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MECHANICAL PROPERTIES AND ELCETROCONDUCTIVITY OF ALUMINUM ALLOYS PROCESSED USING UNIAXIAL COMPRESSION

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ABSTRACT

The objective of this research work is to study the effect of uniaxial compression (UAC) on electrical and mechanical properties of aluminum alloy. In present investigation aluminum AA6063 alloy were uniaxiallly compressed with 0.69 compressive strain at room temperature and at 150° C. Mechanical behavior of the Al6063 alloy after UAC processing and its electrical conductivity are analyzed .Here, it is observed that UAC of alloy at different temperature affects the Mechanical properties and electrical conductivity of processed material. Improved mechanical properties are subject to work hardening during the UAC at room temperature. Mobility of dislocation at working on high temperature is being correlated affected mechanical properties in UAC at 150° C. Both UAC Al sample showed increased electrical conductivity as comparison with undeformed sample.

***Keywords:* Aluminum Alloy, Electro Conductivity, Uniaxial Compression**

I. INTRODUCTION

Aluminum alloy is used for the electrical applications. Two major properties in conducting material are assumed to be the mechanical strength and electrical conductivity. Electrical conductivity is determined by the scattering of electrons, hence may sensitive to the microstructure of the metallic materials [1]. Increased electrical conductivity after eight Accumulative roll bonding (ARB) cycles is observed in Copper which is attributed to elimination of point defects because of the dynamic [2]. UFG Cu alloy processed using ARB has s high strength and electric conductivity due to the perfectly coherent atomistic structure of twin boundary [3]. Grain refinement through severe plastic deformation (SPD) and alloying are the two techniques of strengthening the engineering materials. Electrical conductivity might degrade during alloying, while improved due to

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accumulation of lattice defects in SPD [4]. In another work enhanced electrical conductivity in Al alloy after ECAP has been reported. The author has mentioned that the electrical conductivity may affected by the microstructural features. Ultrafine grains and second phase particle may be there so for enhanced mechanical strength and electrical conductivity [5]. On the other hand Adeosun S O et al. [6] has shown the improvement in the electrical resistance in Aluminum Alloy after rolling. Reduced electro conductivity has been reported by A Habibi [7] after equal channel angular rolling [ECAR] specimen comparative to pure copper. Uniaxial deformation may affect the both mechanical behaviour and microstructural features which may affect the electrical conductivity. Hence, it is interesting to study the electrical conductivity of Aluminum alloy after the UAC.

II. EXPERIMENTAL PROCEDURE

The Aluminum AA 6063 alloy was used in present study. The specimens were machined into cylindrical shape with the diameter of 20 mm and the height of 30 mm for uniaxial compression. The specimen (aspect ratio, L/D=1.5) has been chosen is less than 2, required for homogeneous compression and less friction [8, 9]. UAC were performed on a universal testing Machine (TUN 400UTM) Graphite powder reduces the friction between die and specimen [9, 14]. UAC was carried out (i) on cylindrical specimen at strain of ε=0.69. and (ii) on the heated specimen at temp 150° C after a soaking period of 50 minutes by giving a deformation at strain of ε=0.69.The shape of specimen before and after compression is shown in Fig. 1 and 2 respectively.

The hardness measurement of the two specimens (undeformed and after UAC 31°C temperature was performed using a FIE-VM50 PC Vickers hardness tester with a 5 kg load at dwell time 10 seconds. An average of five reading was taken to evaluate mean hardness. The tensile specimens were prepared for tensile test with a gauge length of 8 mm and width of 1.5mm. These dimensions were chosen based on a previous work [10]. The tensile test was conducted on (H25 K-S Tinius Olsen) testing machine at a cross-head speedof0.1mm/min. The electrical conductivity was measured on undeformed and after UAC specimen, with an accuracy within ±0.5%IACS (International Annealed Copper Standard). Scanning Electron Microscopy (SEM) ZEISS, was used to analyze the morphology of fractured surfaces of tensile samples.

