STUDIES CONCERNING THE POSSIBILITY OF HARDENING THROUGH THERMIC ISOTHERMAL TREATMENT OF THE CASTING ALLOYS OF ALUMINUM

Maria STOICĂNESCU
Transilvania University of Brasov, Romania

Abstract. The studies undertaken have the objective of proving the property of a hardening aluminum alloys through warm oil-quenching. Maintaining in the stair of the temperature intermediary between one of heating and one environment he had the same influence with the one the ageing realized after accustomed hardening. In this kind there are coupled two distinct operations of thermal treatment in only one.

Keywords: heat treatment, aluminum alloys

1. Introduction

The aluminum alloys of casting, ally with Mg and Cu can be hardened through thermal treatment. Hardening with ageing is less important in the case of aluminum alloys for casting than in the case of the deformable alloys, but sometimes is needed to remove certain deficiencies practically. The ultimate treatment for the aluminum alloys for casting consists in the hardening and the ageing [4, 5].

The hardening heating is done afloat from the temperature of 520 - 540 °C, and artificial ageing is done at temperatures at 170 - 190 °C with duration of sustentation of some hours [1]. The aim of the researches do is the object girlish were, use of an alternative to the thermal usual treatment, treatment which to lead to same results as in the classic case, but with possible shorten the thermal cycle.

Thus, purposely the coupling of the two operations (hardening and the ageing) in only one, the treatment is realised only heating. From the temperature of heating in the hardening sight it proposed quick refrigeration below the curve of capable solid solubility copper and or magnesium, practice 170 - 190 °C. This the temperature which corresponds and the used aisle to the ageing artificial accustomed. After a period of maintaining of 0.5 - 2 hours, cooled continued air.

Considered as temporally maintaining isotherms below the curve of solubility, from basic solid eliminated a part from the atoms cuprous and or magnesium to the limit of solubility solution solid, corresponding to the temperature of maintaining. The atoms, thus taken up from matrix can form zones Guinier–Preston or coherent phases θ^{I} and θ^{II}. Through appearance massively solid these solution "anomalies" is produced the cold hardening crystalline meshes the default and, increases the hardness [2, 3, and 5].

2. Experimental procedure

These they are accomplished about of a alloys Al-Si-Cu, having chemical composition from the Table 1. Excepting the alloy 1, the others were elaborated special for these experimentations.

Table 1. Chemical composition

Alloy no.	Mark alloy	Chemical composition [%]					
		Si	Fe	Cu	Mn	Mg	Al
1.	AlSi5Cu1	4.87	0.66	1.11	0.50	0.72	remnant
2.	AlSi5Cu2	4.8	0.62	2.15	0.48	0.69	remnant
3.	AlSi5Cu3	4.72	0.59	3.01	0.43	0.66	remnant
4.	AlSi5Cu4	4.7	0.58	4.10	0.40	0.65	remnant

The samples from these alloys were submissive the common thermal treatment with the results presented in the Table 2.

The results presented in the Table 2 constituted the values of references in report with the one obtained through the suggested method. To this after heating maintaining of the temperature of regime applied heating (one as in case of were) a quick refrigeration to 170 °C. To the step temperature they achieved maintaining with different durations then cooled air to the temperature the environment. The results parameters obtained is presented in the Table 3. Cooling from 510 °C to 170 °C and maintaining afterwards he did in oil hot and maintained to this

temperature of 170°C. The accuracy of maintaining was of 3 °C. Comparing the results obtained after the suggested method with one of the classical method consisted the same values or just superior, such according as shown and in the diagrams presented in the figures 1 and 2.

Table 2. Heat treatment

Alloy no.	Quenching			Ageing at 170°C			
	Temp [°C]	Agent	Hardness [HB]	Natural [HB]	Artificial		
					Temp [°C]	Time [h]	Hardness [HB]
1.	510	Water	72	95	170	1h	102
2.	510	Water	64	115	170	1h	106
3.	510	Water	69	112	170	1h	109
4.	510	Water	65	105	170	1h	111

Table 3. The parameters results

Alloy no.	Quenching		Temp. step [°]	Hardness [HB] after different maintaining periods		
	Temp. [°]	Maintain [h]		0.5h	1h	2h
1.	510	0.5	170	75	97	96
2.	510	0.5	170	79	118	95
3.	510	0.5	170	74	113	101
4.	510	0.5	170	72	102	90

Heating in the sight of hardening done at 510 °C realizes the dissolution of soluble phases of the obtaining of solutions of the solid enriching in copper and or magnesium. High cooling speed below the curve of capable solid solubility drives to transforming the solution solid in balanced state to a solid solution saturated [6]. The maintaining at the temperature superior makes, the atoms have a high mobility, what causes to is possible in a certain measure to elimination of the excess copper (and magnesium) [4]. As it is shown from this process result zones Guinier–Preston and afterwards the coherent phases θ^{I} and θ^{II} [2]. The extension of the duration of sustentation the isotherm to 170 °C, he can facilitate these precipitation phases, facts suggested and of lowering hardness to over of the duration of the precinct a hour.

