EFFECTS OF HEAT TREATMENTS ON THE MICROSTRUCTURE OF ALUMINUM ZINC ALLOY (Al-Zn)

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ABSTRACT

This study focused on the effect of heat treatment on the microstructure of Aluminum - Zinc Alloy. The method of casting employed WAs Sand casting, while annealing and quenching were subjected to heat treatment processes. The composition of the Aluminum Zinc alloy used was eighty percent of Aluminum and twenty percent of Zinc. It is concluded that heat treatment have effect on the microstructure of Aluminum - Zinc alloy and responded well to Oil quench. Oil quench Aluminium Zinc alloy (Al-Zn) is more appropriate for the production of Armored vehicle, Military bridge, Motorcycle frames and Bicycle frames and Air frames.

Keywords: *Aluminum-Zinc Alloy, Heat treatment, Microstructure, Tensile test, Hardness test, Annealing, Water quenching.*

INTRODUCTION

The extensive application of metals in the field of Engineering has necessitated the need for metal heat treatments in order to meet the taste of firm, industries and individual as a result of their wide engineering application. One of the major engineering fields where the application of various metals is prevalent is automobile engineering. In order to reduce motor vehicle weight, many automotive components have been redesigned to take advantage of materials such as lightweight and polymers. To this end aluminum casting alloys are being widely used for many automotive components (CAD, 2006), the alloys have good casting characteristics, reasonable mechanical properties, and are heat treatable (Melo, Rizzo and Santos, 2005).

Material science and engineering today has developed to a stage where correlations between microstructure, properties and application can be established for many commonly used alloys. The structure of a material is related to its composition, properties, processing history and performance (Argo and Gruziesk, 1988 and Rooy, 1993). And therefore, studying the microstructure of aluminum alloys provides information linking its composition and processing to its properties and performance interpretation of microstructure requires the understanding of the process by which various structures are formed. There are many processes by which aluminum alloys can be formed. The major process that is common and the focus of this study is the Sand casting process (Albert, 1957). One of the common defects in aluminum castings is porosity (Monroe, 2005; Tyler, 1981). It is a clear fact that the quantity and the appearance of the porosity are very crucial to the mechanical properties of the aluminum alloy casting, most especially the fatigue properties because the pore in micro scale are primary source of initial cracks for the final failure of the aluminum parts. Due to this the aluminum alloys structure need to be improved by metal treatment to have the required properties.

Metal treatments are classified into two groups namely: Heat treatment and surface treatment. Surface treatment as corrosion resistance operations includes phosphating, chroming, nickeling, anodization and so on, while heat treatment as structural adjuster includes hardening, tempering toughening and so on (Ojediran and Alamu, 2005; Vincet, 1968). In this study, the aim is to determine the effects of heat treatment on the aluminum - Zinc alloys (Al-Zn).

MATERIALS AND METHODS

Table 1: The Composition, Uses and Forms of Aluminum Alloys

Composition	Uses	Forms
Al - Zn 20%	Armored vehicle, Military bridge, Motorcycle and Bicycle frames, Air frames etc	Rod (10mm x 150 mm)

The targeted materials composition, uses and forms are shown on table 1. The materials include Pit furnace, Sand mould, Electrical furnace, and Crucible Pots at FIIRO, Nigeria and Mosanto Tensometer, Wild metallurgical Microscope, Polishing Machine, and Manual Grinding Machine at Obafemi Awolowo University, Ile-Ife, Nigeria. Others are Digital Cameras, Patterns, Grit papers, Emery Cloth/Paper, Silicon carbide solution of different grade and Sodium Hydroxide (NaOH) Solution.

In the casting process, a crucible pots, 1kg of commercial purity Aluminum (99.7 % pure by weight) and 250g of Zinc were used. The alloying element Zn was put first in the Pot because of its high melting point (1108^{o}C) which is higher than that of the base metal aluminium (660^{o}C). So, the Zinc (Zn) in the pot was lowered first into the furnace while the aluminium is added after the Zn has commenced melting. The mass of each of the alloying elements used for each sample was obtained. The method adopted in casting the samples is sand molding (Sand casting). The casting process was performed at FIIRO Nigeria Limited, Lagos. The pattern was made from wood with the following dimensions: Height = 15cm; Diameter = 1.2cm

The sand used was the traditional-green sand' which is a mixture of sand grains and clay particles, clean sand with oil and binders). The mould used was a conventional vertical sand mould. The drag was placed upside down on a firm flat surface and the pattern was placed face down and then, dusted with a parting powder. Handfuls of sifted sand were then thrown at the pattern, covering every detail (Sand slinging). The sand was rammed. The drag was turned upside down with a swift movement. The cope was fitted onto the drag. The cope was rammed with sand and strictly making the top smooth and firm, and the cope was removed. The crucible was held about half way down with tongs and withdrawal from the furnace. Dross was raked away from pouring lip with heated skimmer and the metal poured in one continuous stream until it appears at the head of the riser. When the casting had solidified and cooled, the sand was knocked out and the casting fettled.

