

Effect of Heat Treatment on Mechanical Properties of Al7075 AND Al-3.15 Cu-3.0 Zn-1.75 Mg Alloys

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ABSTRACT: In this investigation, the influence of heat treatment on mechanical properties of Al7075 (Alloy 1) and Al-3.15Cu-3.0Zn-1.75Mg (Alloy 2) alloys was studied. Both the as-cast and heat treated samples in each alloy were subjected to hardness measurements and tensile tests. The samples prepared were solution treated at 450°C for 2 hrs and then water quenched to obtain the super-saturated solid solution (SSS). After solutionizing the samples were undergone for aging process at various temperature and time period. Nearly 130HB hardness was obtained with solutionizing at 450°C for 2 hrs and aging at 120°C for 6 hrs in Al7075 alloy. In alloy 2 there was no significant increase in hardness value for various aging process. Tension test of Al7075 alloy specimen solutionizing at 450°C for 2 hrs and aging at 120°C for 8 hrs shown the increase in yield tensile strength value.

KEYWORDS: Al7075; Solutionizing; Yield strength.

1. INTRODUCTION

Al-Zn-Mg alloys are used extensively in aerospace industry due to their ultrahigh strength as well as their low density. These alloys have also the advantage of being readily weld able. Their properties can be obtained through control of the precipitation hardening process. Age hardening of aluminum alloys has been investigated in the past few years. Therefore, many researchers have been concentrated on the precipitation and on the related hardening of the alloys both from the experimental and theoretical viewpoint [1].

For the purpose of the alloy design, the relationship between fracture behavior and microstructure is a vital requirement. The objectives of the work are to investigate the effect of annealing and precipitation hardening (age hardening) heat treatment on the hardness and tensile strength of aluminum-zinc alloy.

II. EXPERIMENTAL PROCEDURE

2.1. Material preparation

The present investigation was carried out on 7075 Al alloy and Al-3.15Cu-3.0Zn-1.75Mg alloy (Alloy 2) whose chemical compositions are listed in the table 1 and table 2. The material was cast in the form of round cylindrical rods from both the alloys. The specimens were machined for both hardness test and tensile test as per standards.

2.2. Heat treatment

Two types of heat treatments were carried out namely annealing and precipitation hardening on sample machined from the castings. Annealing was carried out by heating the already machined, metallographic and hardness test piece samples to

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450 °C, soaking them at this temperature for 2 hours and then furnace cooled.

Precipitation hardening was carried out by first solution treated another set of machined, metallographic and hardness test piece samples at a temperature of 450 °C for 2 hours followed by rapid quenching in cold water.

These quenched samples were then subjected to a precipitation hardening treatment (age hardening) by heating them to 120°C, holding them at this temperature for 2, 4, 6 and 8 and 10 hours and then followed by air cooling to room temperature.

Another aging temperature was 180°C, holding at this temperature for same above mentioned time period. These two set of heat treatment was carried out for both the alloys.

2.3 Tensile testing

Tensile testing of all these specimens was conducted per British Standard BSEN 10002-1:1990. Three samples were tested for various heat-treated condition and as-cast samples

The tests were carried out at room temperature with a crosshead speed of 0.12 mm/min using a computerized Instron 3369 electromechanical testing machine. Load – displacement plots were obtained on an X-Y recorder and ultimate tensile strength and percentage elongation values were calculated from this load – displacement diagrams.

Table 1: Chemical Composition Al7075 alloy (1)

Elements	Composition%
Zn	3.0
Fe	0.24
Cu	3.15
Mn	0.031
Mg	1.75
Si	0.072
Cr	0.18
Ti	0.075
Al	Bal

2.4. Hardness test

The control and the heat treated samples were subjected to the Brinell hardness test using the Hounsfield extensometer in compression mode. The specimens were polished to 600 microns and mounted on the machine using a dwell time of 15 seconds. The diameter of the impression left by the ball was then measured using the Brinell calibrated hand lens and the corresponding Brinell hardness number was determined.

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Table 2: Chemical Composition Al-3.15 Cu-3.0 Zn-1.75 Mg

Alloy (2)

Elements	Composition %
Zn	6.8
FE	0.24
Cu	1.19
Mn	0.031
Mg	2.58
Si	0.072
Cr	0.18
Ti	0.075
Al	Bal

III. RESULTS AND DISCUSSIONS

Hardness and aged samples are tested and the results are plotted below and then compared as graph

Sample	Hardness Value, HB	Yield Strength (MPa)	Ultimate Tensile Strength (MPa)	Percentage Elongation
As-Cast	45	201	205	7.77
ST & Aging at 120°C for 2 hrs	109	601	601	19.6
ST & Aging at 120°C for 8 hrs	119	639	639	19.6
ST & Aging at 180°C for 2 hrs	109	548	548	16.6
ST & Aging at 180°C for 8 hrs	93	507	507	17.1

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Result of Mechanical properties for as-cast and heat treated Al7075 alloy samples

Samples	Hardness Value, H [Ⓜ]	Yield Strength (MPa)	Ultimate Tensile Strength (MPa)	Percentage Elongation
As-Cast	60	9.85	121	3.4
S.T. & Aging at 120°C for 2 hrs	65	12.21	205	1.11

Result of Mechanical properties for as-cast and heat treated Al-3.15Cu-3.0Zn-1.75Mg alloy (Alloy 2) samples

