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Study on Mechanical behaviours of newly formulated Aluminium 6061 Reinforced with Graphite and Rice Husk Ash (RHA)

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Abstract This paper investigates the mechanical properties like tensile strength, hardness, porosity and ductility of newly formed Al6061-Gr-Rice husk ash (RHA) metal matrix composite. In this investigation we added reinforcement in different weight ratio in Al6061. The reinforcement weight ranges from 0 to 6% Graphite and 0 to 5% of RHA are prepared by using stir casting technique. The scanning electron microscopy (SEM) analysis is used to analyse the microstructure of the prepared Al6061 metal matrix composite. The mechanical properties like hardness, tensile strength, ductility and porosity tested using standard methods and compared with the theoretical calculated value. The maximum tensile strength Al6061+4%Gr+5% RHA) 296 MPa is achieved at same composition. The maximum ductility observed at Al6061+2%Gr+1%RHA. Finally, the studies going on with distribution of micro structure on MMC as is condition and heat-treated condition.

Keywords –Metal Matrix Composites, Aluminium alloy, Graphite, Rice Husk Ash, As Cast (AC)

I. INTRODUCTION

Metal matrix composites (MMCs) are one of the important modernizations in the development of innovative materials. Among MMCs available, aluminum and its alloy are extensively used in the fabrication of MMCs. Aluminium element, whose symbol Al, is the most resourceful metallic element in the Earth. Pure form of Aluminium element is very soft in nature and it is a very light metal in weight with a specific weight around the 2699 kg/m^3, which is very less as compared to the steel. Graphite has a high melting point, like to that of diamond. In order to melt graphite, you have to break the covalent bonding throughout the entire structure. Graphite has a lower density than diamond. It has Lubricating feature because of this reducing friction during compaction. It has High resistant to corrosion resulting into long life of the components. Increases overall hardness of the Aluminium up to certain level and increases the tensile and yield strength of the metal. Reinforcement increases the strength, stiffness and the temperature resistance capacity and lowers the density of MMC. In order to achieve these properties, the selection depends on the type of reinforcement, its method of production and chemical compatibility with the matrix.

Mechanical testing plays an important role in evaluating fundamental properties of engineering materials as well as in developing new materials and in controlling the quality of materials for use in design and construction. If a material is to be used as part of engineering structure that will be subjected a load, it is important to know that the material is strong enough and rigid enough to withstand and the loads that it will experience in service. As a result, engineers have developed a number of experimental techniques for mechanical testing of engineering materials subjected to tension, compression, bending or torsion loading. It has enlarged ends or shoulders for gripping. The important part of the specimen is the gauge section. The cross-sectional area of the gauge section is less than that of the shoulders and grip region, so the deformation will occur at reduction in cross section area.

The most important aspects of the microstructure is the distribution of the reinforcing particles, and this depends on the processing and fabrication routes involved. The oxides of reinforcing particles used in the composites have a varying density. Density of the particles is one of the important factors determining the distribution of the particles in molten metal. Particles having higher density than molten metal can settle at the bottom and particles of lower density can segregate at the top. During subsequent pouring of the composite melt, the particle content may vary from one casting to another or even it can vary in the same casting from one region to another. Therefore, uniform distribution of the particles in the melt is a necessary condition for uniform distribution of particles in the castings. The properties of composites are finally dependent on the distribution of the particles. Hence the study of the distribution of the particles in the composite is of great significance.

II. Experimental Work

2.1 The tensile tests were conducted at room temperature by using universal testing machine (UTM) as per the E-8M ASTM Standard. The E-8M standard dimensions of tensile specimens of gauge length (G) five times more than diameter (D). The tensile tests samples 30 mm of diameter, the test uses specimens of 20 mm grip diameter, 30 mm grip length, 62.5 mm gauge length, 75 mm length of reduced cross section, inner diameter of 12.5 mm fillet radius of 10mm and total length 155 mm were machined from those cast composites for the gauge length of the sample parallel of the longitudinal axis of the castings. Five examples were tried and the average values of the ultimate tensile strength and ductility (in terms of percentage elongation) were measured. The schematic block diagram shown in below fig 1.

