Heat treatment of EN AC-AlSi13Cu2Fe silumin and its effect on change of hardness of the alloy

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Received 05.03.2010; accepted in revised form 23.03.2010

Abstract

Wide application of aluminum casting alloys is connected with their very good physical and technical properties. Within such group of alloys, silumins play important role in automotive and aviation industry, as well as in another branches of technique, because the silumins enable casting of complicated shapes. The most important parameters which predetermine mechanical properties of a material in aspects of suitability for castings of machinery components are: tensile strength (Rm), elongation and hardness. Alloys based on equilibrium system of Al-Si comprise additional constituents (e.g.: Mg, Cu) enabling, except modification, improvement of mechanical properties, obtained in result of heat treatment. In the paper are presented results of investigations concerning effect of the heat treatment on change of hardness (HB) of the EN AC-AlSi12Cu2Fe alloy. Investigated alloy was melted in an electric resistance furnace. Run of the crystallization was presented with use of the thermal-derivative method (ATD). This method was also implemented to determination of heat treatments temperature range of the alloy. Performed heat treatment gave effect in change of the hardness. Performed investigations have enabled determination of heat treatment parameters range, which conditions suitable hardness of the investigated alloy.

Keywords: heat treatment, ATD, hardness

1. Introduction

Among alloys of non-ferrous metals, aluminum alloys have found their broadest application in foundry industry. Silumins belong to alloys which can be characterized by low density, good thermal conductivity, good corrosion resistance, satisfactory strength parameters in ambient and increased temperature, as well as excellent technological properties.

Obtainment of adequate mechanical properties is connected directly with change of alloy’s structure. To obtain suitable structure, and the same to have an effect on properties of silumins, in practical applications one makes use of processes of refining and modification as well as improves processes of heat treatment [1-11].

To operations of the heat treatment, used to casting of aluminum alloys belong: soft annealing, stress relief annealing, solutioning and quench ageing. For majority of the alloys, solutioning temperature is contained between 490-530°C; for alloys with magnesium and zinc the temperature is a little lower; whereas Al-Cu alloys are solutioning heat treated between 510-540°C. Structure received after solution heat treatment is unstable and a component dissolved into solid solution is susceptible to separate from the solution. Therefore it is necessary to accomplish next operation of the heat treatment, i.e. ageing. The ageing may proceed in temperature range of 150-230°C and operation time may be included between 5÷20 hours [12-14].

Usage of the ATD method enables recording of the heating process (melting) and crystallization of aluminum alloys, as well as enables determination of temperatures of solutioning and ageing treatments, basing on analysis of recorded curves.

2. Methodology of the research

The EN AC-AlSi12Cu2Fe alloy is counted among multicomponent alloy commonly used in foundry industry. It is
called as near eutectic alloy (silicon as alloying constituent is present in quantity near to eutectic one).

Investigated alloy was refined with Rafal 1 in quantity of 0.4% of mass of metallic charge, and next modified with strontium in quantity of 0.06% of mass of metallic charge.

Process of solidification and melting of the alloy was recorded with use of fully automatic Crystaldimat device (Fig. 1), where temperature of the test piece was measured in course of its solidification and melting.

A metallic moulds to production of standard test pieces according to the PN-88/H-88002-2 standard were poured with the modified alloy. Obtained test pieces from the investigated alloy underwent treatments of solutioning and ageing.

Temperatures of these treatments were selected on base of values of recorded points from the ATD method melting curves (Fig. 2).

In the Table 1 are shown parameters of the heat treatments for the tristage plan of investigations with four variables.

Measurement of the hardness with use of Brinell method was accomplished according to the PN-75/H04350 standard, using the Brinell type PRL 82 hardness tester, with 10
mm dia steel ball under load of 9800 N sustained during 30 seconds.

Table. 1. Parameters of the heat treatment of the alloy

<table>
<thead>
<tr>
<th>Solutioning temperature</th>
<th>Solutioning duration</th>
<th>Ageing temperature</th>
<th>Ageing duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>$t_p$ [°C]</td>
<td>$\tau_p$ [h]</td>
<td>$t_s$ [°C]</td>
<td>$\tau_s$ [h]</td>
</tr>
<tr>
<td>$t_{p1}$ - 180</td>
<td>0,5</td>
<td>$t_{s1}$ - 525</td>
<td>0,5</td>
</tr>
<tr>
<td>$t_{p2}$ - 250</td>
<td>1,5</td>
<td>$t_{s2}$ - 540</td>
<td>1,5</td>
</tr>
<tr>
<td>$t_{p3}$ - 330</td>
<td>3</td>
<td>$t_{s3}$ - 555</td>
<td>3</td>
</tr>
</tbody>
</table>

3. Description of obtained results

Hardness (HB) of the refined and modified (without heat treatment) alloy amounted from 73,5 to 89. After performed heat treatment, the hardness (HB) of the investigated alloy amounted from 59 to 110 (Fig. 3).

In the Figs. 4-6 is shown an effect of temperatures and duration of solutioning and ageing heat treatments on hardness of the investigated alloy.

One can notice a distinct drop of the hardness in case of solutioning heat treatment temperature of 330 °C.

![Fig. 3. Comparison of obtained values of the HB hardness](image)

Fig. 3. Comparison of obtained values of the HB hardness

![Fig. 4. Effect of heat treatment parameters on hardness of the alloy for temperature of solutioning heat treatment of 525 °C](image)

Fig. 4. Effect of heat treatment parameters on hardness of the alloy for temperature of solutioning heat treatment of 525 °C

![Fig. 5. Effect of heat treatment parameters on hardness of the alloy for temperature of solutioning heat treatment of 540 °C](image)

Fig. 5. Effect of heat treatment parameters on hardness of the alloy for temperature of solutioning heat treatment of 540 °C

![Fig. 6. Effect of heat treatment parameters on hardness of the alloy for temperature of solutioning heat treatment of 555 °C](image)

Fig. 6. Effect of heat treatment parameters on hardness of the alloy for temperature of solutioning heat treatment of 555 °C

4. Conclusions

On base of the obtained test results it can be ascertained that heat treatment of the EN AC-AlSi12Cu2Fe alloy effects in growth of its hardness solely in case when selection of suitable parameters of solutioning and ageing heat treatments was performed.

The highest hardness (HB), which amounted to 110 was obtained for the following parameters:

- a) solutioning temperature - 555 °C,
- b) solutioning temperature - 3 hours,
- c) ageing temperature - 180 °C
- d) ageing duration - 3 hours.

Growth of the ageing temperature (above 250 °C) and duration of the ageing (above 1,5 h) results in reduction of alloy’s hardness.

Acknowledgements
This paper has been written as a result of the research work conducted under Research Project No. 16/I/GW/2008 financed by University of Bielsko-Biała.

References