Investigation on Microstructure, Density, Hardness & Wear Behavior of Al-Si Graphite Composites

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***Abstract*—The Aluminium matrix composites particularly used with reinforcements are advanced materials that are widely used as a substitute materials in automotive industry, to manufacture lighter weights & high performance components. These components are often subjected to sliding wear under working conditions; therefore several of these applications require enhanced wear resistance. The reinforcements are added to the aluminium alloys through liquid casting techniques. The influence of reinforcements in Aluminium matrix composites samples are tested to find improvements in wear resistance. The percentage composition with better wear resistance is identified for the applications.**

I. INTRODUCTION

Aluminium Metal matrix composite are being employed in industrial applications since they have a high specific strength, stiffness and better wear behaviour. Metal matrix composites exhibits enhanced properties compared to conventional alloys in various applications. Aluminium matrix composites with multiple reinforcements are finding applications in aerospace and automotive industries due to enhanced mechanical and tribological properties compared to single reinforced composites.

Wear is the property in which the material is removed from one or both of the two solid surfaces in a solid state contact during relative motion between them. Solid lubricants are used for applications in which any sliding contact occurs to reduce friction between the surfaces. The Solid lubricants provide protection from damage during relative movement between the sliding elements to reduce the friction and wear. Graphite is a better solid lubricant which can be used upto 7.5% due to its limited lubricating effect.

Aluminium alloy graphite composites have better tribological characteristics which is one of the most desirable features in automotive engine pistons, bearings and bushings. The addition of graphite particle to the aluminium alloy matrices makes the alloy self-lubricating since they act as solid lubricants. Eutectic Al-Si alloy have high strength to weight ratio and low co-efficient of thermal expansion and this makes them attractivematerials in many of the tribological applications.

II. METHODOLOGY

The liquid metallurgy which is more economical to fabricate composites with discontinuous fibre or reinforcements is adopted to prepare composite specimens. In the present work, stir casting technique is employed to fabricate AMC's. Which is a liquid state method of composite material fabrication in which reinforcement particulates is mixed with molten metal by means of stirring raw Al-Si alloy was fed into electrical furnace & heated up to 720°c, which was above its melting point 650°c. At this temperature magnesium was added in order to increase wetting ability, hexa-chloro-ethane was added for degassing, coverall (alkaline based) was added to remove slag & improve wetting ability. So that reinforcement added to metal will get evenly dispursed. A known quantity of preheated (300°c) graphite reinforcement was added slowly into crucible & after stirring for 10 minutes,it is then transferred into the die.

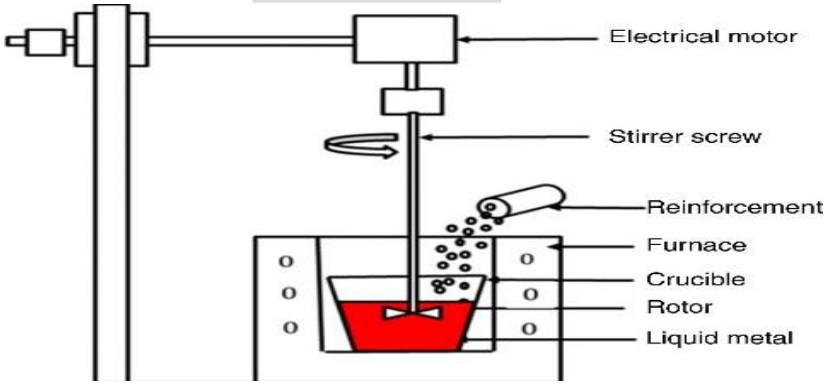

Fig 1. Stir casting.

Composition of the alloy used

Element	Fe	Si	Al
Wt%	0.02	12.6	87.4

Table 1: composition of alloy

Graphite powder size:50µ

III. EXPERIMENTATION

The following table shows the amount of reinforcement added to the alloy:

Matrix	% Reinforcement (graphite)
Al-Si	0
Al-Si	1.5
Al-Si	3
Al-Si	4.5

Table 2 percentage reinforcement added

MICROSTRUCTURE: The specimen subjected to optical micrography were first rough polished with a series of silicon carbide papers of 600, 800, 1000 1/0, 2/0, 3/0, 4/0 and 2000 grid size. Then fine polishing was done by applying Aluminium oxide paste and polishing on disc polishing machine. Microscopic examination was done under optical microscope using 500X magnification lenses.

Fig 2 Microscope

DENSITY: The samples of composites were cleaned carefully and were weighed in air. And then were immersed in distilled water taken in a standard 25.05ml flask. The initial and final water level is noted down to calculate the density using Archimedes principle. Theoretical density was calculated by the rule of mixtures.

HARDNESS TEST: Automatic digital micro hardness tester was used to measure the Vickers hardness of composites. A micro hardness test was conducted on the polished samples under a load of 1kN with a dwell time of 10s in accordance with the ASTM standard.