The tensile tests were conducted at room temperature by using universal testing machine (UTM) as per the E-8M ASTM Standard. The E-8M standard dimensions of tensile specimens of gauge length (G) five times more than diameter (D) are shown in Fig. 4 [18]. The tensile tests samples 30 mm of diameter, the test uses specimens of 20 mm grip diameter, 30 mm grip length, 62.5 mm gauge length, 75 mm length of reduced cross section, inner diameter of 12.5 mm fillet radius of 10mm and total length 155 mm were machined from those cast composites for the gauge length of the sample parallel of the longitudinal axis of the castings. Five examples were tried and the average values of the ultimate tensile strength and ductility (in terms of percentage elongation) were measured. The schematic block diagram shown in below fig 1.

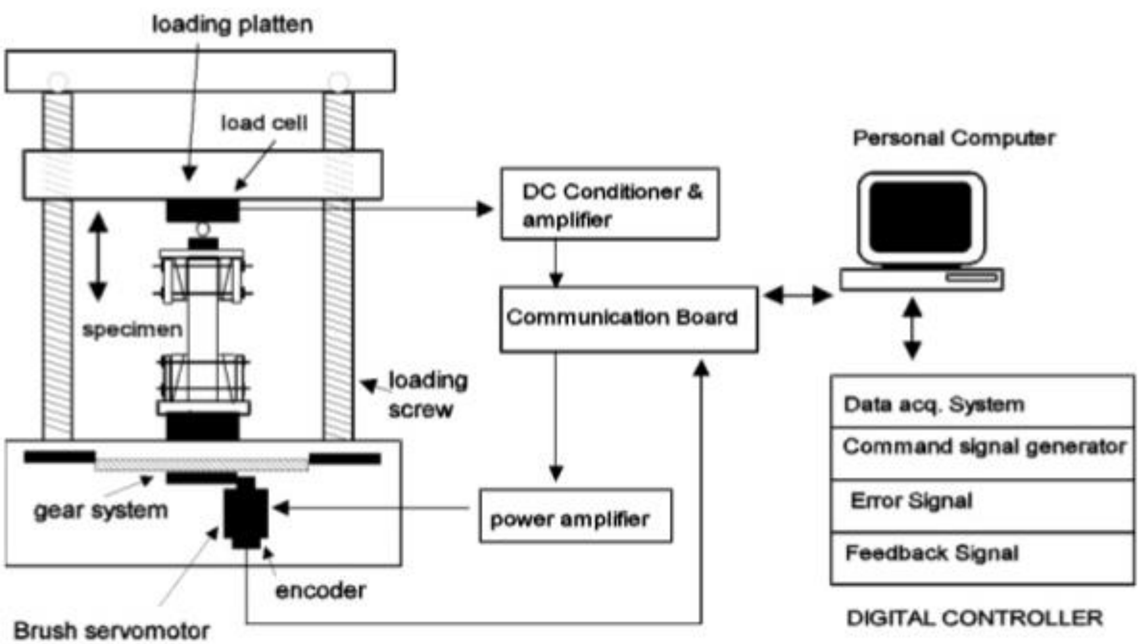


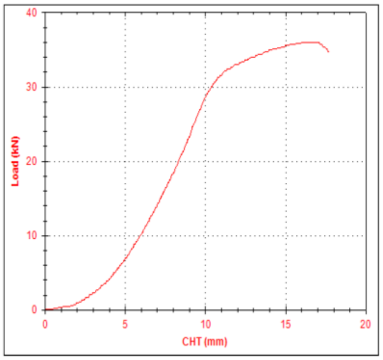
Fig. 1 SCHEMATIC DIAGRAM OF UTM

III. Results and Discussion

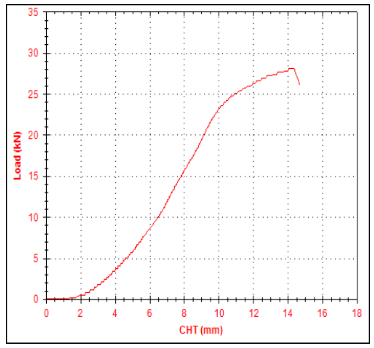
3.1 Tensile Test:

Table 3.1: Test results of UTS, Yield Strength, ductility and hardness for different composition of composites

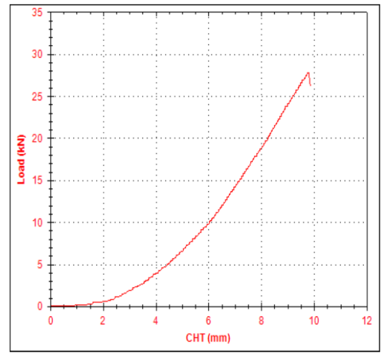
Composition	Heat treatment duration, hours	UTS in MPa	Percentage elongation in %	Yield Strength in MPa
Al6061+2% Gr+1% RHA	1 hour	296.4	12.2	254.1
Al6061+2% Gr+3% RHA	1 hour	231.1	3.9	216.6
Al6061+2% Gr+5% RHA	1 hour	236	7.6	201.5
Al6061+4% Gr+1% RHA	1 hour	34	1.7	31.1
Al6061+4% Gr+3% RHA	1 hour	226.5	1.3	209.4
Al6061+4% Gr+5% RHA	1 hour	205.9	6	187.4
Al6061+6% Gr+1% RHA	1 hour	257	1.7	227
Al6061+6% Gr+3% RHA	1 hour	246.8	2.3	229.5
Al6061+6% Gr+5% RHA	1 hour	170.6	4.1	152.2



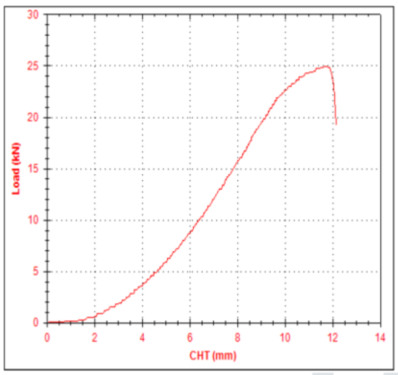
Al6061+2%Gr+ 1%RHA, 1 Hour H.T.



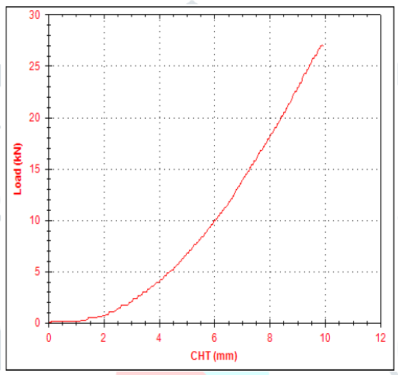
Al6061+2%Gr+ 5%RHA, 1 Hour H.T.



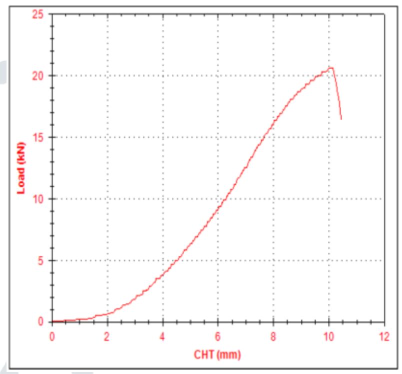
Al6061+4%Gr+ 3%RHA, 1 Hour H.T.



Al6061+4%Gr+ 5%RHA, 1 Hour H.T.



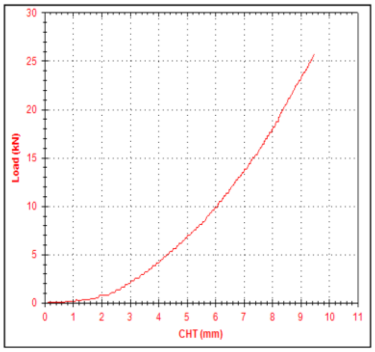
Al6061+6%Gr+ 3%RHA, 1 Hour H.T.



