STUDY ON THE INFLUENCE OF TREATMENT PARAMETERS ON THE HARDNESS OF 6XXX SERIES ALUMINIUM ALLOYS

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DOI: 10.19062/1842-9238.2023.21.1.7

Abstract: *The appropriate application of heat treatments results in structural changes in alloys, and such changes enable the improvement of strength, hardness, ductility and other mechanical characteristics. This paper is mainly aimed at studying and analysing the influence of the quenching temperature and of the ageing holding time on the hardness of 6xxx series aluminium alloys. The thermal processes and parameters involved in the heat treatment of this alloy are studied, such as quenching and ageing, and the manner in which these treatments influence the properties of the resulting materials will be investigated.*

Keywords: *6xxx series Al alloys; heat treatment; microstructure*

1. INTRODUCTION

Aluminium alloys are becoming a more prominent area of research and development in modern industry [1]. Due to their outstanding properties, such as corrosion resistance, ease of processing and low density, aluminium alloys are used in a wide range of industrial applications [2,3]. From the aeronautical and automotive industries to construction and packaging, aluminium alloys offer innovative and economical technical solutions. 6xxx series aluminium alloys are known for their excellent mechanical strength and corrosion resistance properties [4,5,6]. The heat treatment of these alloys is essential for obtaining the desired properties and for optimizing their performance.

2. EXPERIMENTAL RESEARCH

The material used in the experimental tests was 6082 series aluminium alloy.
The chemical composition for the material used is presented in table 1:

Table 1. Chemical composition

Si	Fe	Cu	Mn	Mg	Cr	Zn	Ni	Ti	Al
1,09	0,35	0,08	0,67	0,98	0,14	0,07	0,01	0,03	balance

The alloy en aw-6082 is a high strength alloy for highly loaded structural applications. Due to the fine grained structure this alloy exhibits a good resistance to dynamic loading conditions. En aw-6082 is certified for use in marine applications.

6082 series aluminium alloy samples were used for the study, and they were divided into 3 working variants - quenching temperatures and different ageing holding times.

Variant 1

For the first variant, the samples were heated to 530 °C, held for 30 minutes and cooled in water.

After quenching, the samples were aged at 177°C for different holding times, i.e. 30 minutes and 1 hour.

1. Sample 1 was aged at 177 °C, held at this temperature for 30 minutes and cooled in air.
2. Sample 2 was aged at 177 °C, held at this temperature for 1 hour and cooled in air.

Variant 2

For the second variant, the samples were heated for quenching to 540 °C and held at this temperature for 30 minutes, cooled in water, and artificially aged at 177°C for different holding times.

3. Sample 3 - aged at 177 °C, held for 30 minutes and cooled in air.
4. Sample 4 - aged at 177 °C, held for one hour and cooled in air.

For the third variant, the samples were heated for quenching to 550 °C and held at this temperature for 30 minutes, cooled in water, and artificially aged at 177°C for different holding times.

5. Sample 5 - aged at 177 °C, held for 30 minutes and cooled in air.
6. Sample 6 - aged at 177 °C, held for 1 hour and cooled in air.

After applying the treatment presented above, the hardness of each sample was measured and they were embedded in resin for microscopic analysis.

Table 2 shows the hardness values obtained.

Table 2 Treatment conditions and hardness values obtained

Sample	Heat treatment			Brinell Hardness	
	Quenching temperature [°C]	Ageing temperature [°C]	Holding time [h]	Footprint diameter	Hardness [HB]
1	530	177	0.5	1.10	62.4
2			1	1.08	64.9
3	540	177	0.5	0.97	81.3
4			1	0.93	112
5	550	177	0.5	1.03	71.7
6			1	0.98	79.5

An increase in hardness was obtained for the treatment carried out at a temperature of 540°C/30 min/water followed by ageing at 177°C, for both holding times, i.e. 30 minutes and 1 hour, cooled in air.

Table 1 shows the variation in hardness for the applied heat treatment variants. The hardness value recorded for Sample 4 is higher in relation to the rest of the parts.

Following the heat treatment, all samples were ground, polished and etched, after which they were studied under a microscope.

Figure 1 shows the metallographic structure after annealing (initial state), and a uniform distribution of the components as well as a high porosity can be observed. No inclusions were identified in the analysed samples.

FIG. 1 Metallographic structure after annealing (in the initial state). HF etching. 100X magnification

Figure 2 shows the metallographic structure obtained by quenching from 540 °C, holding for 30 minutes and cooling in water.

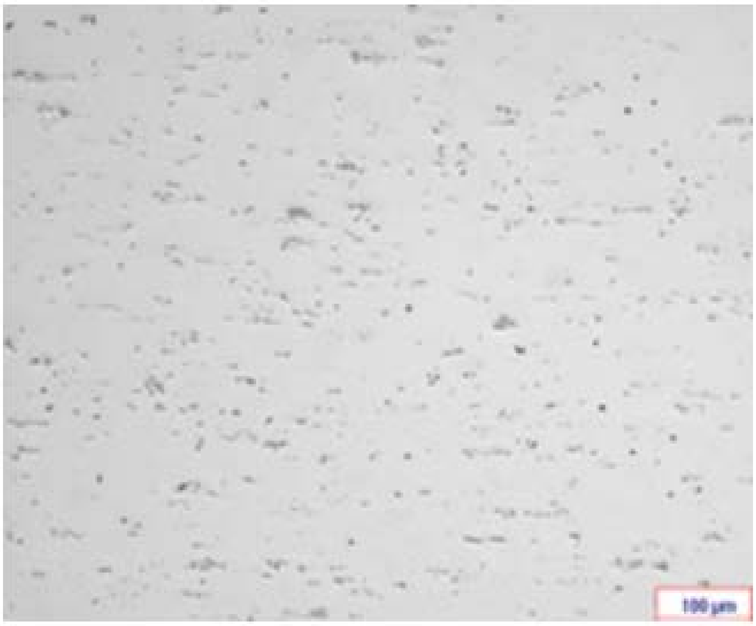

FIG. 2 Metallographic structure after quenching from 540 °C, holding for 30 minutes, cooling in water. HF etching. 100X magnification

Figure 3 shows the metallographic structure obtained by quenching from 550 °C, holding for 30 minutes and cooling in water.

FIG. 3 Metallographic structure after quenching from 550 °C, holding for 30 minutes and cooling in water. HF etching. 100X magnification

The figures above show the gas pores and the basic metallic mass.

Figures 4 and 5 show the metallographic structures after the quenching and ageing heat treatment offering the best hardness values.

FIG. 4 Metallographic structure after quenching at 540 °C, 30 minutes/water and ageing at 177 °C for 30 minutes HF etching. 100X magnification

FIG. 5 The metallographic structure after quenching at 540 °C, 1 h/water and ageing at 177 °C for one hour. HF etching. 100X magnification.

Fine dispersed precipitates of Mg2Si can be observed in the analysed structures.

CONCLUSIONS

The 530 °C heating temperature for quenching shows that it was not high enough and no ageing hardening occurred.

The samples treated according to the structures in Figures 4 and 5 show a substantial increase in hardness.

The heat treatments the structures of which are shown in figures 4 and 5 feature the highest hardness values from the range of analysed heat treatments.

The 550 °C temperature selected for quenching is reasonable considering the hardness results obtained after ageing.

In all cases, the increase of the holding time to one hour led to higher hardness values regardless of the heating temperature for quenching.

The hardening phase of these alloys is the -Mg2Si phase, which precipitates during cooling.

Very fine Mg2Si dispersed precipitates can be observed in the structures obtained.

No inclusions were identified in the analysed samples.

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