Fig 3 Micro hardness Tester

WEAR TEST: Wear is the damage to a solid surface, generally involving progressive loss of material due to relative motion between the surface & a contacting substance.

Sliding wear is wear due to relative motion in tangential plane of contact between two solid bodies typically recognized by linear grooves that are generated from reciprocating or unidirectional contact.

Pin on disc wear test is conducted as per ASTM standard G99

Specimen details:

Diameter: 10mm

Height: 30mm

Hardness of the disc: 60 HRC

Fig 3 Pin on disc Wear testing Machine

IV. Results & discussion

Microstructure:

Following are the figures of microstructure

Fig 4 - 0%

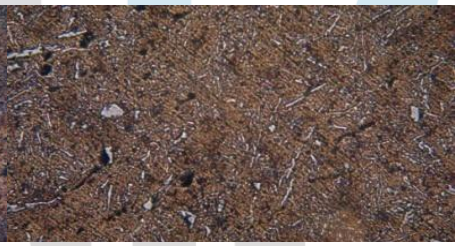

Fig 5 - 1.5%

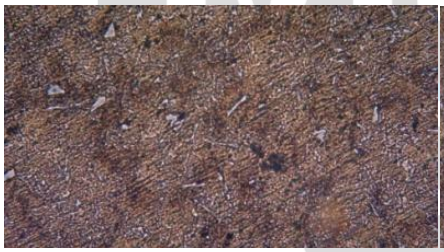

Fig 6 - 3%

Fig 7 - 4.5%

Fig 4 shows the microstructure of Al-Si alloy in which dendrite structure can be observed. It indicates that the silicon is uniformly distributed in Aluminium alloy. Also the porosity can be observed.

Fig 5,6 and 7 shows the microstructure of composites with addition of 1.5%, 3% & 4.5% compositions of graphite respectively. The graphite particles were uniformly distributed in the composite.

DENSITY TEST:

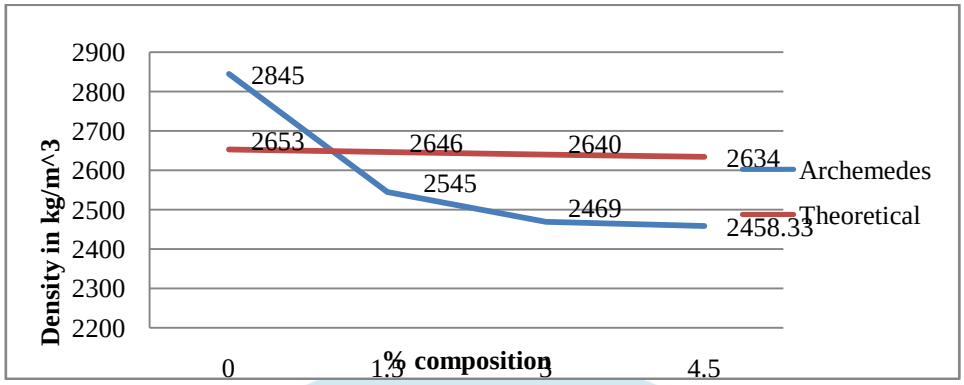

Fig 8 Graph of % composition versus Density

The density of the composite was observed to be decreasing with the increase in percentage composition of graphite both theoretically and experimentally. This is due to porosity occurred during casting process.

HARDNESS TEST:

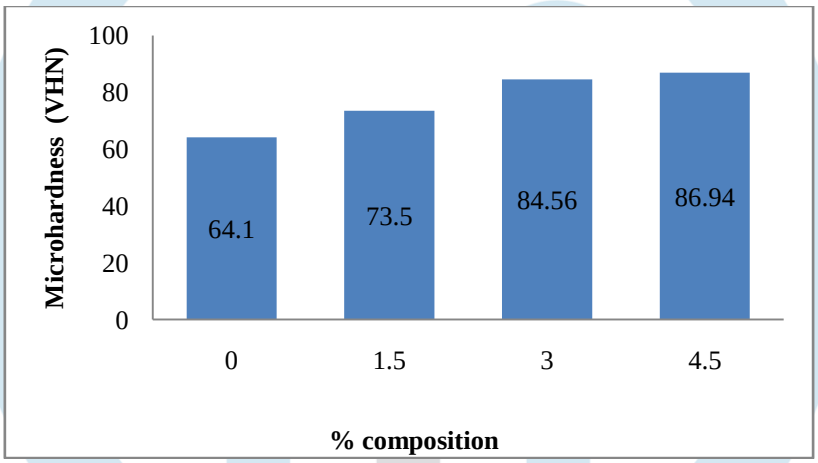

Fig 9 Graph of %composition versus Micro hardness

From fig 9 it is observed that there is increase in the hardness of composite with the increase in percentage composition of graphite.

