminum, heat treatment, microstructure profile, experimental model, cast alloys

1. Introduction

Heat treating on its broadest sense, refers to any of the heating and cooling operations that are performed for the purpose of changing the mechanical properties, the metallurgical structure, or the residual stress state of a metal product. When the term is applied to aluminum alloys, however, its use frequently is restricted to the specific operations employed to increase strength and hardness of the precipitation – hardenable wrought and cast alloys. These usually are referred to as the "heat – treatable" alloys to distinguish them from those alloys in which no significant strengthening can be achieved by heating and cooling. Heat treating to increase strength of aluminum alloys is a two – step process:

- quenching heat treating: dissolution of soluble phases and development of supersaturating;
- aging (age hardening) heat treating: precipitation of solute atoms either at room temperature (natural aging) or elevated temperatures (artificial aging or precipitation heat treating).

2. Experimental results

To take advantage of the precipitation – hardening reaction, it is necessary first to produce a solid solution. The objective of this process is to take into solid solution the maximum practical amounts of the soluble hardening elements in the alloy. The process consists of soaking the alloy at a temperature sufficiently high and for a time longs enough to achieve a nearly homogenous solid solution. Nominal commercial quenching heat treating temperature is determined by the composition limits of the alloy and an allowance for unintentional temperature variations.

The time at the nominal quenching heat treating temperature (soak time) required to effect a satisfactory degree of solution of the undissolved or precipitated soluble phase constituents and to achieve good homogeneity of the solid solution is a function of microstructure before heat treating. This time requirement is variable with the part dimensions.

After quenching, hardening is achieved either at room temperature or with an artificial aging. Artificial aging heat treating generally is low – temperature, long – term processes. Temperatures range from 115 – 190 °C; times vary from 5 to 48 h. Choice of time – temperature cycles for artificial aging should receive careful consideration. Larger particles of precipitate result from longer times and higher temperatures; however, the larger particles must, of necessity, be fewer in number with greater distances between them. The objective is to select the cycle that produces optimum precipitate size and distribution pattern. Unfortunately, the cycle required to maximize one property, such as tensile strength, is usually different from that required to maximize others, such as yield stress and corrosion resistance. Consequently, the cycles used represent compromises that provide the best combination of mechanical properties (it can be referred at a combination of hardness and mechanical stress).

Temperature control and uniformity present essentially the same problems in artificial aging heat treating as they do in quenching heat treating.

Good temperature control and uniformity throughout the furnace and load are required for all precipitation heat treating. Recommended temperatures are generally those that are least critical and that can be used with practical time cycles.

The general methods for heat treating aluminum alloys include the use of molten salt – baths, air – chamber furnaces and induction heaters. The choice of heating equipment depends largely on the alloy and the configuration of the parts to be processed. The type of heat treating can also influence the choice of heating equipment.

Air furnaces are used more widely because they permit greater flexibility in operating temperature. Air furnaces are also more economical when the product mix includes a few parts; holding temperature of a large volume of salt in readiness for an occasional part is far more expensive than heating an equal volume of air. Also, induction methods can provide high heating rates, which affects transformation behavior.

In air furnaces, careful attention should be given to arrangement of the load. Air flow and natural temperature distribution within the furnace should be arranged to:

-offer minimum resistance to air flow

-produce the least disturbance in the natural temperature distribution

-afford constant replenishment of the envelope of air around each part.

This paper presents two cast aluminum alloys, which is used for aeronautical parts. These alloys are heat treated in order to establish the optimum mechanical properties, and we are referring especially at microhardness, tensile strength and elasticity. So, we took 10 parts, of identical measures, from this alloy and we apply the final heat treating. At the end we were studying structural properties, in order to establish the optimum technology.

The experiments were made using modern equipment, which is assisted by computer in order to control the process and to reduce energy consumption, especially at heating for quenching and artificial aging.

Experimental results are shown in fig. 1 and fig. 3 for the two aluminum alloys in cast conditions and in fig. 2 and fig. 4 for heat treating conditions.

