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Influence of Heat Treatment on Microstructure and Mechanical Properties of Particle Reinforced Al2024 Composites

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Abstract: **Aluminium Al 2024 alloy is widely applied in various Industries in automobile and aerospace sectors. This study reveals the effect of microstructure and mechanical properties with impact on heat treatment and aging process. Mechanical tests were conducted to study the behaviour of Al reinforced 2024 matrix composite produced through squeeze cast technique and heat treated to T6 Heat treatment process . Aluminum ingots were melted in a furnace and poured into mould cavity of 25mm diameter. Squeeze casted composites were heat treated as per ASTM standards, at a temperature of 525°C for 12 hours followed by a temperature of 300ºC for 8 hours. In order to examine the effect of heat treatment and aging processes microstructure and mechanical properties such as hardness, tensile strength were analysed in as-cast condition and after heat treatment and aging process. The properties were enhanced for the aged composites compared to as cast condition.**

Keywords: **Aluminium 2024 alloy, Squeeze casting, microstructure, tensile strength, heat treatment & aging.**

I. INTRODUCTION

Al–Cu alloys Al2024 have received a great deal of attention in aerospace and automobile industries for the past decades, due to their low density, high strength, high stiffness, good formability and age hardenability [1–3]. It is well known that in the aging process of supersaturated Al–Cu solid solution, first, GP zones (Guiner Preston Zones) form and then they sequentially grow into GPII zones and semi-coherent meta- stable θ′ precipitates ($CuAl_2$) which are defined as most effective phases for the increase of hardness. Finally, formation of incoherent stable θ precipitates ($CuAl_2$) decreases the hard-ness (over aging) [4-5]. Arakawa et al. [4] showed that there is a threshold for aging temperature of composites at which, and definitely at the temperatures more than that, precipitation of the stable θ phases occurs in the early stages of aging process because of the presence of high density of dislocation in the vicinity of reinforcing particles after quenching. It is well known that the heat treatment is one of the important methods for improving the mechanical properties of aluminum alloys. The heat treatment of age hardenable aluminum alloys involves solutionising the alloys, quenching, and then ageing at room temperature (natural ageing) or at an elevated temperature (artificial ageing) [6].The mechanical properties can determine by controlling the microstructures of the alloys so we can achieve better mechanical properties. [7-8]. Heat treatment and aging are important processes to homogenize α-Al dendrites in aluminium alloys [9]. A standard heat treatment consists in solutioning (holding the alloy in temperature below temperature of the eutectic reaction in order to dissolve the precipitations of Al_2Cu, homogenize the chemical elements concentration on the cross-section of dendrites of the α phase and the change in the silicon precipitations morphology), and ageing (soaking of the supersaturated alloy to separate strengthening phases from the super-saturated solid solution – in case of the silumins com-prising magnesium or copper only, the precipitation strengthening is obtained as a result of the phases pre-cipitation of Al_2Cu) [10-12].

Therefore, the present investigation has been done to study the age hardening behaviour of Al–4.5%Cu alloy reinforced with Fly ash and SiC particles synthesized by Squeeze casting technique, and a comparison is made to investigate the effect of heat treatment and aging process to evaluate the mechanical properties on hardness, tensile strength yield strength which were analysed in as-cast condition and after heat treatment and aging process.

II. EXPERIMENTAL METHOD

In the present investigation Al - 4.5 wt. % Cu alloy having theoretical density 2800 kg/m^3 is used as the base matrix. Fly Ash particulates with theoretical density of 2300 kg/m^3 were used as reinforcements. Average particle size of Fly Ash was taken as 40µ m. Figure 1 & Figure 2 shows the SiC & Fly Ash and particulates.

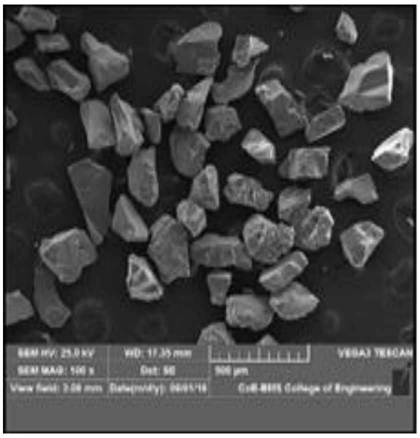


Fig.1

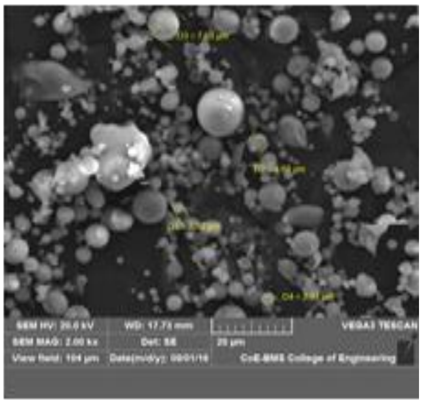


Fig.2

Fig 1, 2: Scanning electron microphotographs of SiC &Fly Ash particulates.

