© 2015 IJSRSET | Volume 1 | Issue 5 | Print ISSN : 2395-1990 | Online ISSN : 2394-4099
Themed Section: Engineering and Technology

Effect of Variation of Copper and Zinc Contents in Aluminium-Zinc-Copper Alloy

Sani A. Salihu[1], Suleiman I. Yakubu[2] , Aliyu Isah[3]
Department of Metallurgical and Materials Engineering Technology, Waziri Umaru Federal Polytechnic, Kebbi State, Nigeria

ABSTRACT

In this work, the effect varying the copper and zinc contents on mechanical properties and microstructure of sand cast Al-Zn-Cu alloy was investigated. The tensile specimens of the as-cast and homogenized alloys were exposed to a solution heat treatment at 4000C for 4 hrs, followed by natural ageing in the room temperature. There were six different alloys and were characterized for optical light microscope, tensiometer and Rockwell B hardness test. Tensile and hardness tests were carried out to examine the effect of varying Cu and Zn contents and influence of solution heat treatment on the precipitation behaviour of the alloys. The results obtained showed that the addition of Cu increase in strength and hardness. There was accelerated precipitation kinetics with increase of Zn contents. The microstructure changes of the alloys were investigated by optical light microscope. The results show that severe dendritic segregation exists in Al-Zn-Cu sand cast alloy. It reveals segregation ("cording") within the dendrites and intermetallic between the dendrites as Cu and Zn contents were altered. There were a lot of eutectic phases at grain boundary and the distribution of these elements varies along interdendritic region.
Keywords: Al-Zn-Cu Alloy, Solution Treatment, precipitation, Hardness, Dendrites Microstructure

I. INTRODUCTION

Aluminium and the aluminium alloys lend themselves to many engineering applications because of their excellent combination of lightness with strength, their high corrosion resistance, their thermal and electrical conductivity and heat and light reflectivity, and their hygienic and non-toxic qualities (A.M. Zahra et al, 1990 and Vadim S., et al, 2007). The variety of forms in which they are available also enhances their utility (Patricia et al, 2009). Aluminium alloys are widely used in constructions of light components at aerospace and automotive industry.

There are two main classes of aluminium alloys, they are wrought alloys and cast alloys. The 7xxx alloys are among the eight cast aluminium alloys that are used for aerospace and automotive applications. There are several alloys in the series that are produced especially for their high toughness, notably 7075, 7136, 7150, and 7475, both with controlled impurity level to maximize the combination of strength and fracture toughness. These alloys are heat treatable and among which are the Al-Zn-Mg-Cu versions that provide the highest strengths of all aluminium alloys (ASM, 1991 and ASM 2004).

The 7000 series is made up of Al-Zn-Cu-Mg alloys where Zn is the strengthening component (Anikumar et al 2011 and Yin Dongsong et al 2009). High strength aluminium alloys of Al-Zn-Cu-Mg series are widely used in automotive and aerospace field due to their high specific strength, toughness and fatigue durability (Grard, 1920, Prabhu, et, al, 2011 and Yin Dongsong,et, al, 2009). The common feature of these alloys is high volume fraction of alloying elements, which leads to severe dendrite and grain boundary segregation in the as-cast alloy. It is well known that the type and intrinsic characteristic of residual phases will differ in different alloys and change with different heat treatment conditions. "Mondal and Mukhopadhyay" (Muzaffer Zeren, et, al, 2011) studied the phases in the as-cast and homogenized 7055 aluminium alloys, and revealed that the major residual phases were η ($MgZn_2$), T ($Al_2Mg_3Zn_3$), S (Al_2CuMg) and θ ($CuAl_2$). The microstructure of the cast 7050 alloy consists of dendrites, high angle grain boundaries, and interdendritic eutectic regions containing phases such as Al2CuMg, MgZn2 and Mg2Si (Verhoeven, 1975).

Despite detailed studies of microstructural evolution in the as-cast and homogenized 7050 and 7055 alloys, less attention has been paid to the evolution of eutectic structure in the Al-Zn-Cu-Mg-Sc-Zr alloy, and the transformation of primary eutectic structure to coarse residual particles is not yet clear.

Researches were conducted on complex aluminium alloys such as Al-Zn-Mg-Cu, Al-Zn-Cu-Mg-Sc-Zr, etc, but there was little research on Al-Zn-Cu alloys. The present study was therefore designed to examine the microstructural evolution of Al-Zn-Cu alloy. The main objective of this work was to investigate the effect of variation of Zn and Cu contents on the microstructure in heat treated condition and evaluate the mechanical properties of the alloys.

