

Effect of T6 Treatment Parameters of AlZn10Si7MgCu Alloy on Change of its Hardness and Impact Strength

J. Pezda

Faculty of Chipless Forming Technology, University of Bielsko-Biala, Willowa 2, 43-309 Bielsko-Biala, Poland
Corresponding author. E-mail address: jpezda@ath.bielsko.pl

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Abstract

Among alloys of non-ferrous metals, aluminum alloys have found the widest application in foundry industry as a competitive alternative of ferroalloys. One from methods to improve mechanical properties of aluminum alloys is a heat treatment consisting in heating a material to solutioning temperature, keeping the material in such temperature, and subsequent rapid cooling and natural or artificial ageing. In the paper are presented test results concerning effects of the T6 heat treatment, comprising solutioning and artificial ageing, on hardness and impact strength of the AlZn10Si7MgCu alloy poured into metal moulds. Temperature ranges of solutioning and ageing treatments were selected on the base of recorded curves from the ATD method. Basing on three-stage plan of the investigations with four variables one determined range of the heat treatment parameters, what is a condition of obtainment of required HB hardness of the investigated alloy. Further investigations shall concern correction of obtained results with respect to the HB hardness and impact strength, obtained for selected castings of machinery components.

Keywords: Aluminum alloy, ATD, Hardness

1. Introduction

Aluminum alloys find their application in machinery industry, automotive and aviation industries, due to low specific gravity and good strength properties. Excellent castability, machinability and abrasion resistance of casting alloys of aluminum bring about their broad application as a material for poured components, mainly in automotive industry.

Direct effect on structure and mechanical properties of aluminum alloys have: preparation process of the alloy (melting), founding technology, structure of a casting and mould, solidification rate, and possible heat treatment.

Alloys from the Al-Zn-Si group (e.g. AlZn15Si8 alloy), in spite of their advantages like good pouring properties, increased mechanical properties without heat treatment (alloys with 10-14% contents of Zn), reduced capacity to mechanical sparking, are applied rather seldom [1,2].

Alloys on base of the Al-Zn feature excellent corrosion resistance owing to presence of aluminum, what enhances resistance of the zinc being the main alloying component of these alloys. It enables their application both as a castings for engine and vehicle constructions, hydraulic units and mould making without the need of heat treatment, because this alloy is self-hardening (UNIFONT® - 90) [3] or as anticorrosion layers [4-6]. Mechanical properties of the Al-Si and Al-Zn-Si depend, besides

contents of Si, Zn, Mg and Fe, more on distribution and shape of silicon particles [1,7-8].

The presence of additional elements in the Al-Zn-Si alloys allows many complex intermetallic phases of which may have different morphology and configuration [9].

The T6 heat treatment produces maximum strength (hardness) in aluminum alloys. Unfortunately it requires a relatively long time to be carried out, and therefore has significant financial implications [10].

Objective of the performed investigations was determination of an effect of the T6 heat treatment parameters (temperature and time of solutioning and ageing treatments) on HB hardness and impact strength of the investigated alloy in aspect of possibility of optimization of the process in area of limitation of individual treatments duration.

2. Metodology of the research

To the investigations one used synthetic AlZn10Si7MgCu alloy, which was melted in electric resistance furnace and refined with Rafal 1 preparation in quantity of 0,2% of mass of charge, in temperature 720 °C

Chemical composition of the investigated alloy is presented in the Table 1.

Table 1.

Chemical composition of the investigated alloy

Chemical composition / mass %							
Si	Cu	Zn	Fe	Mg	Mn	Ni	Al
5,8	0,93	9,8	1,0	0,8	0,2	0,5	rest

Analysis of chemical composition was performed with use of spectrometry method (emission spectrometer with glow-discharge excitation of GDS 850A type).

Specimens to the strength tests were poured in metal mould heated to temperature 250 °C.

In the Figure 1 are presented curves of heating (melting) and crystallization of the alloy, recorded with use of ATD method for the investigated alloy.