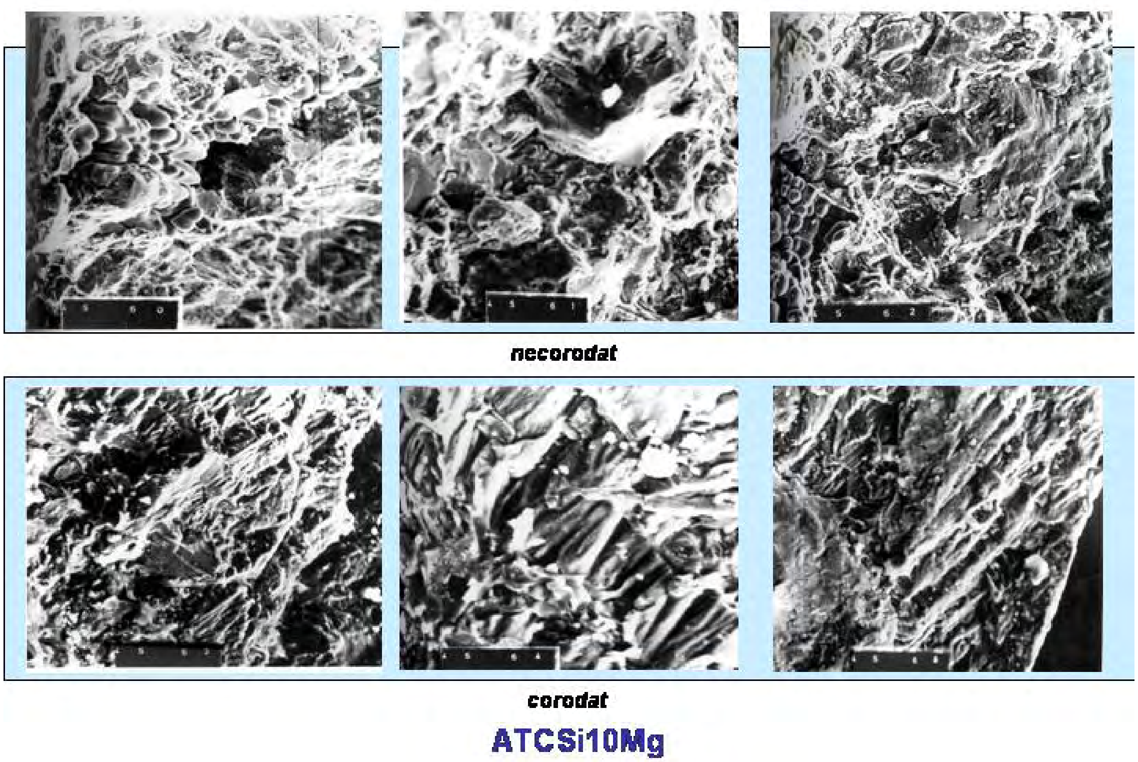
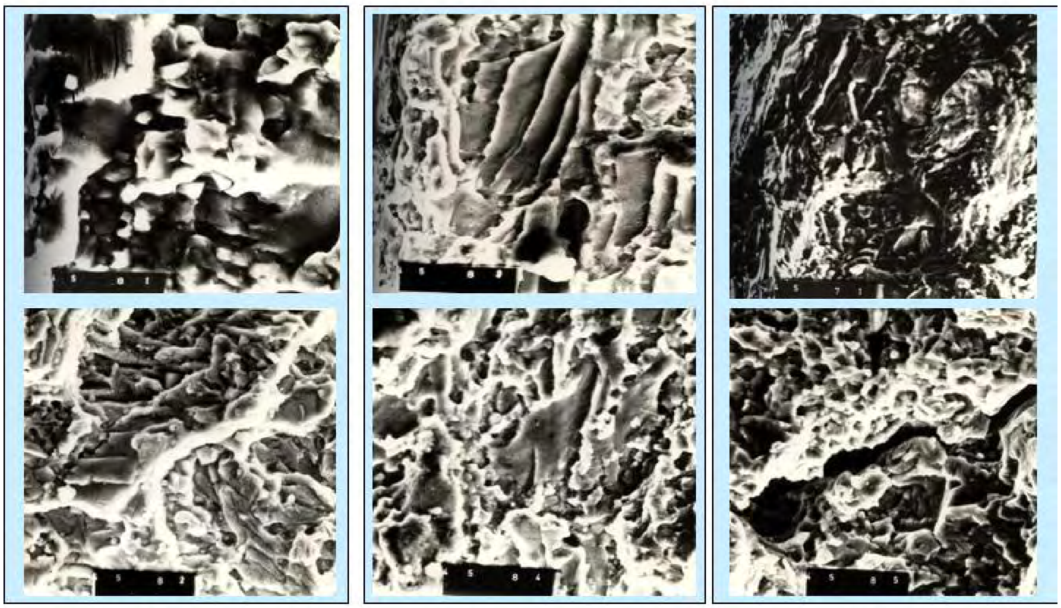