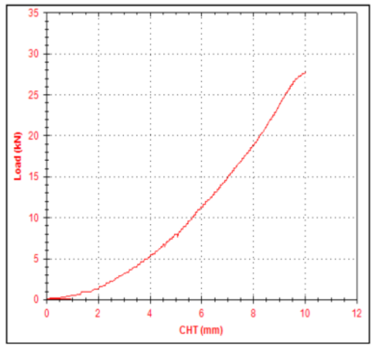
Al6061+6%Gr+ 5%RHA, 1 Hour H.T.

Table 3.2: Test results of UTS, Yield Strength, ductility and hardness for different composition of composites

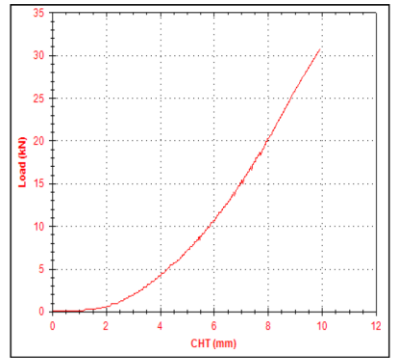
Composition	Heat treatment duration, hours	UTS in MPa	Percentage elongation in %	Yield Strength in MPa
Al6061+2% Gr+1% RHA	3 hours	67.2	2	59.6
Al6061+2% Gr+3% RHA	3 hours	51.1	2.4	60.8
Al6061+2% Gr+5% RHA	3 hours	256.1	1.7	232.5
Al6061+4% Gr+1% RHA	3 hours	228.8	3.2	209
Al6061+4% Gr+3% RHA	3 hours	260.2	3.3	238.5
Al6061+4% Gr+5% RHA	3 hours	52.9	3.6	46.9
Al6061+6% Gr+1% RHA	3 hours	273.9	3	237.9
Al6061+6% Gr+3% RHA	3 hours	172.9	1.2	157.7
Al6061+6% Gr+5% RHA	3 hours	225.9	5.4	210



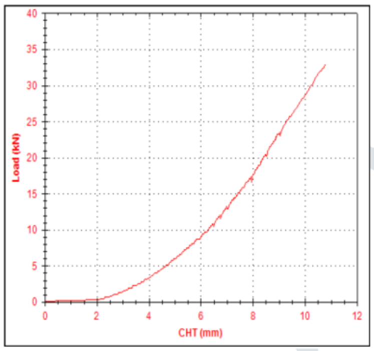
Al6061+2%Gr+ 1%RHA, 3 Hour H.T.



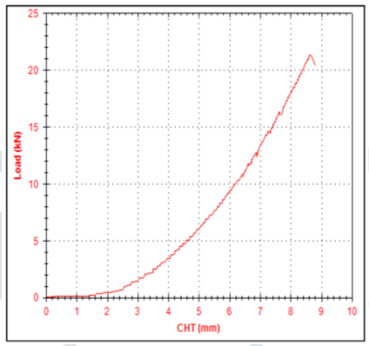
Al6061+2%Gr+ 3%RHA, 3 Hour H.T.



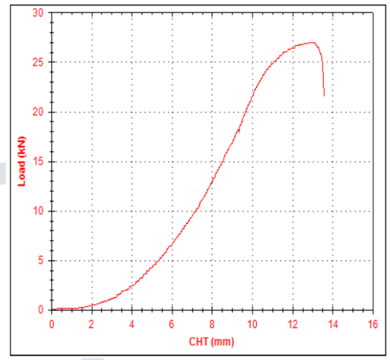
Al6061+2%Gr+ 5%RHA, 3 Hour H.T



Al6061+6%Gr+ 1%RHA, 3 Hour H.T



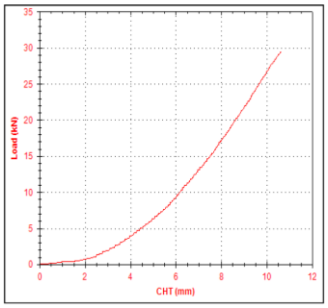
Al6061+6%Gr+ 3%RHA, 3 Hour H.T.