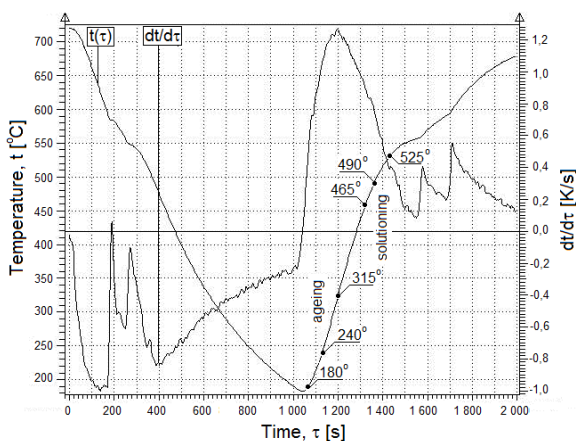


Fig. 1. Curves from ATD method for the AlZn10Si7MgCu alloy

Process of solidification and melting of the alloy (ATD method) was recorded with use of fully automatic Crystaldimat analyzer.

Poured specimens undergo dispersion hardening with heating of the alloy near solidus line. The treatment consisted in heating of poured specimens to temperature of the solutioning (465, 490, 525 °C), holding the specimens in such temperature (30, 60, 120 minutes), and subsequent cooling down in cold water (20°C), and next, artificial ageing in temperatures 180, 240, 315 °C during 60, 180 and 300 minute periods of time.

Temperature ranges of the solutioning and ageing treatments were selected on the base of analysis of recorded curves from the ATD method. The ATD method has been used to recording of crystallization of metals and alloys for many years, both in research projects and in quality control of alloys within industry [11-14]. After performed heat treatment one carried out measurements of the hardness with use of Brinell method according to PN-75/H04350 standard, using the Brinell hardness tester of the PRL 82 type, steel ball with 10 mm diameter and 9800 N load sustained for 30 seconds.

Impact strength of the alloy was determined on the base of simplified impact test [15] with cylindrical bar test pieces (Fig. 2) having annular notch, which underwent bending impact test on the Charpy pendulum machine. This method can be characterized by more easy and more economic production of the test piece.

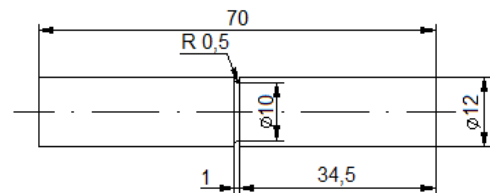


Fig. 2. Test piece to impact strength test

3. Description of obtained results

3.1. The HB Hardness

Hardness of the raw alloy without heat treatment amounted to 103 - 107 HB 10/1000/30. Hardness of the alloy after the T6 heat treatment was included within range from 65 to 127 HB 10/1000/30.

The highest hardness amounted to 127 HB 10/1000/30, was obtained in case of the system No. 13 (Fig. 3) for:

- solutioning temperature 490 °C,
- solutioning time 60 minutes,
- ageing temperature 180 °C,
- ageing time 180 minutes.

In case of the system No. 25 (Fig. 3) one obtained the hardness 126 HB 10/1000/30 for solutioning temperature 525 °C, solutioning time 120 minutes, ageing temperature 180°C and ageing time 300 minutes.

The lowest hardness after performed heat treatment of the investigated alloy was obtained for the systems No. 6 and No. 27 (60 HB 10/1000/30), what resulted, comparing to the test pieces without the heat treatment, in reduction of the hardness of the alloy with about 40 HB 10/1000/30.

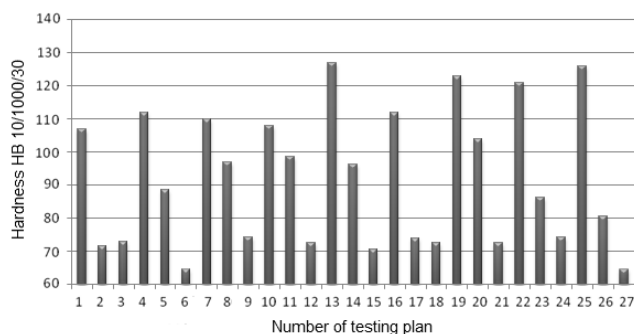


Fig. 3. The hardness HB 10/1000/30 of the investigated alloy for individual systems of the investigation plan

In the Fig. 4 is presented an effect of T6 heat treatment parameters on the HB hardness of the investigated alloy.