Heat treatment was also carried out at FIIRO Nigeria limited, Lagos. The types of heat treatment carried out were: Annealing and Quenching. Three each of Al-Zn casting samples were put in the electrical furnace (up to 3300^{o}C). The soaking time for the sample in the furnace was one hour, after which two of the Al-Zn casting samples were removed and quenched in both water and oil while the last one of Al-Zn was allowed to cool in the furnace atmosphere (annealing).

The microstructure analysis was done at Obafemi Awolowo University, Ile-Ife, Osun State. The samples were machined and grounded to gauge 240, 320, 400, 600 each using Grinding Machine and Grit paper. Each sample was initially polished, using Polishing machine, emery cloth and Silicon carbide. The final polishing was done with the aid of polishing machine, Emery cloth and Silicon carbide of different grades while etching took effect using 5% Sodium Hydroxide (NaOH) Solution. Each sample is examined using the Optical Microscope to check that each reveal clearly the Microstructure of the sample. The photographs of the resulting microstructure of the aluminum-Zinc (Al- Zn) alloy samples were taken using Optical microscope with x100 magnification and Digital Camera.

RESULTS AND DISCUSSION

The mass of each of the alloying elements used for each sample are as follows:

Total mass of mixture for the samples

= frames Mass of Al + Mass of alloying element

= 1kg + 0.250kg = 1.250kg

$$Percentage\ of\ Aluminum(Al)\ in\ the\ mixture = \frac{mass\ of\ Al}{Total\ mass} \times 100 \quad = \frac{1}{1.250} \times 100 = 80\%$$

=1/1.250 x 100 = 80%

$$Percentage\ of\ alloying\ element\ (Zn) = \frac{mass\ of\ alloying\ element}{Total\ mass} \times 100$$

$$= \frac{0.25}{1.250} \times 100 = 20\%$$

The dimension of one sample is as follows:

Height of the sample =150mm (15cm)

Diameter of the sample = 12 mm (1.2 cm)

Radius of the sample =60mm (0.6cm)

Shape of the sample= Cylindrical

Volume of the sample (V) =$\pi r^2 h$ = 3.142 x (0.6)^2 x 13 = 16.96 cm^3

Density of Aluminum = 2.69g/cm^2 (Olagoke, 1999).

Mass of sample used = $\rho \times V$ = 2.69 x 16.96 = 45.64 g

Therefore, 80 % of Aluminum = 36.51g for each sample

Also, 20% of Alloying element (Zn) = 9.13 g

For each sample (rod form) 36.51 g Al + 9.13 g of alloying element (Zn) were used.

The samples for heat treatment are:

Sample 1 =as received from Casting process.

Sample 2 = for quenching in Water.

Sample 3 = for Oil quench

Sample 4 = for annealing (Furnace cool).