WEAR TEST:

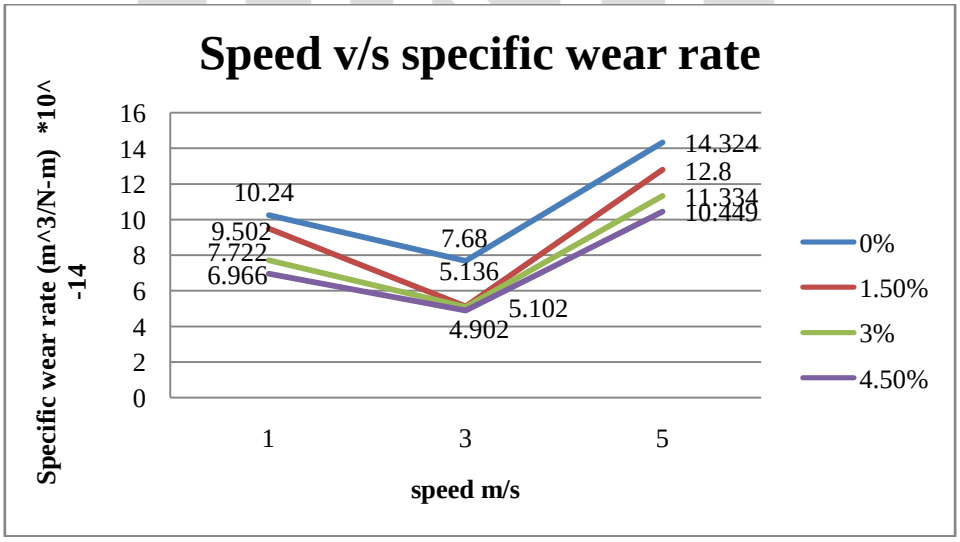

Fig 10 Speed vs Specific wear rate

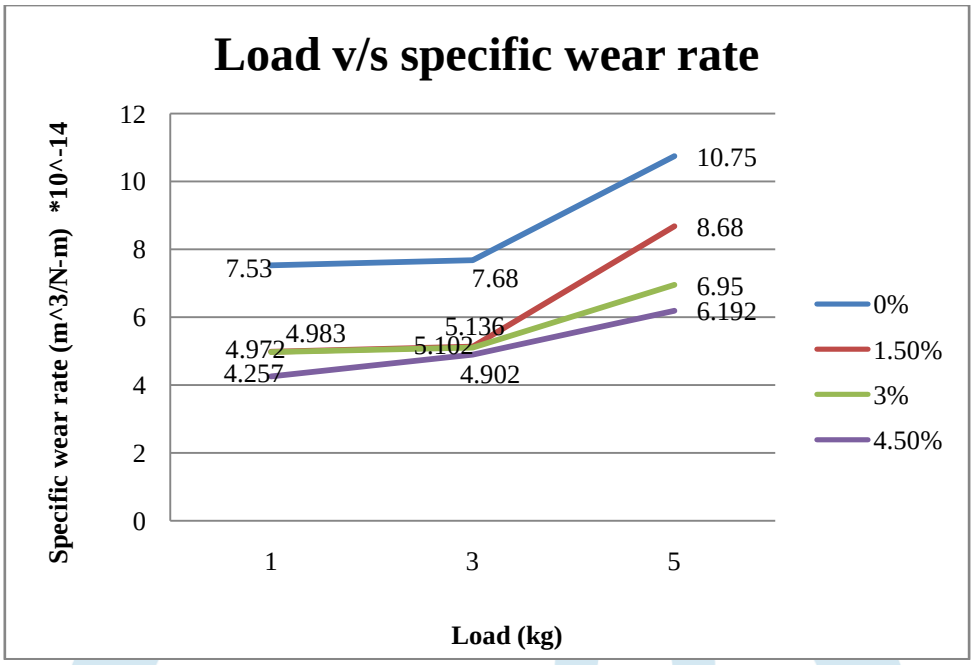

Fig 11 Load vs Specific wear rate

From fig 10 it can be observed that while increasing the speed from 1m/s to 3m/s the specific wear rate decreases, this is due to oxide layer formation. At 5m/s wear rate was observed to be high due to seviour damage occurred.
From fig 11 as load increases specific wear rate increases this due to increase in friction & contact pressure.
From both the figures 10 & 11 as % composition increases wear rate decreases this is due to lubricating property of graphite.

V. CONCLUSIONS

Al-Si graphite composites can be successfully fabricated through stir casting method. The uniform distribution of graphite particles was observed. Density of the composite reduces with increase in % reinforcement. Hardness of the composite increases with increase in graphite content. Wear rate decreases with increase in graphite content& graphite can be used as solid lubricant.

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