THE INFLUENCE OF CONDITIONS OF THE HEAT TREATMENT OF ALUMINUM ALLOYS

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Abstract

Work was followed in determining the optimum parameters of heat treatment of deformable aluminum alloy, regarding both the hardening and aging. The tests were performed on two brands of deformable alloys, both after the usual process and electromagnetic field.

Keywords: Aluminium alloys, heat treatment

Introduction

The variant or the optimum variants can be obtained by correct joining of the chemical composition with the parameters' values of thermic treatments and supplementary by utilization of some factors of process stimulation at the crystalline net level (Koch, 2000, Porter, 1992, Zuo, 2014, Liu, 2013, Chen, 2012). The experimentations were accomplished on two alloys apt to hardenings through thermic treatment, presented in the table 1. The alloys are in accordance with Standard EN 574-2/5/515.

Table. 1: Chemical composition

No	Alloy brand	Chemical composition, in %							
		Cu	Mn	Mg	Cr	Ti	Si	Fe	Al
1	$AlCu_4Mg_{1,5}Mn$ (denoted alloy1 in paper)	4,02	0,541	1,28	0,027	0,0025	0,267	0,481	rest
2	AlCuMgMn (denoted alloy 2 in paper)	3,97	0,628	0,572	0,037	0,0072	0,333	0,476	rest

The samples from these alloys were subjected to the thermic treatment of hardening and aging, after different variants. The dimension for the samples is ϕ 25 x 15mm. For all these variants, from the temperature of heating in the sight of hardening the samples were cooled in water, after a period of maintaining of one hour. Aging was accomplished in oil bath heated and maintained to 170 C, the maintaining at artificial aging was of 1, 5 hours, and at the natural one of 7 days (Stoicanescu, 2001).

Attempts and experimental results

In the sight of hardening there were selected temperatures of 500, 510, 520 and 530° C, and the ultimate hardness, expressed in Brinell units, are presented in the table 2 (Stoicanescu, 2001, Stoicanescu, 2005) and the diagrams from figures 1 and 2.

Table 2: Heat treatments and hardness

No	Type of the heat treatment	Type of the alloy	Hardening temperature, °C			
			500	510	520	530
			Hardness [HB]			
1	Hardening + natural aging	1	117	119	98	106
2		2	116	118	92	102
3	Hardening + normal artificial aging (170°C, 1,5h)	1	112	120	113	102
4		2	102	108	103	102

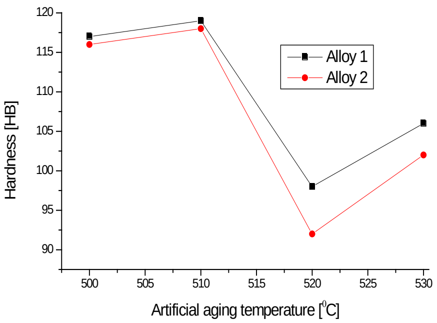

Fig.1. The Brinell hardness obtained after hardening from different temperatures of 500° C, 510° C, 520° C, 530° C and natural aging.

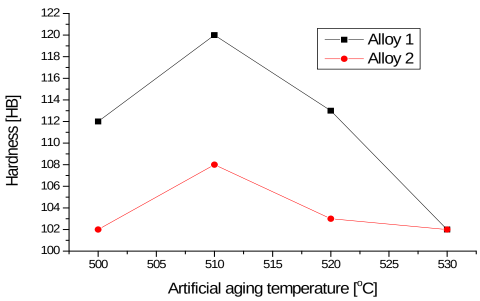

Fig.2. The hardness obtained after hardening in water and artificial aging at 170° C, for the alloys 1 and 2 .

Besides testing the influence of temperature from which is done the hardening there have been also studied the effects of an external field energy at the same time with the artificial aging at 170° C and the duration of 1, 5 hours and the hardness, expressed in Brinell units. The results of experimentations are presented below in the form of table (3) (Stoicanescu, 2005) and charts (fig.3, 4).

Table 3 Heat treatments and hardness [HB]

No	Type of the heat treatment	Type of the alloy	Hardening temperature, °C			
			500	510	520	530
1	Hardening + artificial aging in alternating electromagnetic field	1	126	128	110	106
2		2	124	122	113	109

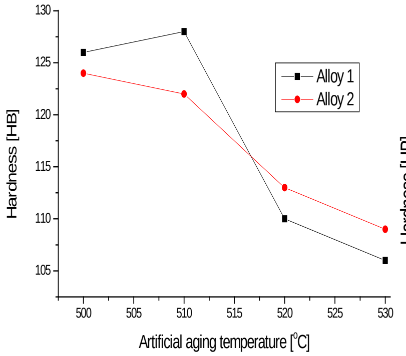

Fig.3. The obtained results after hardening (from alloy1 and 2) from different temperatures and artificial aging in alternative electromagnetic field;

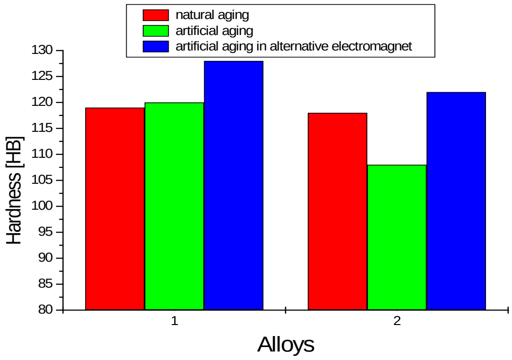

Fig. 4. The comparative results of thermic treatment after many variants of agening: a- obtained aging; b- obtained artificial agings, c- artificial agings in alternative electromagnetic fields

In figures 5 and 8 are shown the structures after various states of treatment.