2.1 Fabrication of composites:

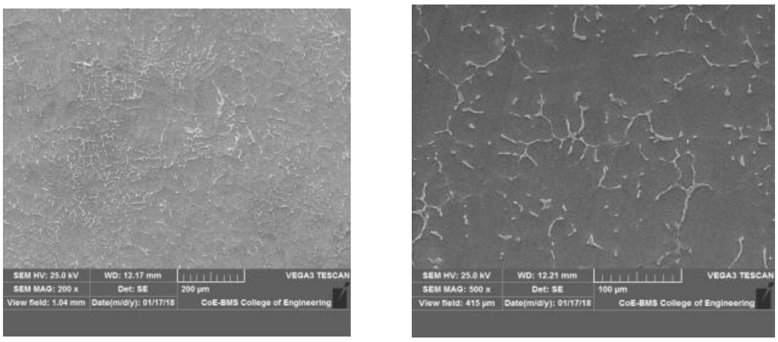
Al–4.5% Cu alloy forms the matrix which is in the billet shape is placed in the graphite crucible and heated to 780 ºC. The reinforcement of SiC particulates is weighed in the ratios of 3% &5% by keeping the constant weight percentage of Fly Ash which was preheated to 400 ºC to remove the moisture contents in the reinforcement.. The reinforcements were preheated prior to their addition in the aluminium alloy melt. The preheating of the reinforcement is necessary in order to reduce the temperature gradient and to improve wetting between the molten metal and the reinforcements. The molten metal mixture was degassed at a temperature of 780 ºC. using hexa- chloroethane degassing tablet. The tablet helps in the removal of entrapped air in the melt and thus prevents casting defects like porosity and blow holes. The molten metal matrix Al–4.5% Cu alloy was stirred using a Stirrer to create a vortex and 0.4% wt. of mg was added to ensure good wettability and the preheated reinforcements were added to the molten metal mixture with a continuous stirring speed of 300 rpm to a time span of 3 minutes. The stirred molten metal mixture with the reinforcements is poured into the preheated cast iron die and the die was placed in a compression testing machine. The plunger is placed into the die and a load of 120 MPa was applied for 4 minutes. The melt was then allowed to solidify in the melds.

2.2. Testing:

In order to examine the effect of heat treatment and aging process on microstructure and mechanical properties, hardness tensile strength and yield strength were measured for as-cast condition, heat treated and aged condition. Specimens were prepared for microstructural analysis by polishing on disc polisher followed by etching with diluted hydrofluoric acid. Microstructural analysis was performed by Scanning Electron Microscope and the microstructures were compared. Cast specimens were machined to ASTM E8 standard with a gauge length of 45mm and gauge diameter of 9mm for tensile test. Tensile test were performed on universal tensile testing machine and ultimate tensile strength value was computed for as-cast condition and after heat treated were compared. Hardness test were performed with Brinell hardness tester by applying a load of 250kgf of 5mm tungsten ball for 20 second both as cast condition and after heat treated condition. All tests were repeated 5 times in both as-cast and aged and heat treated condition.

III. RESULTS AND DISCUSSION

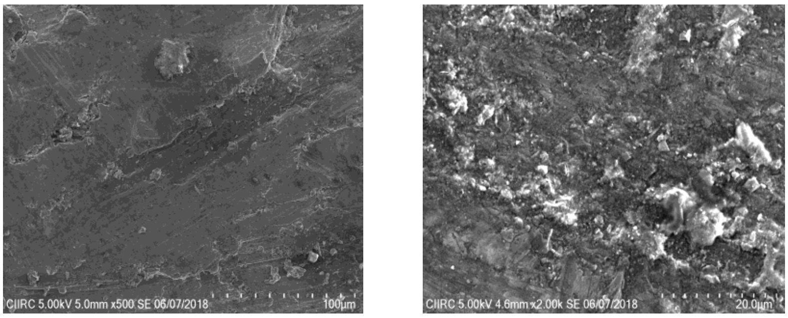
3.1. Microstructure evaluation:



(a) (b)

Fig 3: Change in microstructure of as cast specimens (a) Base alloy (b) Al -4.5 wt. % Cu alloy -3 wt. % of Fly ash 3 wt% of SiC

Fig. 3 shows change in microstructure of as-cast specimens and Fig 4 shows changes in microstructure of heat treated and aged cast specimens. In the as cast condition microstructure was found coarse compared to fine grain structure in heat treated condition.