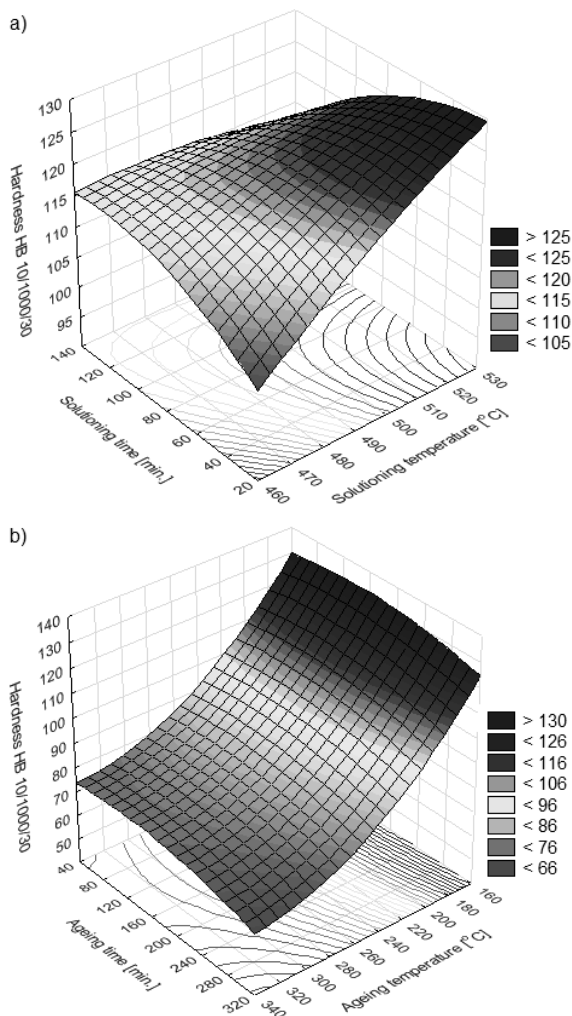


Fig. 4. Effect of the heat treatment parameters on the HB hardness for: a) solutioning (ageing - 180 °C, 180 minutes), b) ageing (solutioning - 490 °C, 60 minutes)

On the base of performed investigations one determined the most advantageous parameters of dispersion hardening in aspects of improvement of the hardness HB 10/1000/30 for the investigated alloy. Obtainment of the highest hardness of the AlZn10Si7MgCu alloy is conditioned by implementation of the following parameters of the T6 heat treatment T6:

- solutioning temperature 490-525 °C
- ageing temperature 180 °C,
- solutioning time 60-120 minutes,
- ageing time - 60-180 minutes.

3.2. The impact strength

Impact strength of the initial alloy (without heat treatment) amounted to from 1,7 to 2,4 J/cm². After performed T6 heat treatment, the impact strength amounted to from 2,6 to 6,8 J/cm².

Maximal value of the impact strength amounting to 6,8 J/cm² after the heat treatment was obtained for the system No. 9 (Fig. 5) for:

- solutioning temperature 465 °C,
- solutioning time 120 minutes,
- ageing temperature 315 °C,
- ageing time 300 minutes.

In case of the system No. 23 (Fig. 5), the impact strength amounted to 6,0 J/cm² for the following parameters: solutioning temperature 525°C, solutioning time 60 minutes, ageing temperature 240°C, ageing time 300 minutes. Similar impact strength was obtained for the systems No. 18, No. 21, and No. 24 (Fig. 5).

