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FABRICATION AND CHARACTERISTICS ON SILICON CARBIDE REINFORCED WITH AA7075-T6 ALUMINUM ALLOY COMPOSITE

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Abstract: Aluminum alloy AA7075 is an important material used in aerospace, electrical and automotive industries due to their better physical, mechanical, corrosion resistive properties. silicon carbide (Sic) is a potential particulate reinforcement to produce Aluminum matrix composites (AMCs) economically . Stir casting method was applied to produce Aluminum alloy AA7075 reinforced with various amount of (3% & 5% in the total composition) of silicon carbide particles. The prepared composites where characterized and mechanical properties such as hardness , tensile & compression strength are determined and also its microstructures properties are analyzed using scanning electron microscope(SEM) .this result will show better mechanical properties with addition of (Sic) to the matrix.

***Index Terms* - Aluminum alloy 7075 , composite , silicon carbide , fabrication**

1.INTRODUCTION

Silicon carbide particles (Sic)-reinforced metal–matrix composites (MMCs) have been considered as an excellent structural materials in the aeronautic–aerospace, automotive industry for its lower density, better corrosion resistance and high specific strength [1]. The key to their property improvement lies in the structure, chemistry and the nature of bonding of aluminum (Al)–silicon carbide (SiC) interfaces[2]. Metal–matrix composites are conventionally fabricated using different techniques such as power metallurgy, squeeze casting, and the stir casting. Stir casting is cost effec-tive. Powder metallurgy is expensive. An inherent difficulty encountered in the fabrication of SiC–Al alloy composites is that the molten Al alloys normally do not wet considerably the ceramic reinforcements.

It is well known that the SiC reinforcements tend to react with aluminum during processing, leading to the formation of Al_4C_3 and Si at the interface. Efforts have been directed to prevent the chemical reaction at interfaces by oxidation of SiC, coating of SiCp, or alloying of Al matrix with Mg or Si.[3] Further efforts are needed to fabricate AA7075/SiC composites, where SiCp are uniformly distributed in 7075 Al alloy matrix and there are no chemical reactions at the interface. Characterization of AA7075/SiCcomposites by various techniques is needed to ascertain the proper microstructure, identification, distribution and weight percentage of different element in 7075 Al alloy. It is also necessary to know if there are any adverse chemical reactions during fabrication

2. COMPOSITE MATERIAL

Composite material is a material composed of two or more distinct phases (matrix phase and reinforcing phase) and having bulk properties significantly different from those of any of the constituents. Many of common materials (metals, alloys, doped ceramics and polymers mixed with additives) also have a small amount of dispersed phases in their structures, however they are not considered as composite materials since their properties are similar to those of their base constituents (physical property of steel are similar to those of pure iron) . [4]Favorable properties of composites materials are high stiffness and high strength, low density, high temperature stability, high electrical and thermal conductivity, adjustable coefficient of thermal expansion, corrosion resistance, improved wear resistance etc.

3. ALUMINUM ALLOY 7075-T6

7075-T6 aluminum alloy is an aluminum alloy, with zinc as the primary alloying element. It is strong, with a strength comparable to many steels, and has good fatigue strength and average machinability. fig.1 shows AA7075-T6 raw materials in a round rod form. It has lower resistance to corrosion than many other aluminum alloys, but has significantly better corrosion resistance than the 2000 alloys. Its relatively high cost limits its use [6].7075 aluminum alloy's composition roughly includes 5.6–6.1% zinc, 2.1–2.5% magnesium, 1.2–1.6% copper, and less than a half percent silicon, iron, manganese, titanium, chromium, and other metals. Physical Properties of Aluminium Alloy is given in table 1.