(a) (b)

Fig 4: Change in microstructure of of heat treated and aged cast specimens (a) Base alloy (b) Al -4.5 wt. % Cu alloy -3 wt. % of Fly ash 3 wt% of SiC

3.2. Hardness test evaluation:

Fig. 5 shows as-cast, heat treated and aged conditions hardness specimens. Hardness was increased from 57 BHN to 88 BNH. Hardness was improved when compared with the as-cast condition. This is due to grain refinement in heat treated and aged condition.[13]. The second phase particles distributed in a ductile matrix can hinder dislocation motion by increasing the hardness of the material.

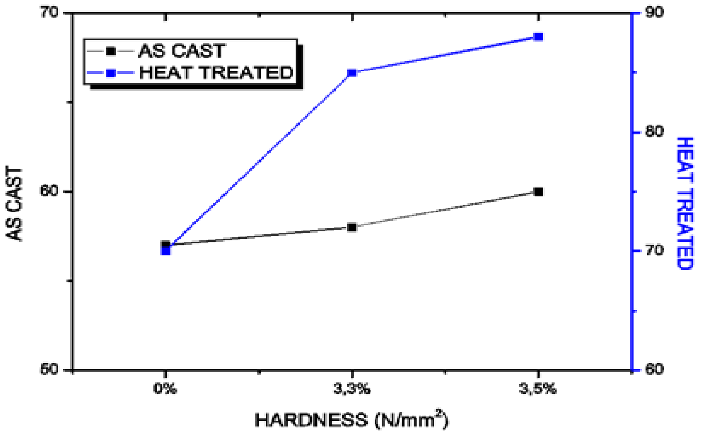


Fig 5: Variation in Hardness with as cast and aged condition

3.3. Tensile test evaluation:

Fig. 6 shows as-cast, heat treated and aged conditions tensile specimens. Ultimate Tensile strength was increased from 102 MPa to 197.4 MPa, This is due to grain refinement in heat treated and aged condition.[13]. The cluster of Cu atoms (Guiner Preston Zones – GP Zones) Coherent with parent lattice resulting in lattice strain which improves dislocation motion and hence the tensile strength increases.Improvement in UTS may be due to the matrix strengthening that might have occurred as a result of the grain size strengthening following a reduction in composite grain size [14].

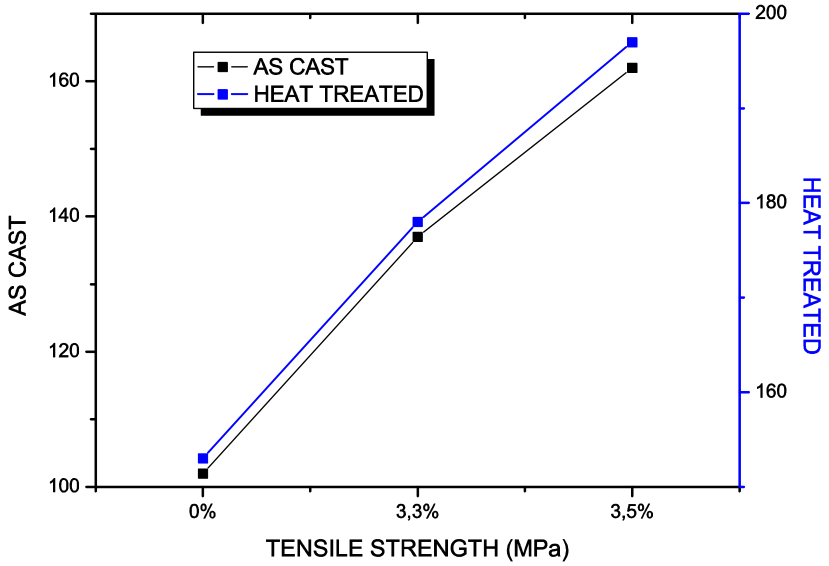


Fig 6: Variation in Ultimate tensile strength with as cast and aged condition

3.4. Yield Strength evaluation:

Fig. 7 shows as-cast, heat treated and aged conditions tensile specimens. Yield strength was increased from 100 MPa to 157 MPa This is due to grain refinement in heat treated and aged condition.[13]. This is due to cluster of Cu atoms (Guiner Preston Zones – GP Zones) Coherent with parent lattice resulting in lattice strain which improves dislocation motion and hence the Yield strength increases.