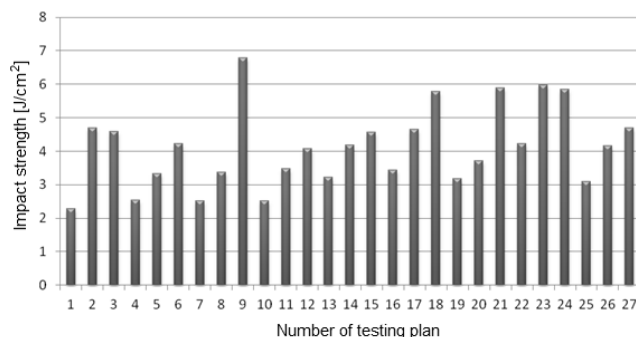


Fig. 5. The impact strength of the investigated alloy for individual systems of the investigation plan

The lowest impact strength after the heat treatment with accelerated artificial ageing was obtained for the system No. 1 (2,3 J/cm²) for solutioning temperature 465 °C, solutioning time 30 minutes, ageing temperature 180 °C and ageing time 60 minutes.

Growth of the impact strength of the investigated alloy is connected drop of its hardness. On the base of performed investigations it can be ascertained that the most advantageous parameters of dispersion hardening, which condition obtainment of maximal impact strength of the AlZn10Si7MgCu alloy in aspect of improvement of its impact strength, are as follows:

- solutioning temperature 490-525 °C,
- ageing temperature 240-315 °C,

- c) solutioning time 60-120 minutes,
- d) ageing time 180-300 minutes.

In the Fig. 6 is presented an effect of temperature and duration of the solutioning on the impact strength of the investigated alloy.

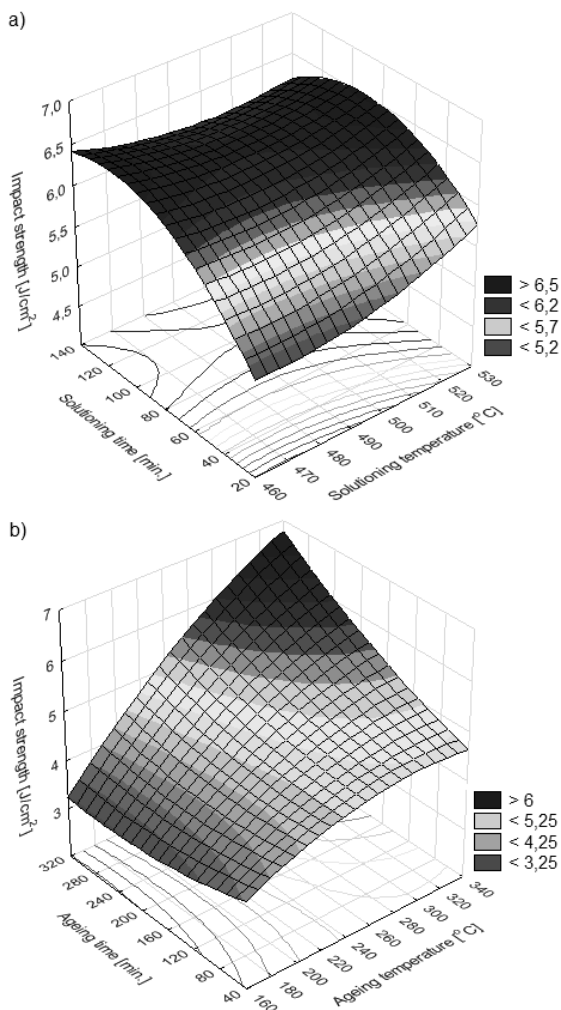


Fig. 6. Effect of heat treatment parameters on the impact strength for: a) solutioning (ageing - 315 °C, 300 minutes), b) ageing (solutioning - 490 °C, 60 minutes)

4. Conclusions

Performed T6 heat treatment affects on change of the hardness and impact strength of the AlZn10Si7MgCu alloy.

High ageing temperature (above 240 °C) and longer time of the ageing (180-300 minutes) affect on growth of the impact strength of the alloy, and thereby result in drop of its hardness, having the maximal values in case of low ageing temperatures (180 °C).

Selection of a suitable temperatures and times of solutioning and ageing treatments is a condition of obtainment of

improvement of the hardness and impact strength of the AlZn10Si7Mg alloy.

Further investigations should concern verification of obtained results for selected castings of machinery parts, produced from the investigated alloy and subjected to the heat treatment, in aspect of a possibility of forecasting of mechanical properties, based on temperature and time of solutioning and ageing heat treatments.

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