Commerce has become one of the vital parts of the modern life. Online payment is the supportive application for the payment of money for the products we buy. For the past years online security breach created a major problem and lots of money had been stolen. The proposed document deals by securing the payment through iris recognition [1]. This method also adds the method of using visual cryptography for securing the user credentials. This visual cryptography method was formerly invented by Moni Naor and Adi Shamir in 1994[6].

II. METHODS AND MATERIAL

Experimental Procedure

High purity Al (99.999%), Cu (99.999%) and Zn (99.999) were used for this study. Six different alloys were utilized for this study. Cylindrical specimens were cast using sand mould for different compositions of alloying elements. The chemical compositions of these alloys are shown in Table 1. As copper metal was melted, aluminium and zinc were added respectively. After melting these materials completely, the melt was sand cast into mould. The aluminium rods obtained from casting were machined on a lathe machine so as to prepare the samples for tensile testing. Tensile testing was done using Tensiometer. Hardness testing was done using Rockwell Hardness testing machine while the microstructure was analyzed by optical microscopy. The specimens were prepared through a conventional grinding and polishing, followed by etching with Keller reagent. The solution heat treatment was performed at 4000C for 4 hrs then quenched in water followed by natural aging.

Table 1. Chemical Composition of alloys Used in this work (wt. %)

Alloy	Zn, (%)	Cu, (%)	Al , (%)
1	2	5	93
2	3	10	87
3	7	15	78
4	10	20	70
5	15	25	60
6	30	0	70

III. RESULTS AND DISCUSSION

3.1 Mechanical Properties

The mechanical properties of Al-Zn-Cu alloys are largely dependent upon both the compositions and heat treatment technology (solution and aging), during which a series of changes in microstructure occur. These changes significantly influence the mechanical properties because of the distribution of the precipitates during heat treatment. From this point of view, the composition and solution heat treatment are critical in determining the final microstructure and mechanical properties of the alloys (Yin Dongsong, et, al 2009) as observed in Figure 1 which shows the variation of tensile strength verse the composition of aluminium ternary alloy, but what is more interesting was result obtained from sample six (70%Al 30%Zn) indicating and confirming the strengthening effect of zinc. Results obtained during tensile tests shows that mechanical properties are affected by the structure. Coarse structure obtained worst and tensile strength in comparison with both finer microstructures.

The results from RockWell hardness testing machine for the six samples are shown in Fig. 2. The analysis of the data in Fig. 2 (87%Al,10%Cu,3%Zn) clearly indicates the highest hardness for sample 2 and the lowest hardness for sample 5 (60%Al, 25%Cu, 15%Zn). The result shows that with increase of Cu content from more than 10%Cu there was a decrease in hardness and this relationship between hardness of the matrix confirms that the optimum % of Cu for this type of alloy should not exceed 10%Cu.

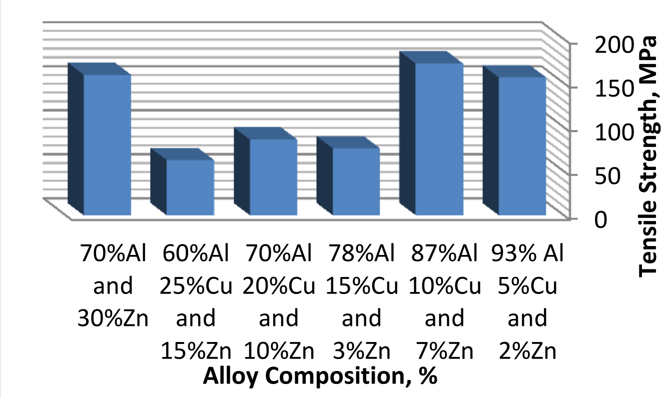


Figure 1: The Variation of Tensile Strength verse the Composition of Aluminium Ternary All