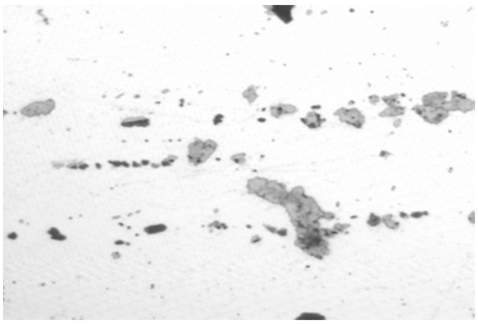

Fig.5. Alloy AlCuMg1, 5Mn after hardening and usual artificial aging. Attack: 10% H_3PO_4. 1000:1

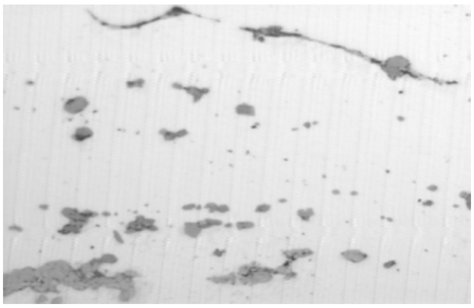

Fig.6. Alloy AlCuMg1, 5Mn after hardening and natural aging. Attack: 10% H_3PO_4. 1000:1

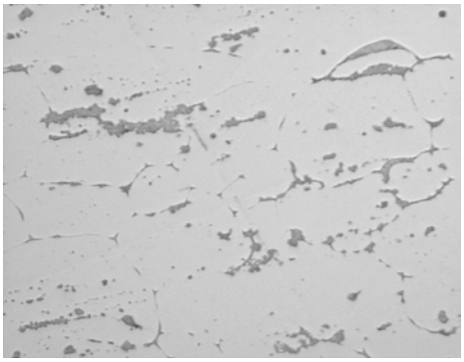

Fig. 7. Alloy AlCu4Mg1, 5Mn after hardening at 510°C and artificial aging in electromagnetic field. Attack: 10% H_3PO_4. 1000:1

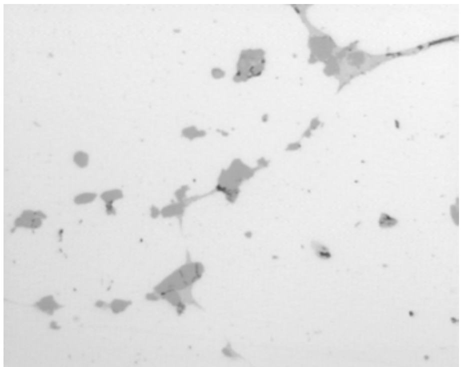

Fig. 8. Alloy AlCu4Mg1, 5Mn after hardening at 510°C and artificial aging in electromagnetic field. Attack: 10% H_3PO_4. 1000:1

It is found that after hardening the quantity of precipitated phase is decreasing. It is about the soluble compounds (Al_2Cu, Al_2CuMg, Al_3Mg_2, Al_6Mn, Al_6Mg_4.etc) which contribute to hardening in the aging process.

After artificial aging are formed the coherent phase types θ^{I} and θ^{II} which, by tensioning the crystalline network, allow cold hardening and therefore increase its hardness.

The used magnetic field had the next parameters:

- frequeny: 50 Hz;
- the magnetic flux : 9, 6 $\cdot 10^{-4}$ Wb.

As in the previous cases, the duration of maintaining at artificial aging was of 1, 5 hours. It is observed that, in the case of electro-magnetic field utilization, the samples hardened in water from 510°C had the best results; at the same time, in all cases, the external field energy has conducted to hardness improve compared to the normal procedure, at overlapping the electromagnetic field. In order to emphasize the efficiencies of the variants of heat treatments, in figure 4 are comparatively presented the results of the heat treatment applied after the studied variants. Therefore it has been chosen the temperature of hardening with the best results, namely of 510° C.

Conclusion

From the experimental studies effectuated in the present work there can be emphasized the following:

- for the alloys taken into consideration, the optimum temperature of heating in the sight of hardening is of 510°C;

- after the usual heat treatment, with natural or artificial aging, the best results of hardness were obtained to alloy 1; this also has the biggest content in copper and magnesium, which make soluble phases appear, which facilitates the hardning;

- overlapping the electro-magnetic field across the thermic one from artificial aging has profitable effects on the process of hardening; we consider that the supplementary contribution of energy from the crystalline net level conduces to the stimulation of the diffusion process, the one which challenges the cold hardening of the crystalline net through the formation of Guinier Preston zones and /or the phases θ^{I} and θ^{II} ;

- passing over the optimum temperature of heating in the sight of hardening compromises the results of the heat treatment in all the variants.

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