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Effect of Graphite Reinforcements on Behaviour of Al6082 Used as a Surface Composite

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ABSTRACT: The ability of graphite particulates on the dry sliding wear behavior of aluminum alloy Al6082 graphite composites has been evaluated using pin-on-disc tools. The materials were fabricated by a liquid casting technique. Composites with 8 wt% graphite particles were processed. The casted composites were subjected to T6 heat treatment. The effect of sliding speed and sliding distance has been studied under dry sliding conditions. The hardness of the composites is measured using a Brinell hardness tester and their tensile strength is measured using a universal testing machine. The wear rate of the composites reduced with the addition of graphite content and reached a minimum with 8 wt% graphite content. The coefficient of friction is decreased with the addition of graphite content and reached a minimum at 8 wt% graphite. The effect of graphite on hardness and tensile strength is also studied. The 6082(Al)aluminum alloy exhibited its probable to act effectively as a self-lubricating material under dry sliding conditions in the lower range of graphite content, and 8 wt% graphite appeared to be optimum.

Keywords:

KEYWORDS: Aluminum alloy, Graphite, Composites, Universal testing

I. INTRODUCTION

In this paper a new method of producing aluminum—graphite particle composite alloys is described in which the copper- or nickel-coated graphite particles are mixed with aluminum powder. These powder mixtures are pressed into pellets and plunged into aluminum alloy melts prior to the hand-stirring of the melt, followed by casting. The variables examined were the optimum size and amount of aluminum powder, the pressure applied to make the pellet, and the size of the coated graphite particles. The pellet technique of producing graphitic aluminum alloys is attractive since it is easier to reproduce and control the composition using this technique than using either the gas injection or the vortex technique years. In an advanced society like ours we all depend on composite materials in some feature of our lives. Fiber glass, developed in the late 1940s, was the first modern composite and is still the most common. It makes up about 65 % of all the composites conceded today and is used for boat hulls, swimming pool linings, surfboards, building panels, sporting goods, and car bodies (Automobile bodies). Composites be present in nature. A piece of wood is a composite, with long fibers of cellulose held in concert by a much weaker core called lignin. Cellulose is also found in cotton and linen, but it is the compulsory power of the lignin that makes a piece of timber much stronger than a bundle of cotton fibers. In engineering materials, composites are created by coatings, internal adhesives and laminating. An important metal composite is dressed metals. Thermostatic controls are made by roll-bonding a very high expansion alloy such as copper to a low expansion alloy like steel. When the composite is heated it will avert to open electrical contacts. Ply wood is a similarly ordinary composite. Since wood is weaker in its transverse direction than its long direction, the alternating grain in plywood overcomes the transverse deficiency.

II. EXPERIMENTAL WORK

A. *Material:* Al6082 is used as the matrix material, which is one type of wrought aluminium. It is an Al-Cu binary alloy, containing aluminium as a major alloying element along with magnesium. The chemical composition of Al6082 is listed in Table I as per ASTM ingot specification analyzed by atomic absorption spectroscopy. It is an age hardenable alloy containing magnesium and copper. It has good strength, good corrosion resistance and good machining characteristics. Due to all these properties Al6082 is used in various applications like jet engines, structural and tubing.

Table 1: Elemental composition of Al6082

Elements	Mn	Fe	Mg	Si	Cu	Ti	Cr	Al
Content(wt%)	0.40	0.23	0.60	0.70	0.10	0.19	0.25	Balance

B. Preparation of Al6082– Graphite Composites:

Graphite composites were prepared by stir casting method. This method is a unique process for the preparation of metal matrix composites because of its simplicity, low economy, flexibility to process and control matrix structure. The method is also suitable for mass production of components. Before the start of casting process the essential sized graphite crucible, stirrer and the required amount (wt %) of B4C particulates were preheated to a temperature of 350o-400°C to reduce the temperature gradient and to improve the wetting between the molten matrix and the ceramic particles. Initially the required amount of Al6082 matrix material.