FIG.1 : AA7075-T6 RAW MATERIALS

TABLE : 1 PROPERTIES OF ALUMINUM ALLOY

PHYSICAL PROPERTIES	METRIC	ENGLISH
DENSITY	2.81 G/CC	0.102 LB/N^3
HARDNESS,BRINELL	150	150
ULTIMATE TENSILE STRENGTH	572 MPA	83000PSI
MODULUS OF ELASTICITY	71.7 GPA	10400KSI
POISSON'S RATIO	0.33	0.33

4. SILICON CARBIDE

Silicon carbide Sic also known carborundum a semiconductor containing silicon and carbon. It occurs in nature as the extremely rare mineral moissanite. Synthetic SiC powder has been mass-produced since 1893 for use as an abrasive [7]. Grains of silicon carbide can be bonded together by sintering to form very hard ceramics that are widely used in applications requiring high endurance, such as car brakes, car clutches and ceramic plates in bulletproof vests.

FIG.2 SILICON CARBIDE

Electronic applications of silicon carbide such as light-emitting diodes (LEDs) and detectors in early radios were first demonstrated around 1907. SiC is used in semiconductor electronics devices that operate at high temperatures or high voltages, or both [8]. Large single crystals of silicon carbide can be grown by the Lely method and they can be cut into gems known as synthetic moissanite. SiC with high surface area can be produced from SiO_2contained in plant material.

PROPERTIES OF SILICON CARBIDE

PROPERTIES	SiC
Melting point temperature	2200-27000C
Hardness(Vickers)	2800-3300

5. EXPERIMENTAL METHODS

Methodology is the systematic, theoretical analysis of the methods applied to a field of study. It comprises the theoretical analysis of the body of methods and principles associated with a branch of knowledge. A methodology does not set out to provide solutions-it is therefore, not the same as a method.

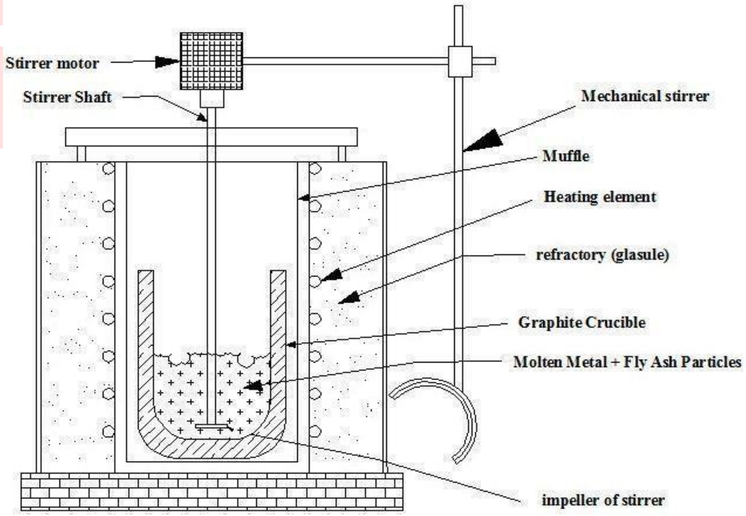
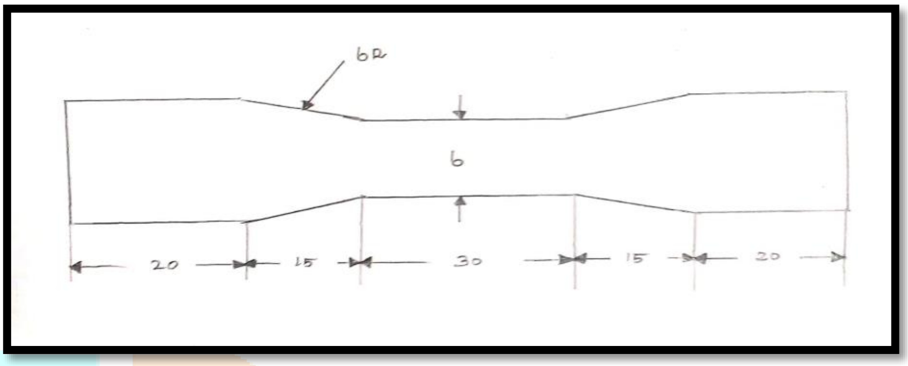


FIG 3 : STIR SQUEEZE CASTING

In stir casting, a dispersed phase (ceramic particles, short fibres) is mixed with a molten metal matrix by means of mechanical stirring[9]. The fig 23 shows the stir Squeeze casting process. In a recent development in stir casting is a two-step mixing process. The matrix material is heated to above its liquidus temperature so that the metal is totally melted. The melt is then cooled down to a temperature between the liquidus and solidus points and kept in a semi-solid state. At this stage, the preheated particles are added and mixed. The slurry is again heated to a fully liquid state and mixed thoroughly. The effectiveness of this two-step processing method is mainly attributed to its ability to break the gas layer around the particle surface.