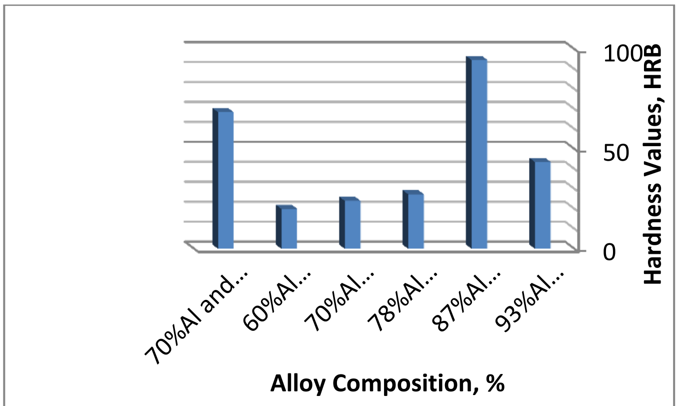
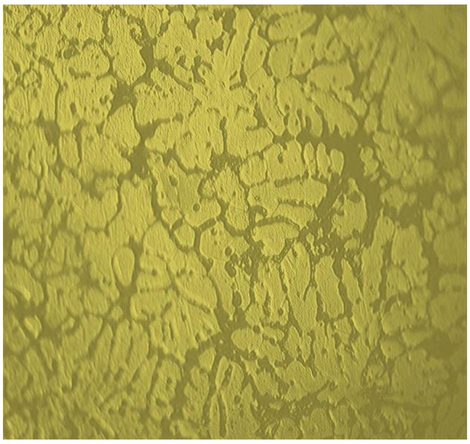


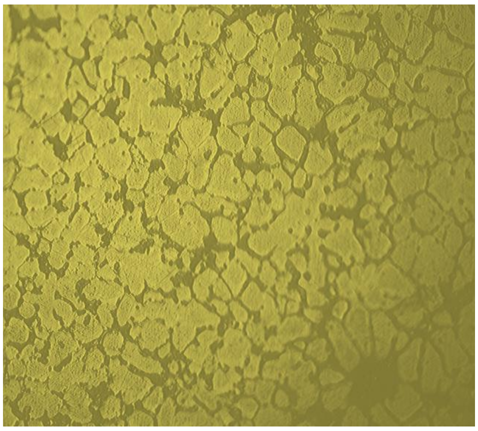
Figure 2: The Variation of Hardness Test verse the Composition of Aluminium Ternary Alloy.

3.2 Microstructure and Phase Analysis

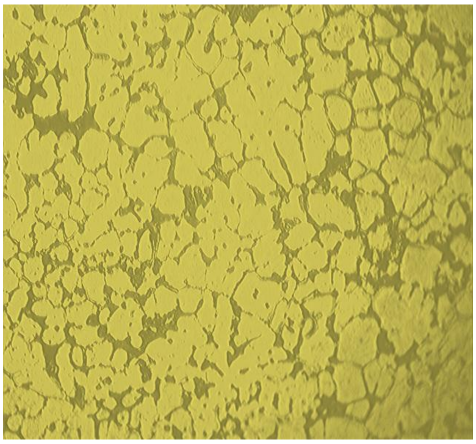
Figures 3a – 3f show the optical microstructures of Al-Zn-Cu alloy casted in sand mould. As observed, when the compositions changes, the microstructures changes adversely. There are some differences visible in form of microstructure morphology changes of the phases and precipitations occurred in the investigated samples. Figure 3a shows that the microstructure consists of α-Al dendrite (light green phase) and eutectic phase (α-Al + Cu) in the inter-dendrite region as observed in Fig. 3b. The microstructure consists of small grains, including the dendrites of Al matrix, interdendritic of the Al matrix and interdendritic network of eutectic Zn and Cu plates. Fig 3c shows optical microstructure consisting of coarsening of precipitates due to Ostwald ripening revealing Cu only partially dissolved in the course of solution heat treatment because of its higher concentration. Fig. 3d characterized by dendrite structure with a homogeneous distribution of eutectic of zinc.



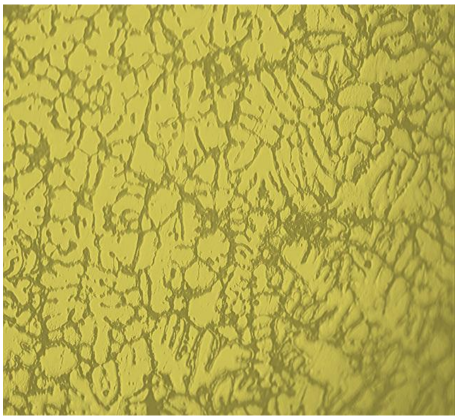
(a)



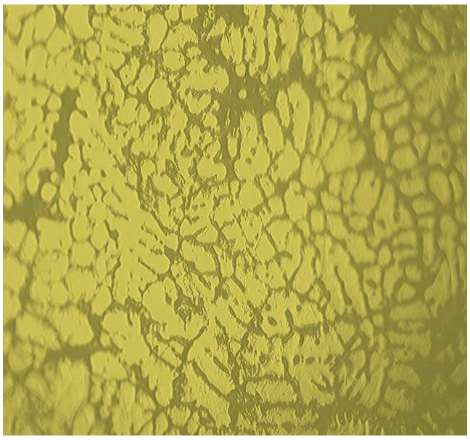
(b)