Figure 1 Undeformed sample

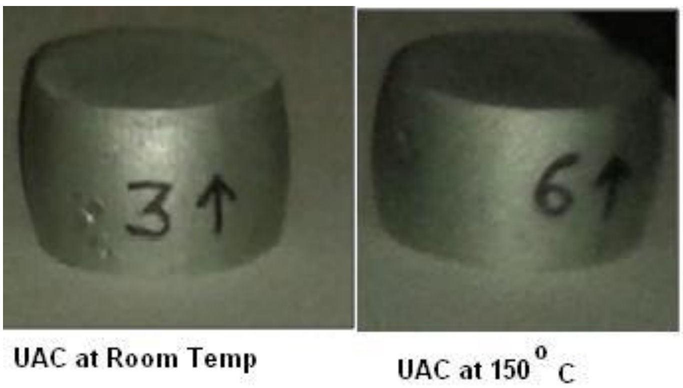


Figure 2 Deformed Samples

III. RESULT AND DISCUSSION

3.1 Hardness

Fig. 3 shows the comparative result of Vickers hardness of three different samples undeformed (UD), deformed at room temperature (RT) and deformed at temperature 150°C temperature (T150). The hardness of deformed specimen at room temperature increases due to strain hardening [11]. When a metal is plastically deformed, dislocations move and additional dislocations are generated. The more dislocations within a material, the more they will interact and become pinned or tangled. This will result in a decrease in the mobility of the dislocations and a strengthening of the material. While deformed specimen at temperature 150°C, the hardness decreases because at higher temperatures the dislocations can rearrange and little strengthening is achieved or the strengthening that resulted from the plastic deformation can be lost [11].

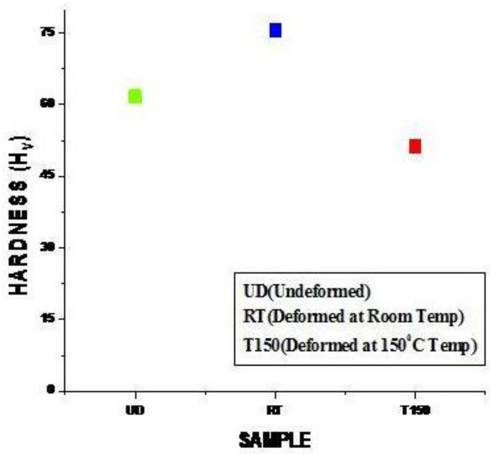


Figure3 Comparative Variation of Mean Hardness

3.2 Tensile Test

Fig. 4 shows the comparative result of tensile test of three different samples undeformed, deformed at room temperature and deformed at temperature 150°C temperature. The tensile strength of deformed specimen at room temperature increases, the stress rises and the curve exhibits work hardening which indicates that work hardening plays a dominant role [12]. While deformed specimen at 1500C temperature, the flow stress decreases as compared to the sample deformed at room temperature where strain hardening dominants. This is because the increases in temperature will increases atomic activity, which causes the work hardening induced by the dislocation pile-up reduced, hence the strain softening effect dominants [12]. Fractured surface of tensile specimen has been analysed using SEM to investigate the mode of failure. Fig. 5, 6 and 7 shows the fractograph (SEM images of the fractured surface of tensile specimen) for as-received material, deformed at room temperature and deformed at 150°C respectively. It has being observed that all the specimen has fully dimples features which show the complete ductile fracture.

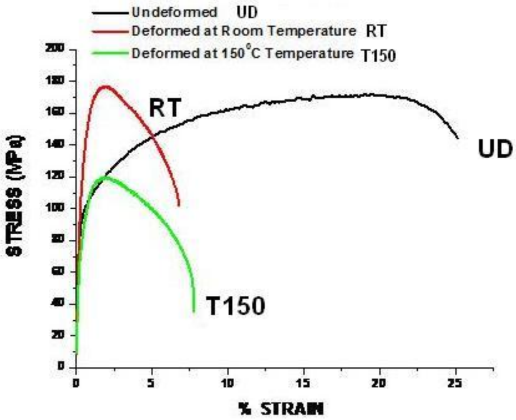
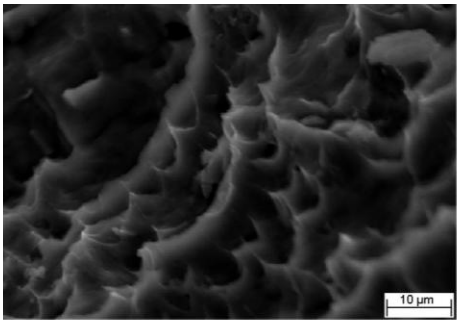