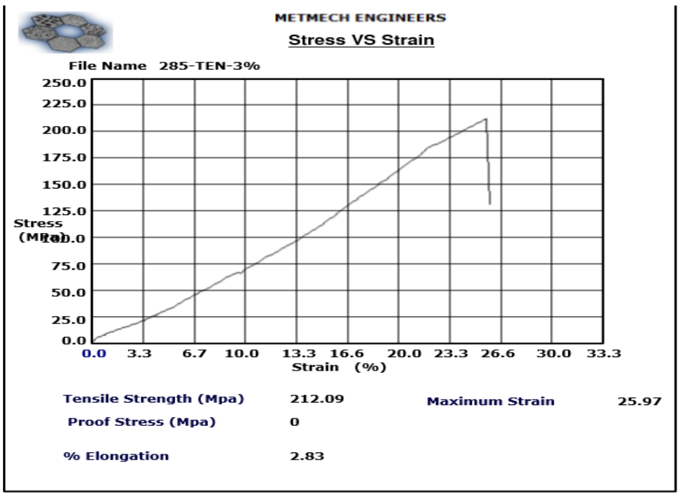
6. TENSILE TEST

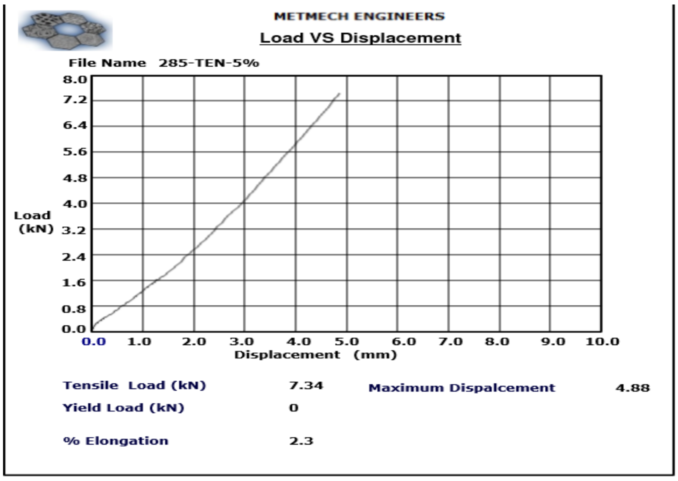
The tensile tests were used to assess the mechanical behavior of cast the composites and the matrix alloy. The tensile specimens were prepared from the cast MMCs as per ASTM E08 standard. [11]The Ultimate Tensile Strength (UTS) was estimated using a computerized universal testing machine (TUE-C-1000). Three specimens prepared from each HMMC and base alloy as shown in Figure were tested and the average value of tensile strength was estimated.



(D) DIMENSIONS OF TENSILE SPECIMEN OF AA7075-SIC

Tensile Specimen





7.HARDNESS TEST

To evaluate the hardness of the composites, the Brinell hardness was conducted. The micro hardness of polished samples was measured at different locations using the Brinell hardness at a load of 500 gram for 10 sec.