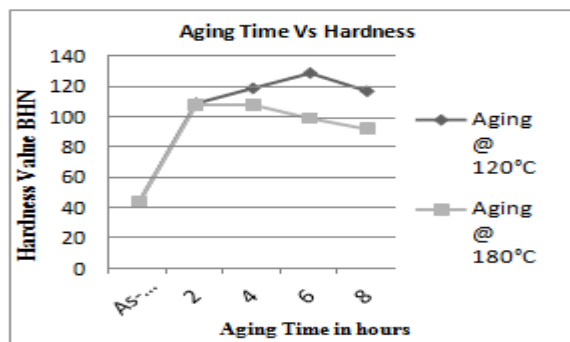


Figure 1: Hardness Vs Aging Time curve of Al 7075 alloy

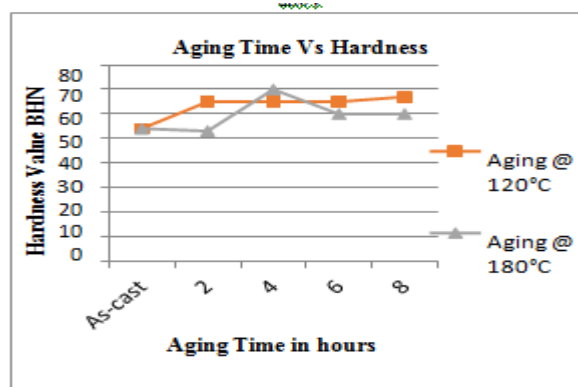


Figure 2: Hardness Vs Aging Time curve of Al-3.15Cu-3.0Zn-1.75Mg alloy

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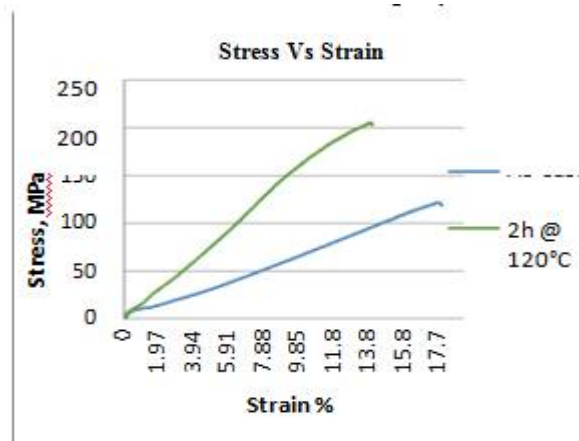


Figure 3: Stress Vs Strain curve of Al-3.15Cu-3.0Zn-1.75Mg alloy

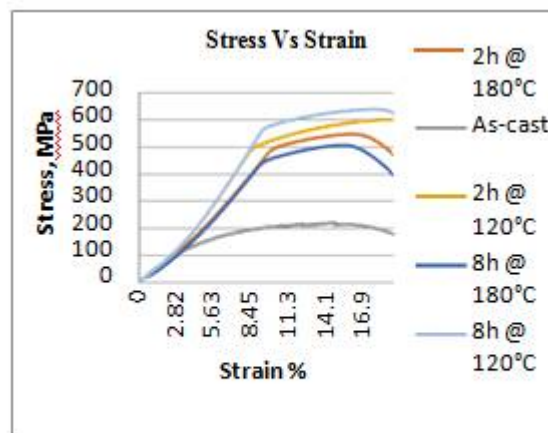


Figure 4: Stress Vs Strain curve of Al7075 alloy

IV. RESULTS

A study of the effect of solution heat treatment times of 2,4,6 and 8hours on the microstructure and hardness artificially aged at 450°C, A study of the effect of different quenching conditions on the microstructure and hardness artificially aged at 450°C, A study of the effect of different natural aging times on microstructure, hardness and impact properties of unmodified and modified coupons and impact test bars artificially aged for 2hours at 450°C, Grain refinement of aluminum alloys is by heterogeneous nucleation and growth of grains. These particles pin the grain boundaries during recrystallization and grain growth in commercial aluminum alloys.

Figure 2: Hardness Vs Aging Time curve of Al- 3.15Cu-3.0Zn-1.75Mg alloy

In this grain refinement the size of grain is modified with regarding to heat treatment temperature of 120°C and 180°C at different interval of time.

As a result of this research work, a new window of opportunities for the heat treatment of A7075 alloy has been opened. Currently, the T6 heat treatment of permanent mould A7075 alloy according to ASTM standard practices consists of:

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1. A solution heat treatment at 450°C for 2 to 8 hours,
2. A quench in water at 120°C and 180°C for 15 minutes,

V. CONCLUSION

From the results it can be concluded that the mechanical properties are improved drastically after heat treatment in Al7075 alloy as follows:

1. The hardness value increased from 45 HB to 130 HB after solutionizing the as-cast sample at 450°C for 2 hrs. and aged at 120°C for 6 hrs.
2. The ultimate strength value was also increased to 640 MPa from 222 MPa after solutionizing the as-cast sample at 450°C for 2 hrs. and aged at 120°C for 8 hrs.

In the case of Al-3.15Cu-3.0Zn-1.75Mg alloy (Alloy 2) there was no significant improvement in mechanical properties after solution treatment at 450°C for 2 hrs and aging treatment at maximum of 180°C for 8 hrs. Hence, the optimized aging temperature and time to achieve maximum mechanical properties are 120°C and 6 hours respectively. It is necessary to conduct aging treatment for Al-3.15Cu-3.0Zn-1.75Mg alloy (Alloy 2) at higher temperature and time to study the mechanical properties.

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