Initially the required amount of Al6082 matrix material was placed in a graphite crucible, and then placed in an electric resistance furnace, having 800oC temperature. The matrix was heated to 730oC. Once the entire Al6082 alloy matrix was completely melted, the degassing tablet known as solid hexachloroethane (C2Cl6) was added to the matrix melt to remove all the unwanted trapped gases from the crucible ensuring that the temperature in the crucible did not get transferred easily to atmosphere, thus preventing casting defects like blow holes and porosity.

After mixing of the reinforcement in two stages the temperature would have reduced and started to solidify, so again the composite temperature was increased to obtain a fully molten state and then stirring was continued for another few minutes at an average speed and finally poured into the permanent mould made from cast iron. After complete solidification of the composite, it was withdrawn from the mould.

Sener Karabulut et al [1]: The hardness, TRS (transverse break quality), also prolongation conduct technique for AA7039 strengthened for particulates of SiC, Alumina, GRAPHITE were investigated to clarify those impact of reinforcement substance. 3 composite AA7039 reinforced with 10% wt. of sic, Sic produced with solid metallurgy technique. Hardness, elongation, drilling behaviour, TRS tested for above composites. Useful interfacial holding might have been attained between Aluminium alloy7039, reinforced component. AA7039 composite strengthened with Graphite for 10% exhibited results with elevated hardness, elongation, TRS, prolongation among investigated examples. Crack surface dissection revealed uncovered cracks on crack surface for AA7039/GRAPHITE, 7039/SiC. The Graphite-reinforced composite exhibited better bonding against with the GRAPHITE, Sic reinforced composites. Better surface was achieved for AA7039/Graphite composite for drilling. Chip formation was affected by mechanical & morphological properties of work materials.

K. Umanath et al [2]: This paper displays those wear self-destructive considerations and conduct from claiming Al6082-T6 discontinuously fortified with silicon carbide (SiC), aluminum oxide (Graphite) composite. ASTM standard specimens were prepared. Those examinations conducted utilizing an pin for circle wear analyzer. Experimental connection to estimate wear, utilizing variance analysis (ANOVA), statistical analysis were done. The Outcomes demonstrated that the wear safety of the 15% mixture composite is superior to that of the 5% composite. Those crack surfaces for composites indicates ductile tear ridges and cracked Graphite particles demonstrating both flexible, fragile crack system.

T. Rajmohan et al [3]: Hybrid metal grid composites comprise about three constituents-a metal or a compound grid, two reinforcements on different forms, fortified together in atomic level in composite. In spite of their higher particular properties of quality, stiffness, those non homogeneous, anisotropic way joined together with abrasive reinforcements render their machining difficulty. In this work, surface integument of machining drilled hybrid composites been examined. Penetrating tests in changing shaft speed, bolsterrates, different drill materials.

will investigate impact for distinctive cutting parameters related to surface, level of deformity for penetrated surface due to infiltrating.. Materials utilized for examination were Al356/10SiC (wt %) metal grid, Al356/10SiC-3mica (wt%) mixture composites. The composites are created utilizing stir casting. Drilling tests on CNC center utilizing carbide, polycrystalline jewel (PCD) drills were done .Surface unpleasant for raising shaft speed reduces, increases with increasing feed rate. Machined surface is analyzed by electron microscopy (SEM). SEM pictures of the machined surfaces show the vicinity for grooves also pits. Micro hardness profiles demonstrate that those subsurface harm will be restricted to the top of 100-250 µm.

M. Ramulua et al [4]: Metal grid composites been found quite advantageous in number of engineering applications including the purchaser merchandise. However, machining these materials will be extreme because of abrasive qualities of reinforced particulates. In this study drilling investigations on Graphite aluminum-based MMC have been directed by utilizing diverse drills (high-speed steel, carbide-tipped, and polycrystalline jewel (PCD) drills) to process holes in 10%, 20% volume (Graphite)p/6082. Those drilling strengths were recorded utilizing dynamometer. Surface finish assessed by surface profilometer. Tool wear geometry inspected utilizing optical SEM. Those penetrating forces were assessed in terms of drilling forces, chip formation, drilled-hole nature, tool wear. It might have been discovered that PCD drills outperformed the greater part different drills as far as drilled-hole quality with less force. Exceptional outcomes attained with those PCD drills in line with other comparative investigations for other methods.