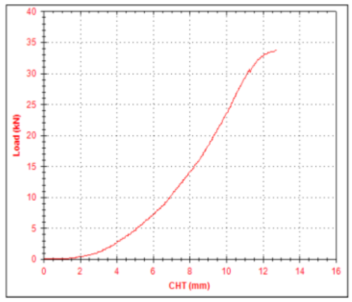
Al6061+6%Gr+ 5%RHA, 3 Hour H.T.

Table 3.3: Test results of UTS, Yield Strength, ductility and hardness for different composition of composites

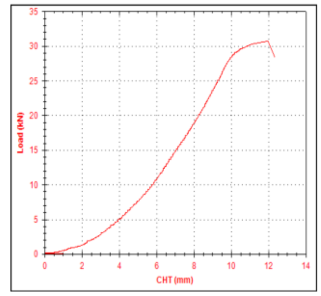
Composition	Heat treatment duration, hours	UTS in MPa	Percentage elongation in %	Yield Strength in MPa
Al6061+2% Gr+1% RHA	5 hours	274.2	2.8	247
Al6061+2% Gr+3% RHA	5 hours	255.9	1.2	237
Al6061+2% Gr+5% RHA	5 hours	253.1	4.9	233.7
Al6061+4% Gr+1% RHA	5 hours	219.9	1.3	203.5
Al6061+4% Gr+3% RHA	5 hours	137.2	2.5	137.2
Al6061+4% Gr+5% RHA	5 hours	224.1	2.1	204.9
Al6061+6% Gr+1% RHA	5 hours	242.7	1.6	225.6
Al6061+6% Gr+3% RHA	5 hours	262.2	1.8	230.9
Al6061+6% Gr+5% RHA	5 hours	140.2	2.6	127.7



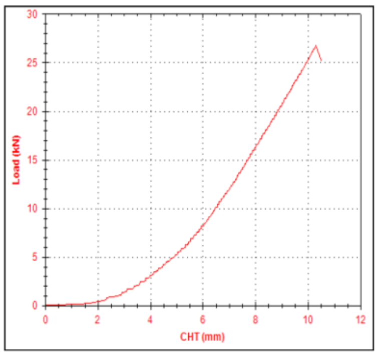
Al6061+2%Gr+1%RHA, 5Hour H.T.



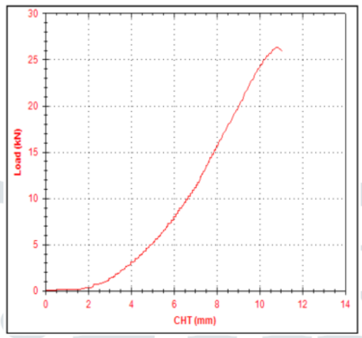
Al6061+2%Gr+3%RHA, 5Hour H.T.



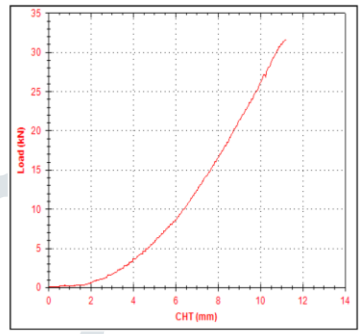
Al6061+2%Gr+3%RHA, 5Hour H.T.



Al6061+4%Gr+1%RHA, 5Hour H.T.



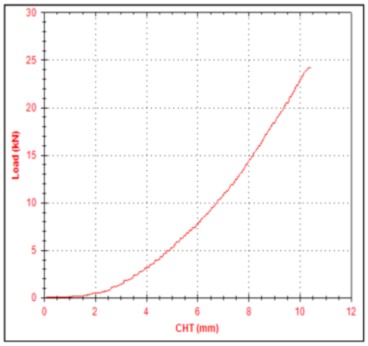
Al6061+4%Gr+3%RHA, 5Hour H.T.