Hardness specimen

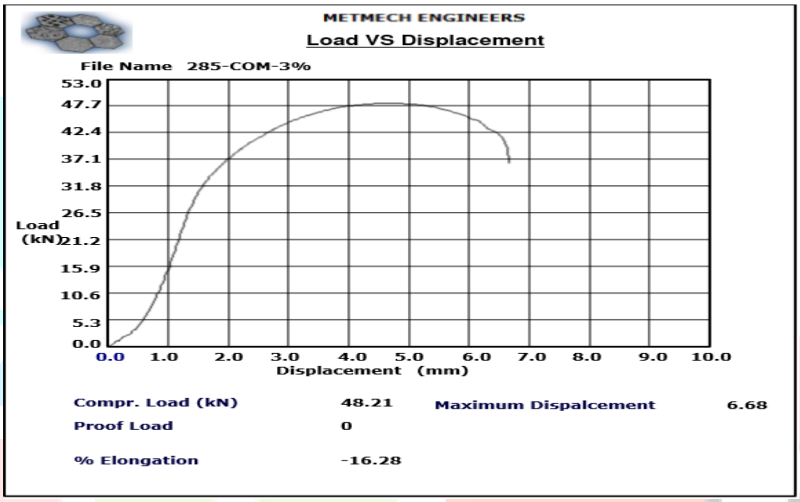
Dwell time: 10 seconds.
Unit: H.V. @ 0.5 Kgf load.
Hardness:
Sample No: 1 56.5, 56.1, 58.5 H.V. @ 0.5 Kg load.
Sample No: 2 64.0, 64.2, 64.8 H.V. @ 0.5 Kg load.

8.COMPRESSION TEST

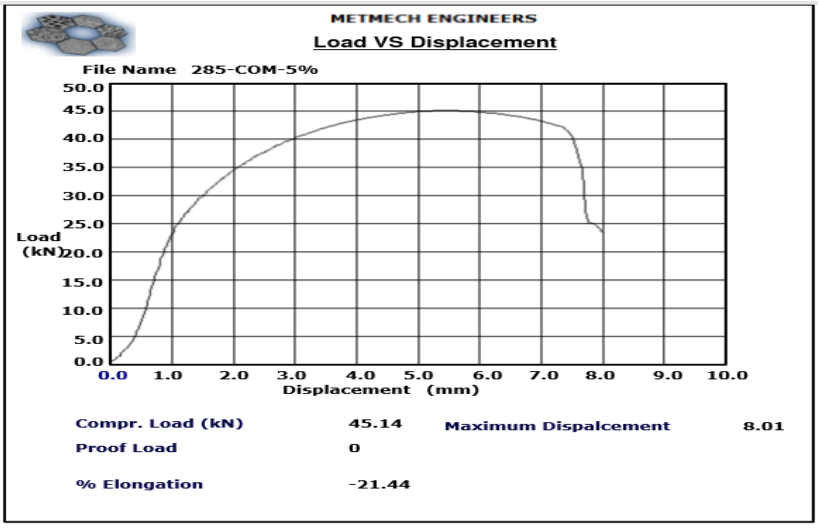
Compressive strength or compression strength is the capacity of a material or structure to withstand loads tending to reduce size, as opposed to tensile strength, which withstands loads tending to elongate.

In other words, compressive strength resists compression (being pushed together), whereas tensile strength resists tension (being pulled apart). In the study of strength of materials, tensile strength, compressive strength, and shear strength can be analyzed independently.

Compression test



Some materials fracture at their compressive strength limit; others deform irreversibly, so a given amount of deformation may be considered as the limit for compressive load. Compressive strength is a key value for design of structures.



9. MICROSTRUCTURE ANALYSIS

This test looks at a sample of your urine under a **microscope** [12]. It can see cells from your urinary tract, blood cells, crystals, bacteria, parasites, and cells from tumors. This test is often used to confirm the findings of other tests or add information to a diagnosis.

Sample-1-AA7075+3% SiC

As polished:

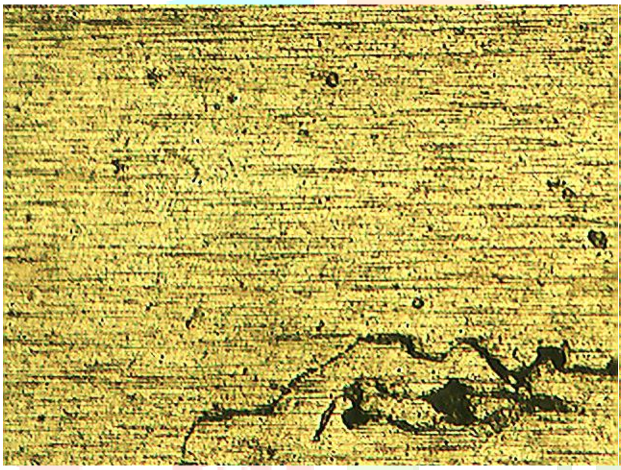


Fig-1

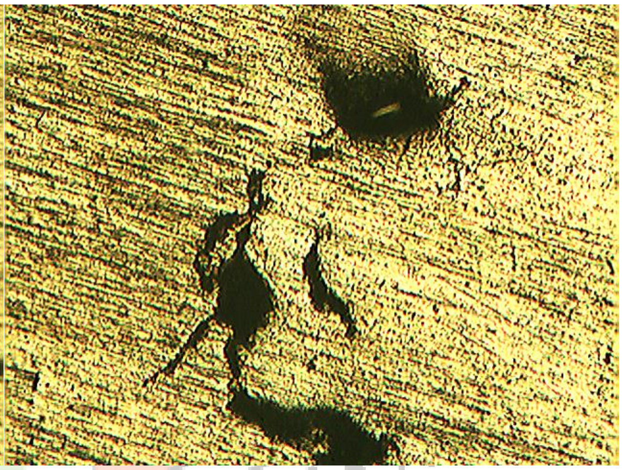


Fig -2

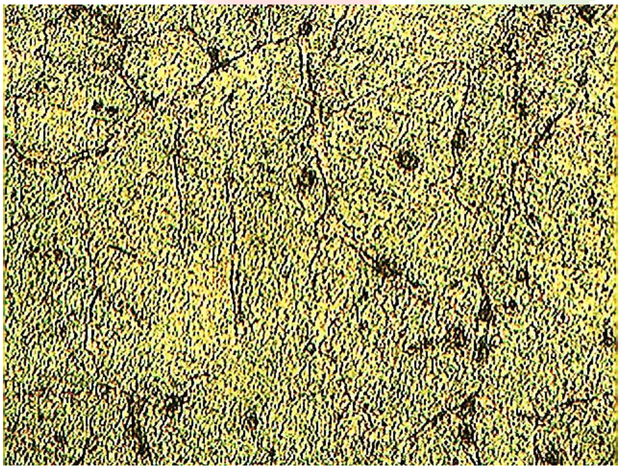


Fig -3

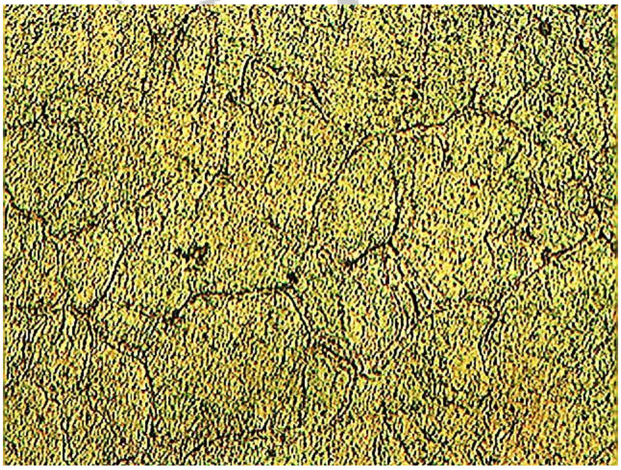


Fig -4

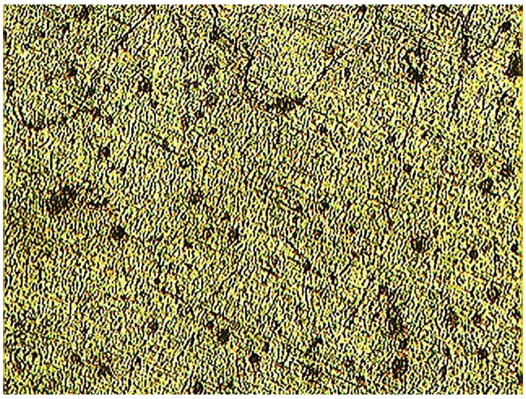



Fig -5 **Fig -6**

Magnification: 100X & 220X **Etchant: Keller's Reagent.**

Fig -1 & 2: Shows the polished matrix of the metal matrix composite of stir cast AA 7075-T6. The micrograph shows the distribution of large sized composite particles of SiC in aluminium metal matrix. The particles are larger in size and spread as group of particles. **Fig** -3 & 4: Shows the etched metal matrix at 100X magnification. The microstructure shows the fine composite particles distribution in the aluminium solid solution. However the eutectic particles of Cu-Al2 and Mg2Si particles are also precipitated in the matrix. **Fig** -5 & 6: Shows the same sample at higher magnification which shows the uniform distribution of composite particles in aluminum matrix.