A.Pramaniketal[5]:Surface integrity, machining forces, friction angles, chip formation, shear, are significant elements to understand machinability about metal grid composites (MMCs). However, due to those complexity of reinforced components for ceramic particles, an unreasonable appraisal of the machinability about MMCs will be still a troublesome issue. This work investigates tentatively the impacts of support particles on machining MMCs. The major discoveries are: (1) the surface remaining focuses on the machined MMC would be compressive; (2) the surface unpleasantness may be controlled by feed; (3) molecule pull-out impacts those unpleasantness at low feed; (4) particles encourage chip breaking and effects generation of residual stresses; and (5) shear, rubbing angles depend fundamentally for feed independent of speed.

K.M. Shorewardi et al [6]: Three aluminum metal grid composites considering supporting particles for SiC, Graphite, GRAPHITE (0-20 %) Volume changed. The stir-molding process taken after high temp expulsion was been utilized, always a standout around expense compelling mechanical systems. An adequate interfacial reaction product or layer might have been viewed throughout Al-SiC interface for components held for more than 30 minutes. No reaction result might have been viewed Previously, Al-Graphite likewise Al-Boron carbide interfaces throughout the determination of SEM. On the diverse hand, two discretionary phases (alumina stage holding boron, aluminium, carbon) were found in the aluminum grid away from interface over Al-GRAPHITE components. Beginning with split surface analysis, the composite showed up remarkable interfacial considering contrasted for remaining composites.

Sener Karabulut et al [7]: AA7039/Graphite MMCs were generated from powder metallurgy, impact for milling parameters on surface unpleasantness, cutting force utilizing a uncoated carbide embed were investigated. Those processing tests were performed by Taguchi configuration utilizing L18, 21 x 32 with blended orthogonal array. Those impacts of cutting elements on surface unpleasantness, cutting force, were dictated utilizing variance analysis (ANOVA). Those dissections comes about indicated that material structures have been powerful element for surface unpleasantness, while feed rate might have been the prevailing element influencing cutting energy. Surface unpleasantness qualities were essentially progressed between 196% and 312% in milling, Graphite particle-reinforced. Aluminum compound composite in contrast with AA7039 aluminum. ANN regression investigation was applied for anticipating surface unpleasantness and cutting drive. ANN might used to foresee surface unpleasantness, cutting energy for mean squared slip equivalent to 2.25%, 6.66% individually

A. Baradeswaran et al [8]: This study investigated individual effect for red mud on wear activity for Al 7075-Graphite-5%wt red mud mixture composite. The individual's examination uncovers the invariability of red mud in composite for gaining wear reduction.

Al6082 strengthened to Graphite-red mud were investigated. Those work material produced with liquid metallurgy span. Ceramic particles with strong lubricating materials were joined with aluminium alloy to decline wear resistance, coefficient of friction. Al6082/Graphite/red mud mixture composite could have been primed for 5% red mud particles, 2, 4, 6, 8 wt.% about Graphite. Those hardness, flexible strength, flexural caliber, compressive strength of Al6082-Graphite-red mud mixture composites was increased with increased weight percentage for ceramic phase. Wear properties for mixture composites considering red mud exhibited excellent wear-resistance properties.

T. J. A. Doe1 et al [9]: This study investigated tensile examination for room heat situation for MMCs, on Al6082 alloy of reinforcement SiC for three apparent sizes 5, 13, 60pm. Above grid agedness states were studied, peak aged, equivalent underaged, overaged matrix condition based on micro harnesses timations. Those effects from agedness state on the flexible properties of the composites were on unreinforced material. Composites considering 5pm, 13 pm particles both required a greater amount staggering 0.2% confirmation anxiety in addition

unbending nature qualities again unreinforced matter. Composite specimen reinforced to 60 pm element obliged decrease 0. 2% confirmation tension In addition unbending nature in the under aged also peak time of reptiles condition. An additional staggering 0.2% stress in averaged form contrasted for individuals robust compound. Every single standout amongst composites necessary cut down pliability again the unreinforced material, to the material considering 5 pm SiC continually adaptable in addition that reinforced for 60 pm SiC facilitating inside and out low ductility. Failure appears to be will happendue to inner part damage withparticles fracture. Such harm initiates voids which create additionally prompt reduced pliability again these composites. Broad 60pm particles split undoubtedly to low associated stresses, provoking diminished 0. 2% confirmation tension and premature frustration contrasted for exchange composites. Little 5 besides 13pm particles harm few simply, subsequently those specimen might tough over those robust material.