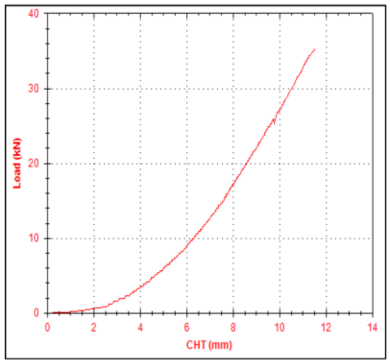
Al6061+6%Gr+5%RHA, 5Hour H.T.

Table 3.4: Test results of UTS, Yield Strength, ductility and hardness for different composition of composites

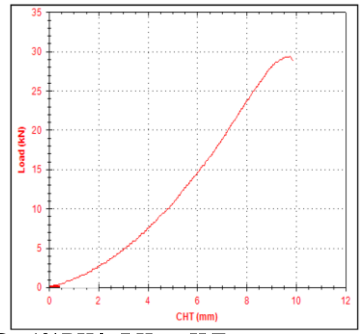
Composition	Heat treatment duration, hours	UTS in MPa	Percentage elongation in %	Yield Strength in MPa
Al6061+2% Gr+1% RHA	7 hours	292.3	2	261.8
Al6061+2% Gr+3% RHA	7 hours	203. 1	2.4	181.7
Al6061+2% Gr+5% RHA	7 hours	242.9	3.7	227.4
Al6061+4% Gr+1% RHA	7 hours	237.8	3	222.3
Al6061+4% Gr+3% RHA	7 hours	56.4	1.2	49.3
Al6061+4% Gr+5% RHA	7 hours	248.5	5.6	229.3
Al6061+6% Gr+1% RHA	7 hours	232.2	2.1	211.6
Al6061+6% Gr+3% RHA	7 hours	249.1	1.9	225.4
Al6061+6% Gr+5% RHA	7 hours	199.9	2.5	179.6



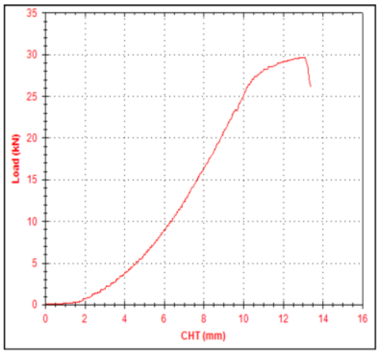
Al6061+2%Gr+3%RHA, 7 Hour H.T.



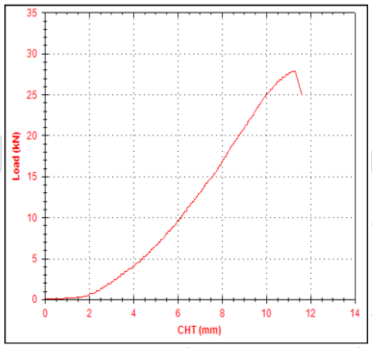
Al6061+2%Gr+5%RHA, 7 Hour H.T.



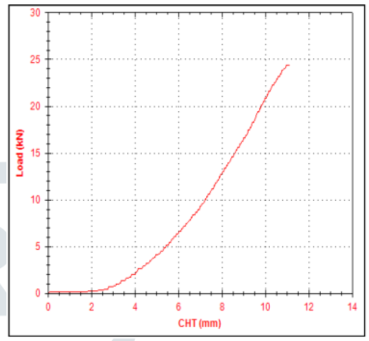
Al6061+2%Gr+1%RHA, 7 Hour H.T.



Al6061+4%Gr+5%RHA, 7 Hour H.T.



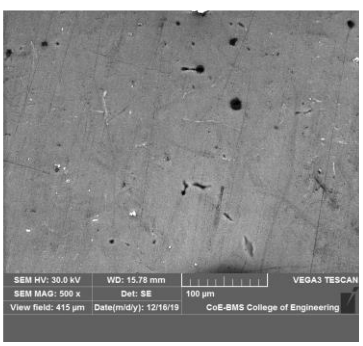
Al6061+6%Gr+1%RHA, 7 Hour H.T.