Sample-2-AA7075+5% SiC

As polished:

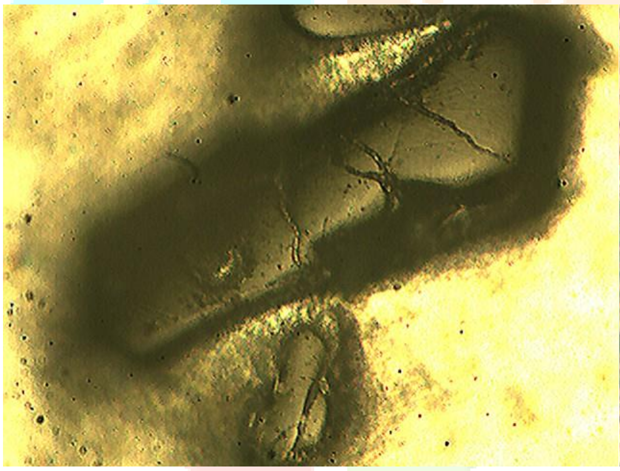
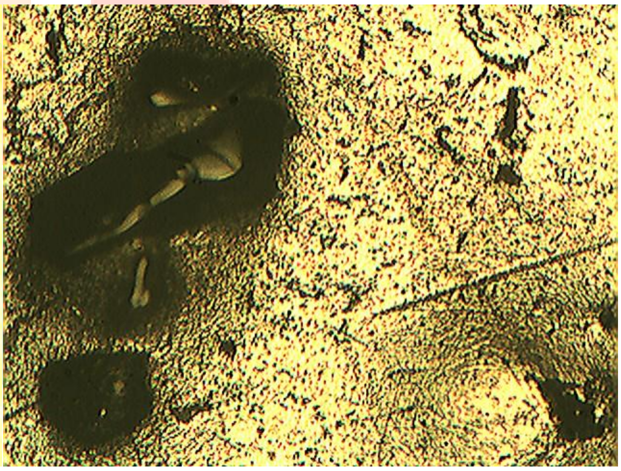



Fig -1&2 Shows as polished

AsEtched:

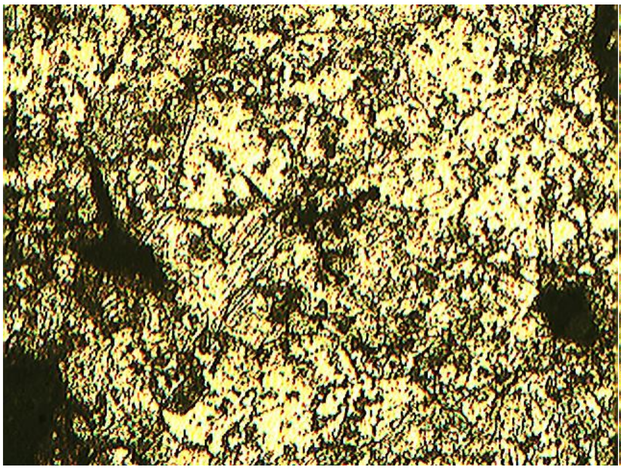
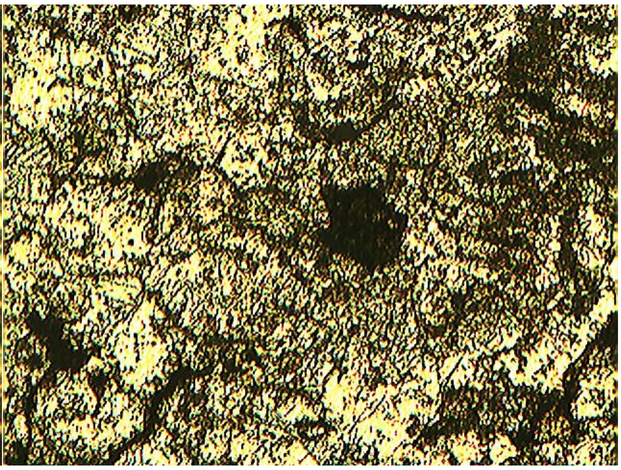