Figure 4 Stress strain curve for samples of undeformed, UAC at room temperature and UAC at 150°C of Al alloy



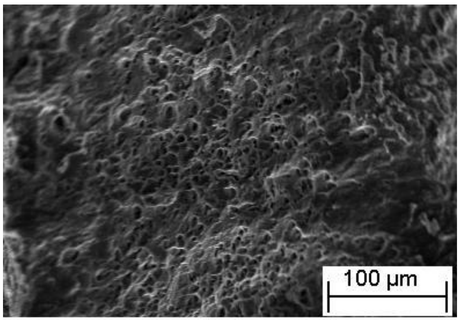


Figure 5: SEM Fractograph of UD sample Figure 6 SEM Fractograph of RT Al Alloy

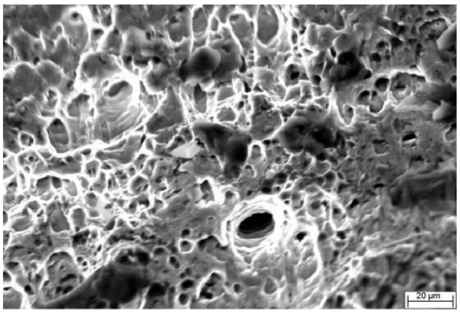


Figure 7: SEM Fractograph of T150 Al Alloy

3.3 Electrical Conductivity

Figure 8 shows the electrical conductivity of UD sample, RT and T150. It can be observed that the electrical conductivity of as received alloy about 61.90% IACS. It increases to 62.80% IACS of RT sample and the 65.80% IACS in UAC at 150°C. The slightly increase of electrical conductivity in RT sample is due to coalescence of dynamic recrystalline grain in the UAC sample and also responsible with metallurgical hardening process [13].While in T150 may attribute to the grain coalescence subjected to an increase in temperature.

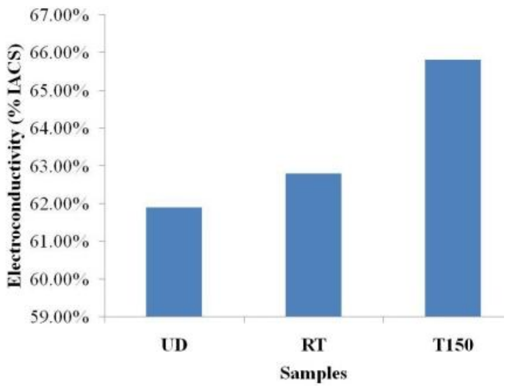


Figure 8: Electro conductivity of UD, RT and T150 Aluminum Alloy

IV. CONCLUSION

In present study aluminium AA 6063 has been uniaxially compressed in single pass.

1. Vickers Hardness (VHN) of UAC Al alloy increases by 20% in comparison to undeformed Al alloy. Ultimate tensile strength of UAC Al alloy increase by 4% and ductility decreases 73 % as compared to undeformed Al alloy. Increased tensile strength is attributed to work hardening

2. Hardness of Aluminum alloy deformed using UAC at 150°C decreases as compared to undeformed alloy, marginally as 51.2 VHN to 61.6 VHN. Maximum tensile strength decrease by 30% while ductility decreases by 69% as compared to as received material. Strain softening effect is mainly attributed for reduction of tensile strength and hardness.

3. Increase of electrical conductivity is attributed to coalescence of dynamic recrystallized grain.

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