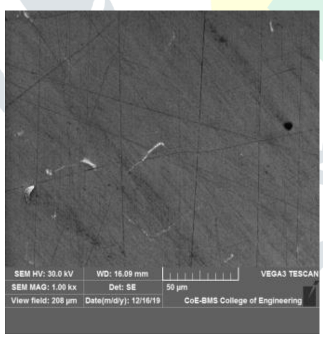


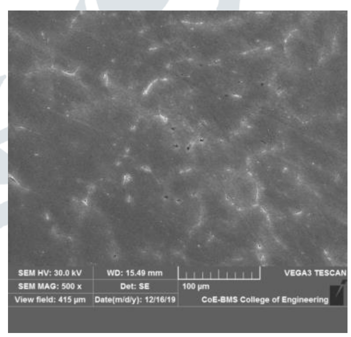
Al6061+6%Gr+5%RHA, 7 Hour H.T.

3.2 Microstructural studies using SEM

3.2.1 Effect of Graphite on microstructural studies with Heat treatment specimens:



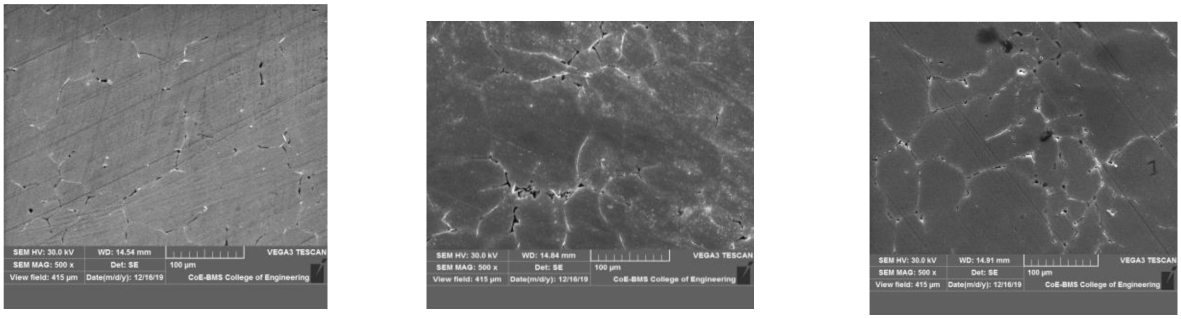




(a) (b) (c)

Fig 3.2.1: SEM of (a) Al6061+2%Gr+1%RHA (b) Al6061+4%Gr+1%RHA (c) Al6061+6%Gr+1%RHA

3.2.2 Effect of Graphite on microstructural studies without Heat treatment specimens:



(a) (b) (c)

Fig 3.2.2: SEM (a)Al6061+2%Gr+1%RHA(AC) (b)Al6061+2%Gr+3%RHA (AC) (c) Al6061+2%Gr+5%RHA (AC)

Conclusion:

By observing the tensile test report, it can be seen that the Ultimate tensile strength along with yield strength increases up to a level on reinforcing graphite powder and RHA in Aluminium alloy 6061. Furthermore, the Ultimate tensile strength increases on increasing the graphite reinforcement in the Aluminium alloy, but would start to decrease after a certain level. Here, on adding graphite by the variation of 2% by weight to the Aluminium alloy.

It is very clear that as reinforcement increase in base material, ductile tear occurs and ductility decreases as the reinforcement percentage increase in base material.

Microstructure tests were carried out to analyze the distribution pattern of Graphite and RHA reinforcements in the matrix material Al6061 specimens with and without Heat treatment. The microstructure study shown in figure 3.2.1 and 3.2.2 clearly indicates the uniform distribution of RHA particles in a matrix alloy. From fig it is very clear that as the RHA increases grains are refined and properties of martial also increases. It is evident that good bondage between the base matrix and RHA along with the graphite reinforcement.

References

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