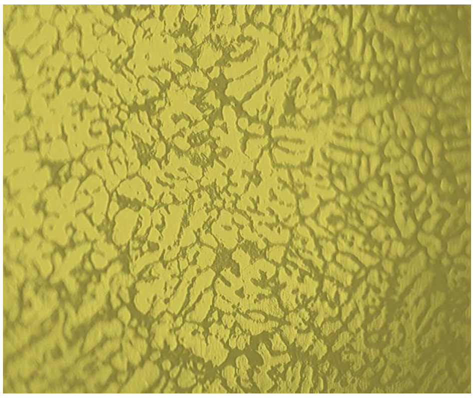
(c)



(d)



(e)



(f)

Figure 3: Optical Micrographs showing the effect of various content of Cu and Zn in Al-Zn-Cu alloys (refer to Table 1 on the composition of alloys).

IV. CONCLUSION

Experiments have been carried out to observe the effect of Zn additions (2 to 30 wt.%) and Cu additions (5 to 25 wt.%) in Al-Zn-Cu alloys and the following observations were made:

1. The mechanical properties of Al-Zn- Cu alloys largely depend on the heat treatment parameters and composition of the alloys as observed from the micrographs.
2. The characteristics of heat treatment and composition of the alloys greatly affect the mechanical properties and ultimately the microstructure of the alloys.
3. Addition of 10% Cu 3% Zn and 87%Al gave the optimum properties, but with increase of copper content above 10% decreases the mechanical properties.
4. Addition of 70%Al and 30%Zn shows appreciable strength than all other alloys accept 10%Cu, 3%Zn, 87%Al. Thus Zn had shown strong strengthen effect. Both Zn and Cu contents in Al-Zn-Cu alloys affect the mechanical properties. With increasing Cu content, the tensile strength and hardness increase due to precipitation hardening.

V. REFERENCES

[1] ASM Metal Handbook Volume 4 Heat Treating, ASM HandBook, 1991, USA.

[2] ASM Metal Handbook Volume 9, "Metallography and Microstructure", (Vander Voort, George, F. ASM International, 2004, USA.

[3] Vadim S. Zolotorevsky, Nikolai A. Belov and Michael V. Glazoff, " Casting Aluminum Alloys", 2007, Elsevier, Pittsburgh, Moscow.

[4] Anikumar, H. C., Hebbar, H. S., and Ravishankar, K. S.2011, "Mechanichal properties of fly ash reinforced aluminium alloy (A16061) composites", International journal of mechanical and materials engineering, (2011), 6 (1); pp: 41-45

[5] A.M. Zahra, C. Y. Zahra, J. Dutkkiwicz, and R.Ciach, 1990"The influence of Cu and Mg additions on the decomposition of Al-(40 to 50) wt% Zn alloys during isothermal and continuous heating", Journal of Mat. Science, vol.25, Issue 1, (1990), pp: 391 -398

[6] C. Grard, "Aluminium and its Alloys their properties, thermal treatment and industrial application". Cambridge, UK,1920, pp: 56-187

[7] Muzaffer Zeren, Erdem Karakulak, Serap Gumus, 2011, "Influence of copper addition on microstructure and hardness of near-eutectic Al-Si- xCu –alloys, Science Direct, Elsevier, Science Press, (2011), pp: 1698-1702.

[8] Patricia M. K., Lauralice C.F. Canale, George E.Totten, Quenching of Aluminium Alloys, CRC Press, BocaRaton, 2009, pp: 6-212, USA.

[9] Prabhu, R.,Ganapatly, T; and Venkatachalapatly, V. S. K., 2011 "Process parameters optimization of porthole – die hot extrusion of aluminium alloy tubes using taguchi method, International journal of mechanical and materials engineering", vol. 6 ; No 8, (2011), pp: 102-108.

[10] Verhoeven J.D., "Fundamentals of physical metallurgy". 1975, New York: Wiley & Sons Publishers, USA. 11Yin Dongsong, Zhang Erlin and Zeng Songyan, 2009."Effect of Zn content on microstructure, mechanical properties and fracture behavior of Mg-Mn alloy", journal of materials science and engineering, Harbin Institute of Technology (2009), vol. 8 No 10, Harbin, China.