From the research of the structures consisted same appearances as the and in the case of thermal usual treatment, respectively a table of solid solution of color alba and hurried phases (CuAl2) insoluble of heating the color closed, as in the Figures 3, 4, 5 and 6 for the alloy 1 and respective 7 and 8 for the alloy 3.

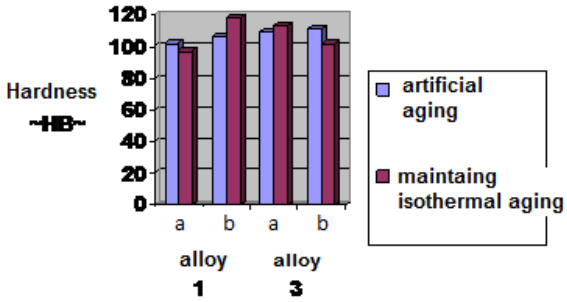

Figure 1. The obtained hardness after the classic method (a) - and one suggested (b) after a hour of sustentation, for the studious alloys

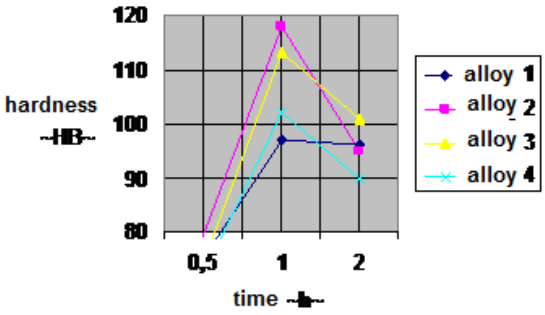

Figure 2. Development of hardness depends on lingering of sustentation the isotherm for the alloys 1, 2, 3 and 4

3. Conclusions

The experimental realized attempts, as and the practical results obtained can confirm the following:

- Hardening through thermal treatment of the alloys of aluminum of casting with content of copper-bearing is possible;
- Hardening is only that less intense than to the alloys deformable;
- The thermal isothermal treatment assures the curtailment of the time and saving of the energy;
- The heat isothermal treatment have practical results alike superior as against the classic method;
- The extension of the duration maintaining the temperature of step 170 °C across of value can

have as the effect increase of the hardness and resistance the mechanical;

Figure 3. Alloy 1 after usual thermal treatment, of hardening to 510 °C and the artificial ageing at 170 °C, with maintaining of 1 the hour. Attack HF, 200:1

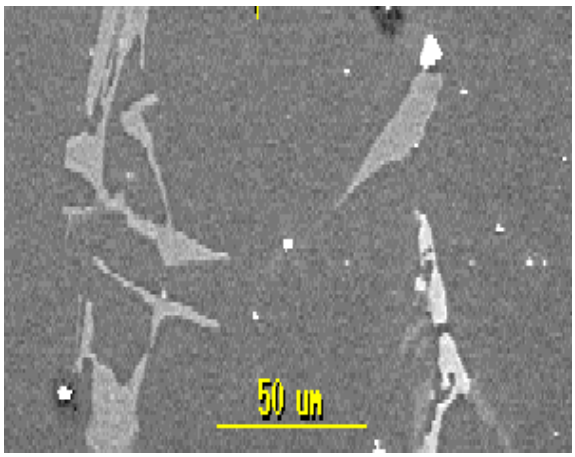

Figure 4. SEM structure for alloy 1 after usual thermal treatment, of hardening to 510 °C and the artificial ageing at 170 °C, with maintaining of 1 the hour. Attack HF

- The optimum time of maintaining the case studied is of the a hour, but he can be rigorous ascertainable through attempts in concrete cases;
- The presence of copper in the alloy composition of the aluminum casting induces to the effect of increasing the hardness through of the formed chemical compounds (compounds of the type Al-Cu);

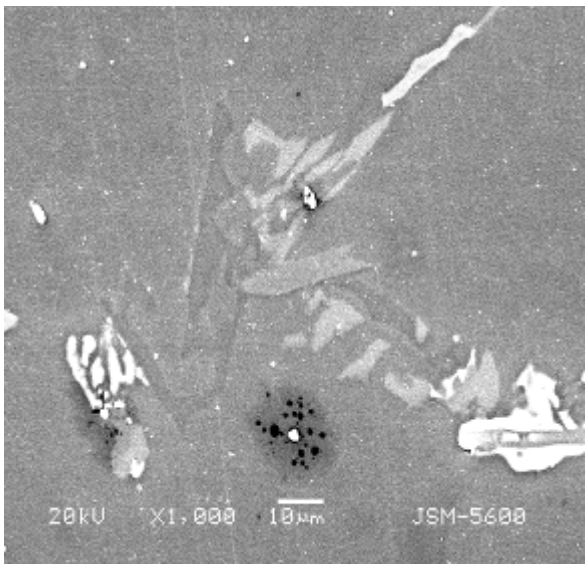

Figure 5. SEM structure for alloy 1 after usual thermal treatment, of hardening to 510 °C and the artificial ageing at 170 °C, with maintaining of 1 the hour. Attack HF