III. METHODOLOGY

The fabrication of Al60-Graphite composites will be carried out by liquid metallurgy route via stir casting technique. The major components of the casting process consist of electrical resistance furnace; zirconium coated steel impeller and cast iron permanent mould. The power rating of electrical furnace will be 60kw and maximum temperature limit is 1200 degree Celsius. The mechanical stirrer used for stirring the molten alloy during the preparation of composites with high temperature and to prevent migration of ferrous ions from the stirrer material into Al6082 alloy melts.

Calculated amount of the Al6082 alloy ingots are charged into the furnace for melting. The melting point of Aluminium alloy is 660 °C. The melt superheated to a temperature of 750 °C. The temperature will be recorded using achrome-alumel thermocouple. The molten metal is then degassed using solid hexachloroethane (C₂Cl₆) for 3 min. A stainless steel impeller coated with zirconium is used to stir the molten metal to create a vortex. The stirrer will be rotated at a speed of 300rpm and the depth of immersion of the impeller was 60 percent of the height of the molten metal from the surface of the melt. Further, the Graphite particulates are preheated in a furnace upto 300°C will be introduced into the vortex. Stirring is continued until interface interactions between the reinforcement particulates and the matrix promotes wetting. Then, Al6082- 2,4 and 8 wt. % Graphite mixture are poured into permanent cast iron mold having dimensions 125mm length and 15mm diameter.

The micro structural study was carried out on the investigating composites using scanning electron microscope and EDS. Samples around 15 mm diameter cut from the castings and are polished properly. Keller's reagent is used to etch the samples. Further, based on the microstructural study compression, fatigue and wear properties are evaluated as per ASTM standards.

IV. EXPERIMENTAL RESULTS

Tensile Strength The mechanical testing of composite structures to obtain parameters such as strength and stiff less is a time consuming and often difficult process. It is, however, an essential process, and can be somewhat simplified by the testing of simple structures, such as flat coupons. The data obtained from these Tensile tests can then be directly related with varying degrees of simplicity and exactness to any structural shape

Dimensions

diameter of narrow section=10mm

length of narrow section= 100mm

over all length of section=160.0mm

overall diameter of section=15.0mm

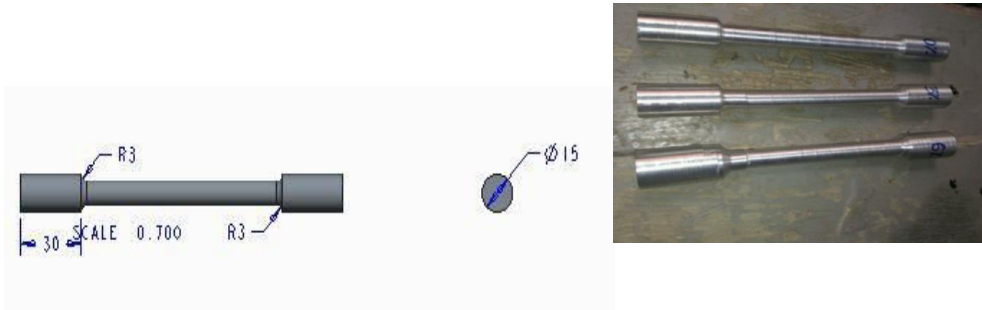
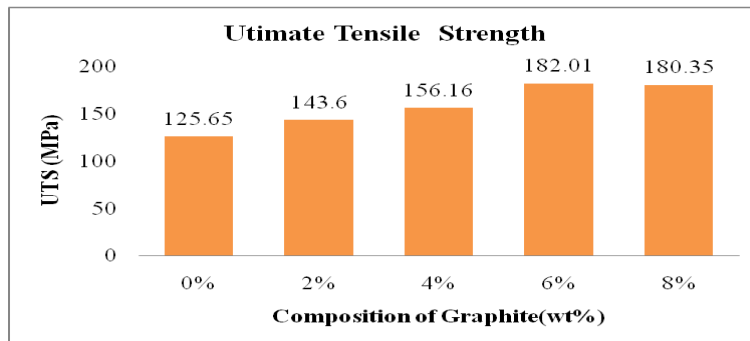