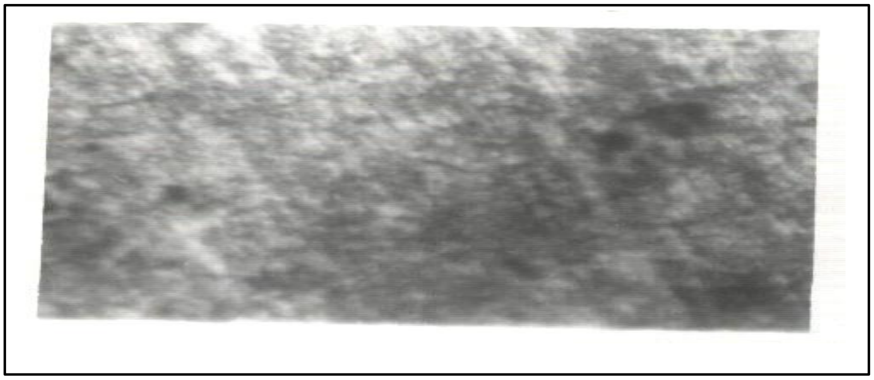

Figure 1: Microstructure of Al - Zn alloy As Received; Sample 1

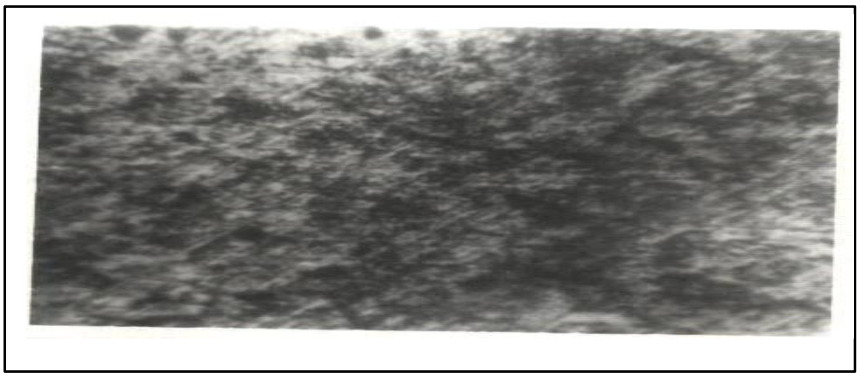

Figure 2: Microstructure of Oil Quench; Al - Zn Alloy Sample 3

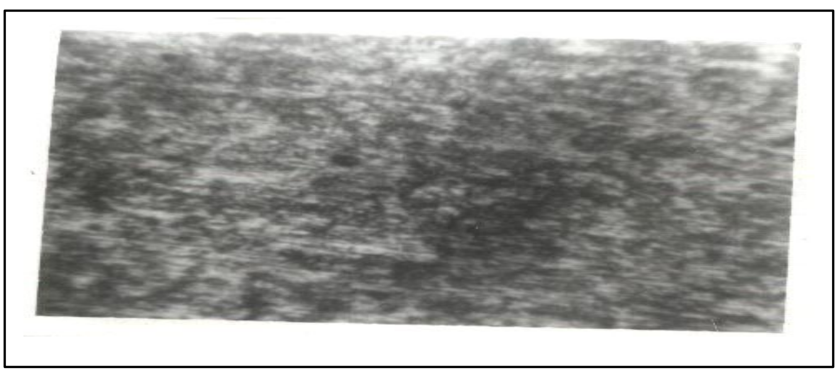

Figure 3: Microstructure of Furnace Cooled; Al - Zn Alloy Sample 4

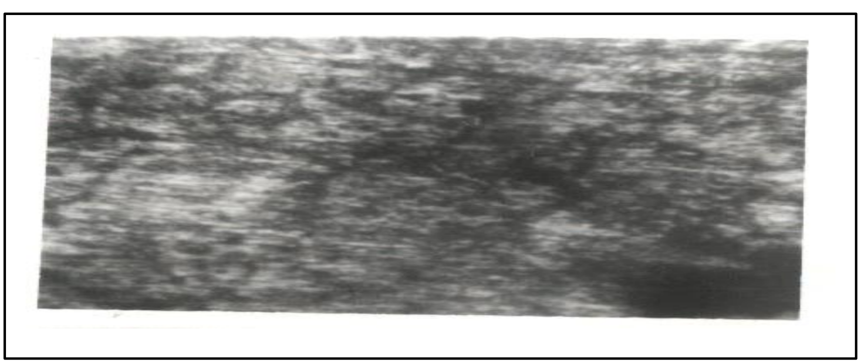

Figure 4: Microstructure of Water Quench; Al - Zn Alloy Sample 2.

The Microstructure Results of Al- Zn Alloys

Figure 1 shows the microstructure of Al-Zn alloy, as received sample that is, without heat treatment. It can be observed that the grains were not homogeneous and pores are numerous towards the peripheral zone. The figure 2 shows the microstructure of Al -Zn alloy, Oil quenched sample. It was observed that the grains are more homogeneous and well distributed towards the core. The pores are not numerous compared to Al- Cu alloy, as received sample. Figure 3 shows the microstructure of Al- Cu alloy as furnace cooled sample. It can be observed that the grains were deformed at peripheral more than at the core of the structure and there are more pores than that of as received sample and oil quenched sample. This indicates that there is no significant improvement in the microstructure arrangement of grains when Al-Cu alloy is oil quenched. Figure 4 shows the microstructure of Al- Zn alloy, as water quenched sample. It can be observed that the grains were deformed throughout the structure and there were more pores than that of received sample and oil quenched sample. This indicates that there is no significant improvement in the microstructure arrangement of grains when Al-Zn alloy is water quenched.

CONCLUSION

This study aimed at determining the effect of heat treatment on the Aluminum-Zinc alloys (Al-Zn). Pit furnace, Sand mould, Electrical furnace, and Crucible Pots at FIIRO, Nigeria and Mosanto Tensometer, Wild metallurgical Microscope, Polishing Machine, and Manual Grinding Machine at Obafemi Awolowo University, Ile-Ife, Nigeria. Others are Digital Cameras, Patterns, Grit papers, Emery Cloth/Paper, Silicon carbide solution of different grade and NaOH Solution were the equipment used for the study. From the result of the experiments, it can be deduced that: (i) The arrangement of the microstructure grains and pores are more even with the Oil quench method than any other heat treatment methods in Al - Zn alloy, (ii) There is relationship between the heat treatments method (Oil quench) and microstructure of Al- Zn alloy and (iii) Oil quench Aluminium Zinc alloy (Al-Zn) is more appropriate for the production of Armored vehicle, Military bridge, Motorcycle frames and Bicycle frames and Air frames.

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