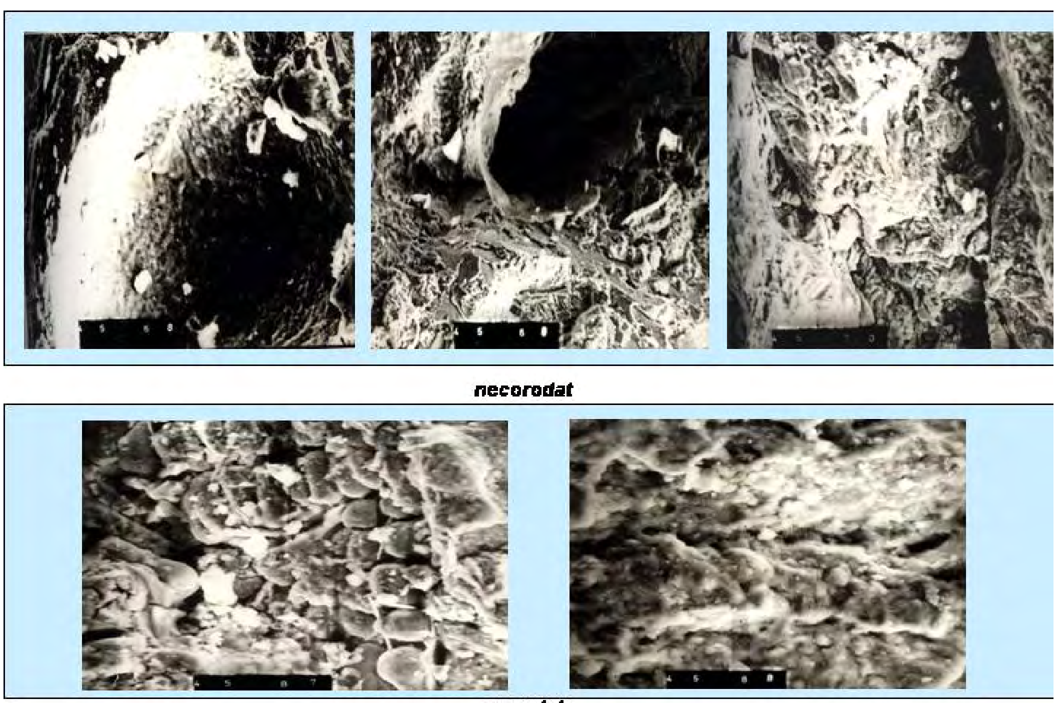
Fig. 1. *Structure of a cast aluminum alloy – ATCSi10Mg.*



140°C, 11h, corodat   160°C, 9h   160°C, 7h, corodat

ATCSi10Mg quenched and artificial aged

Fig. 2. *Structure of a cast aluminum alloy – ATCSi10Mg, in heat treating conditions*