Figure shows Tensile testing samples

Table 1: Shows the tensile result

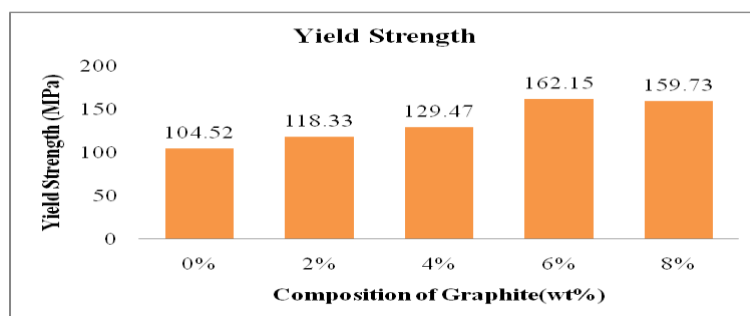
Sl. No.	Sample	UTS (MPa)	YS (MPa)	% Elong
1	Al6082 Alloy	125.6	104.52	15.33
2	Al6082-2% Graphite	143.6	118.33	14.30
3	Al6082-4% Graphite	156.2	129.47	13.73
4	Al6082-6% Graphite	182.0	162.15	13.07
5	Al6082-8% Graphite	180.3	159.73	12.13

➤ Ultimate Tensile Strength



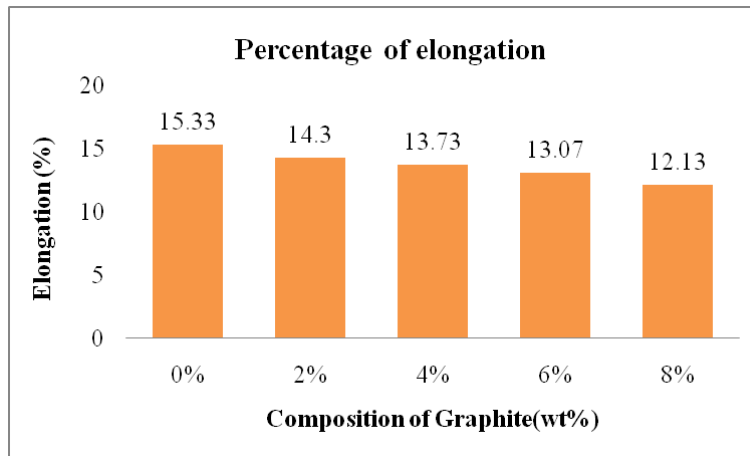
Graph1: showing the variations in ultimate tensile strength of Al6082 before and after addition of different wt. % of Graphite particulate

Yield Strength



Graph2: showing the variations in Yield strength of Al6082 before and after addition of different wt. % of Graphite particulate

Percentage Of Elongation



Graph3: showing the variations in % of Elongation of Al6082 before and after addition of different wt. % of Graphite particulate