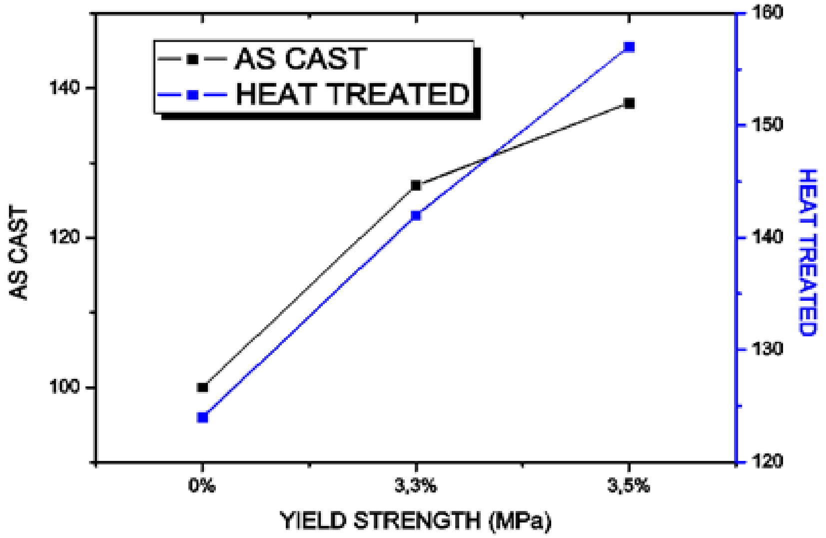


Fig 7: Variation in Yield strength with as cast and aged condition

IV. CONCLUSION

The Al-4.5 Cu composites with different weight percentage (i.e. 3 wt. % Fly ash and 3wt. % SiC and 3 wt. % Fly ash and 5wt. % SiC) particulates were produced by Stir Squeeze Cast technique has led to the following conclusions. As-cast condition Mechanical properties such as ultimate tensile strength from 102 MPa to 197.4 MPa, Hardness from 57 BHN to 88 BHN and Yield strength from 100 MPa to 157 MPa were increased due to grain refinement. Heat treated and aged condition mechanical properties such as Hardness, ultimate tensile strength, Yield strength were improved. This is due to further grain refinement in heat treated composites.

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REFERENCES

[1] Choi HJ, Min BH, Shin JH, Bae DH, "Strengthening in nanostructured 2024 aluminum alloy and its composites containing carbon nanotubes", Cojmpos A — Appl Sci Manuf , vol42, pp1438–1444, 2011.

[2] Mousavi Abarghouie SMR, Seyed Reihani SM, "Aging behaviour of a 2024 Al alloy–SiCp composite". Mater Des; , vol 31, pp 2368–2374, 2010.

[3] Sharma A, Das S, "Study of age hardening behaviour of Al–4.5 wt%Cu/zircon sand composite in different quenching media" — a comparative study. Mater Des, vol 30, pp 3900–3903.

[4] Arakawa S, Hatayama T, Matsugi K, Yanagisawa O, "Effect of heterogeneous precipitation on age hardening of Al_2O3 particle dispersion Al–4mass%Cu composite produced by mechanical alloying". Scripta mater, vol42, pp 755–760, 2000.

[5] Starink MJ, Zahra AM, "Mechanisms of combined GP zone and θ′ precipitation in an Al–Cu alloy", J Mater Sci Lett, vol 16, pp 1613–1615,1997.

[6] Ringer SP, Hono K, "Microstructural evolution and age hardening in aluminium alloys: atom probe field-ion microscopy and transmission electron microscopy studies", Mater Charact, vol 44, pp 101–131, 2000.

[7] S. A. Kori, B. S. Murty, M. Chakraborty, "Preparation and characterization of Al–B and B-rich Al–Ti–B master alloys for the grain refinement of Al–7Si alloy", AFS Trans, vol 109, pp 267–286. 2001.

[8] D. L. Zhang, L. Zheng, "The quench sensitivity of cast Al–7 wt.%Si–0.4 wt.%Mg alloy", Metall Mater Trans, vol 27, pp 3983–3891, 1996.

[9] E. Ogris, A. Wahlen, Luchinger, P. J. Uggowitzer, "On the silicon spheroidization in Al–Si alloys", J Light Metals, vol 2, pp263–269, 2002.

[10] S. Pietrowski, Siluminy, Wydawnictwo Politechniki Łodzkiej, Łodź, , pp. 249. 2001

[11] J. L. Cavazos, R. Colas, "Precipitation in a heat-treatable aluminum alloy cooled at different rates", Materials Characterization, vol 47, pp 175-179,2001.

[12] S. C. Wang, M. J. Starink, Precipitates and intermetallic phases in precipitation hardening Al–Cu–Mg–(Li) based alloys, International Materials Reviews, vol 50, pp 193-215,2005.

[13] K.T. Akhil, SanjiviArul, R.Sellamuthu, "The Effect of Heat Treatment and Aging Process on Microstructure and Mechanical Properties of A356 Aluminium Alloy Sections in Casting", Procedia Engineering,vol 97, pp 1676 – 1682, 2014.

[14] S.C Sharma & A Ramesh, "Effect of Heat Treatment on Mechanical Properties of Particulate Reinforced Al6061 Composites", Journal of Material Engineering and Performance, vol 9, no 5, pp 557-561 , Oct 2000.