Fig -3 **Fig -4**

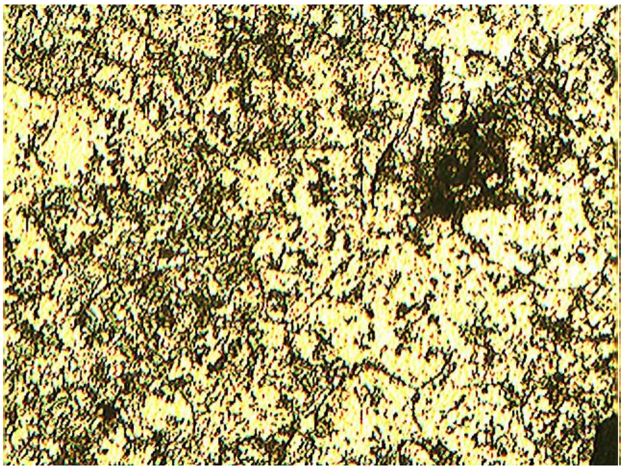


Fig -*5*
Magnification: 100X & 220X

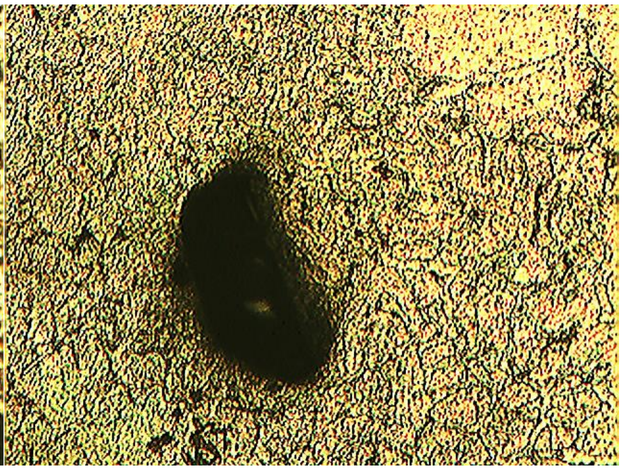


Fig -*6*
Etchant: Keller's Reagent.

Photo-1 & 2: Shows the very large particles of SiC composite particles distribution in the metal matrix of stir cast AA 7075-T6 aluminum matrix. The size of the particles are more than 100 microns and some smaller particles also present as groups.

Photo-3 & 4: Shows the etched matrix of composite added stir cast AA 7075 –T6 [13]. The microstructure shows fine dendritic grains of primary aluminum solid solution grains with particles of composite occupies the junction of the grains. The eutectic constituents also precipitated at the grain boundaries and the grain boundaries appear thick,

Photo-5 & 6: Photo-5 shows the fine grained inter dendritic aluminum primary phase grains with precipitated particles of eutectics [14] . However the composite particles are present as lumps in the metal matrix. Photo-6 shows the isolated large particles of SiC in metal matrix. Other fine particles are the precipitated eutectic particles in aluminum solid solution.

During **Microstructure Analysis** of metals and alloys, a Microscopic Examination is conducted to study the structure of the material under magnification. The properties of materials determine how well they'll perform under a given application, and these properties are dependent on the material's structure.

10.RESULT AND CONCLUSION

The silicon carbide was mixed with AA7075 to from an alloy using stir casting method 3% and 5% of silicon carbide was mixed with AA7075-T6 [15]. The addition of silicon carbide to AA7075 improved the mechanical strength of the base metal. It was found that 3% silicon carbide inclusion showed the best mechanical properties than 5% silicon carbide inclusion.

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