necorodat

corodat

ATCSi5Cu1

Fig. 3. *Structure of a cast aluminum alloy – ATCSi5Cu1.*

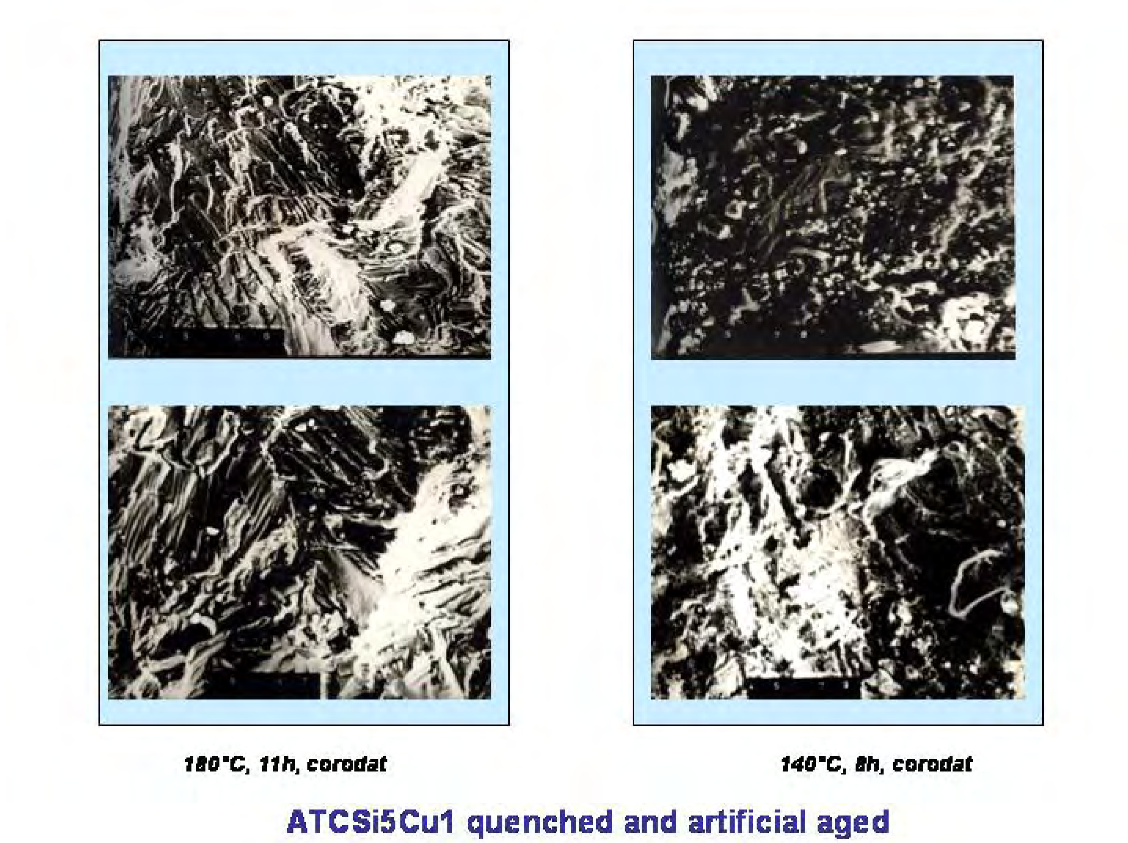


Fig. 4. *Structure of a cast aluminum alloy – ATCSi5Cu1, in heat treating conditions.*

Otherwise, for improvement of aluminum-alloy final heat treating technology we care about aspects like: -

- applying methods that can eliminate human work;
- eliminating manuals commands by using smart-systems;
- reducing heat losses by using correct isolations.

3. Conclusions

This paper contains a study regarding the improvement of heat treating parameters, which determine a better heat treating technology for aluminum alloys and low energy consumption.

In this paper is presented the variation of structure characteristics with aging and quenching heating temperature.

We consider that the researching methodology choused is original and allow realizing the experiments to reveal the following improvements of the final heat treating technology for an aluminum alloy:

- correct calculation of the final heat treating technology for the studied alloy;

-choosing a performant heating furnace, an air chamber furnace with controlled heating;

-using modern equipment for testing the final heat treated parts, and we are referring at mechanical stress and hardness;

-correct programmed experiments and interpretations.

In this context, final heat treating technology optimization for aluminum alloys, with a high degree of predicting the mechanical characteristics of the working parts is an important contribution in the industry field.

As a conclusion, the paper presents the algorithm for applying the optimum heat treatment in order to obtain the necessary properties for the working parts.

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