Figure 6. Alloy 1 after thermal isothermal treatment, with sustentation at 170 °C, with maintaining of 1 the hour. Attack HF, 200:1

- The hardening phases are zones Guinier–Preston or coherent phases θ^{I} and θ^{II};
- With strengtheners same effect as it had Mn and Mg for aluminum alloy for casting;

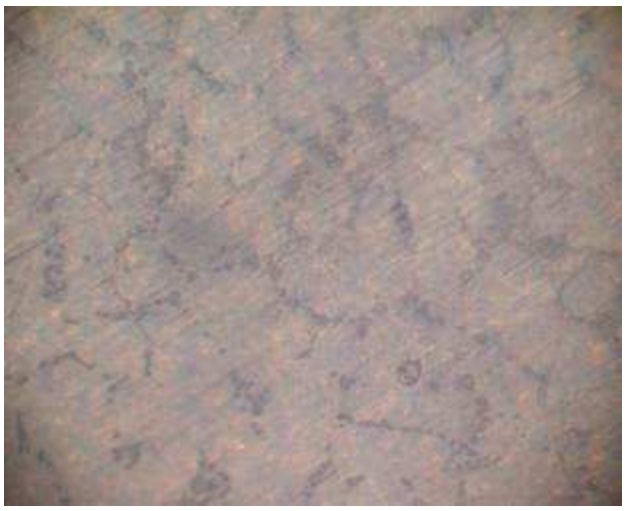

Figure 7. Alloy 3 after thermal usual treatment, of hardening to 510 °C and the artificial ageing at 170 °C, with maintaining of 1 the hour. Attack HF, 200:1

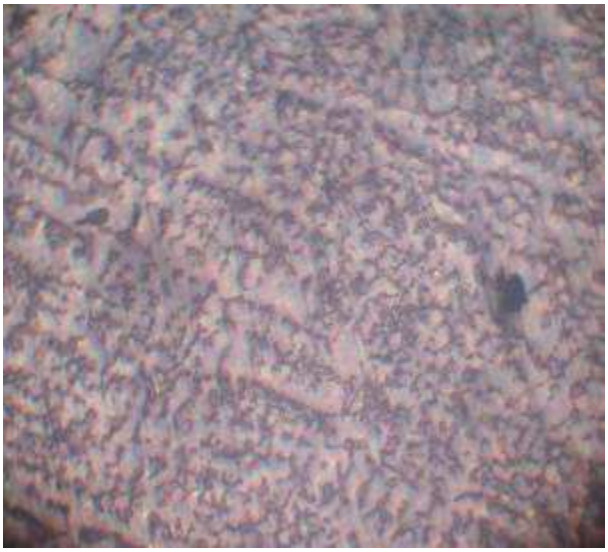

Figure 8. Alloy 3 after thermal isothermal treatment, with sustentation at 170 °C, with maintaining of 1 the hour. Attack HF, 200:1

- Concluded the usual thermal treatment, with natural or artificial ageing, the best results of hardness obtained to the alloy 3; this has and eldest content in copper and magnesium, carry call forth soluble phases, which provide the hardness;
- For the alloys taken under consideration, the optimal time of maintain in the sight of hardening is of 1h.

References

1. Stoicănescu, M., Giacomelli, I., Florea, R. (2001) *The influence of the magnetic field in the solidification of aluminum alloys of the results of subsequent heat treatment.* Procedings BRAMAT, vol. II, p. 285
2. Stoicănescu, M., Giacomelli, I. (2002) *The influence of the magnetic field on the structure of cast aluminum alloys*. Bulletin of the Polytechnic Institute of Iasi, Romania, ISSN 1011-2855, TOM XLVIII(LII), FASC. 3-4, p. 193
3. Stoicănescu, M., Giacomelli, I. (2001) *Influenţa tratamentului termomagnetic asupra proprietăţilor aliajelor de aluminiu plasticizabile şi de turnare* (*The influence of the properties of the thermomagnetic field for the aluminum alloys of casting*). Revista de turnătorie (Romanian foundry journal), ISSN 1224-2144, no. 4, p. 7 (in Romanian)
4. Koch, C.C. (2000) *Experimental evidence for magnetic or electric field effects on phase transformation*. Materials Science and Engineering: A, Vol. 287, Issue 2, p. 213-218, DOI: 10.1016/ S0921-5093(00)00778-4
5. Conrad, H. (2000) *Influence of an electric or magnetic field on the liquid – solid transformation in materials and on the microstructure of the solid*. Materials Science and Engineering: A, Vol. 287, Issue 2, p. 205-212, DOI: 10.1016/S0921-5093(00)00777-2
6. Al Kahtani, S.A., Doty, H.W., Samuel, F.H. (2014) *Combined effect of melt thermal treatment and solution heat treatment on eutectic Si particle in cast Al-Si alloys*. International Journal of Cast Metals Research, ISSN 1364-0461, vol. 27, no. 1, p 38-48, DOI: http://dx.doi.org/10.1179/ 1743133613Y.0000000077

Received in October 2014