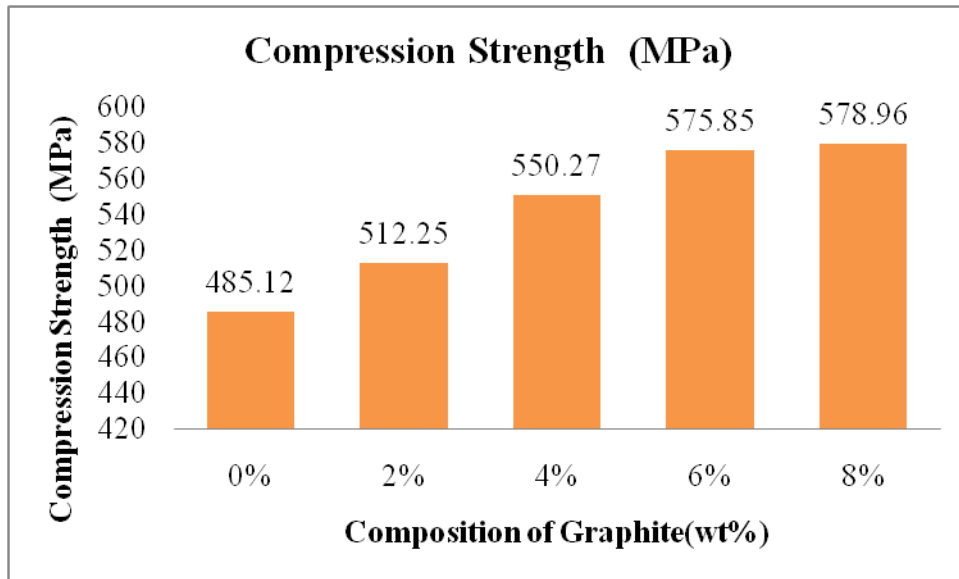
Compression Strength

A majority of parts of structures, machines or devices are invariably subjected to uniaxial compression load. The behaviour of a material under simple uniaxial compression is called compression behaviour. The test performed for this purpose is referred to as compression test.

Among the various mechanical testing, compression testing is one of the most important and widely used. One can obtain important information concerning the materials ductile properties, the character and extent of plastic deformation, ultimate strength and toughness. The response of materials to other type of loading can sometimes be explained or predicted on the basis of their behavior under simple compression. So much information can be obtained from a single test justifies its extensive use not only in engineering materials research but also in engineering industries for quality control and design purpose. Different materials respond differently to uniaxial compressive forces. The compressive curves correspond to these responses have discussed in below:

Table2: Shows the Compression results

Sl. No.	Sample	CS (MPa)
1	Al6082 Alloy	485.12
2	Al6082-2% Graphite	512.25
3	Al6082-4% Graphite	550.27
4	Al6082-6% Graphite	575.86
5	Al6082-8% Graphite	578.96



Graph4: showing the variations in Compression strength of 6082Al before and after addition of different wt. % of Graphite particulate

The compression strength of Al6082 alloy and various wt. % of Graphite composites. From the graph as weight percentage of Graphite reinforcement increases from 2 to 8 wt. %, This increase compression strength is mainly due to high compression strength of Graphite particulates. The compression strength of Al6082 alloy increased from 512.25 MPa to 578.96MPa by adding 8 wt. % of Graphite particulates in the matrix.

Hardness Strength

In a standard Brinell test 10.1 mm diameter (D) hardened steel ball is forced to go through the material by 3000 kgf for steels and cast iron (Brittle Material). The balldiameter (D) and given load selection is significant depending on the hardness of materials and 500 kgf is used for lighter materials with the same ball diameter. Keeping the ratio of load (P) to the square of diameter (D) constant different load and ball diameter combination can be definite and used in Brinell hardness testing.

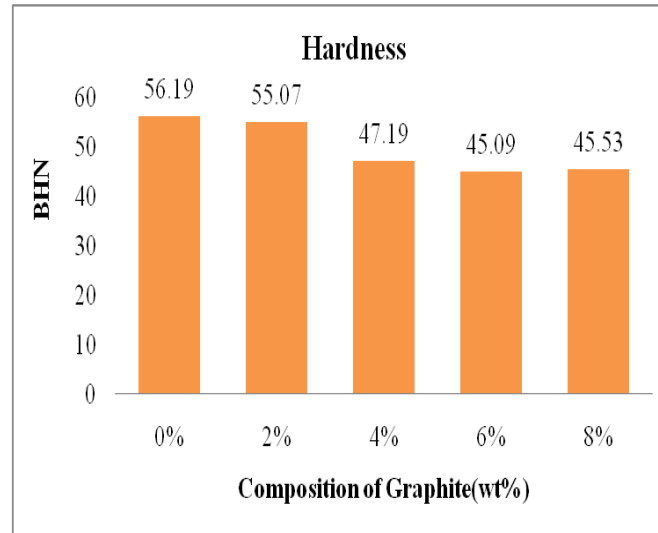


Figure shows sample for Hardness tested samples

TABLE 3: Shows the hardness results

Sl. No.	Sample	BHN
1	Al6082 Alloy	56.19
2	Al6082-2% Graphite	55.07
3	Al6082-4% Graphite	47.19

4	Al6082-6% Graphite	45.09
5	Al6082-8% Graphite	45.53



Graph5: showing the variations in BHN of 6082Al before and after addition of different wt. % of Graphite particulate

It is observed macro-hardness of increasing linearly with increase in weight percentage of Graphite particles. this may be attributed because of escalation in occurrence of hard Graphite particles in the aluminium matrix and high hardness of Graphite particles. incorporation of reinforcement particles in the aluminium matrix enhances their surface area and the size of aluminium matrix grains reduced. the occurrence of these hard surface areas of Graphite particles offers huge resistance to the plastic deformation which results into augmentation of the hardness of fabricated.

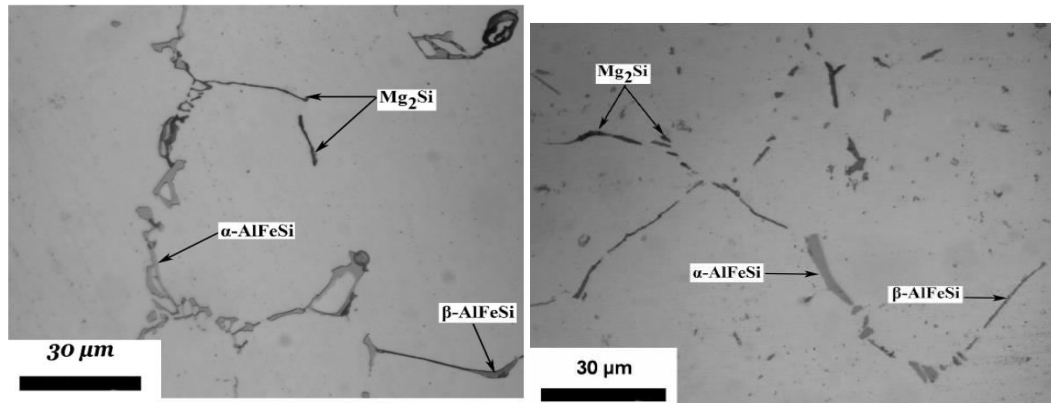
Microscopic analysis

Microscope was used to examine the casted surfaces of the test samples. In present study, OLYMPUS Microscope BX51M with Clemex Image analyzer was used for the analyzing material characterization of surface of the materials. Microscopic images of different casted specimen such as 0%, 2%, 4%, 6% and 8 wt% of Graphite were analysed .



Figure shows sample for Characterization analysis

Scanning Electron Microscope Images



For both the composite rods, the microstructure shows the grain boundaries, interdendritic network of graphite particles distributed in a matrix of aluminium solid solution throughout the structure. The composite reinforced with graphite in also presents a microstructure without porosity with uniform distribution of the reinforcing phase (Graphite) and without the presence of agglomerations.

V. CONCLUSION

The AMMC with different Weight fraction of graphite is fabricated and various investigations were made.

- Hardness values of the components were found and the hardness of the component increases with the increase in Graphite percentage.
- Tensile strength has been increased at 2, 4 and 6 wt.% of Graphite, but when the percentage of Graphite is increased further to 8 wt.%, the tensile strength is decreased.
- The microstructure shows the grain boundaries, interdendritic network of aluminium oxide and graphite particles distributed in a matrix of aluminium solid solution throughout the structure.
- There is increase in compression strength with addition of 6 and 8 wt. % Graphite particulates to base Al6082 alloy.

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