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International Journal For Research in Applied Science and Engineering Technology



INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 7 **Issue:** VII **Month of publication:** July 2019

DOI: http://doi.org/10.22214/ijraset.2019.7013

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.177
Volume 7 Issue VII, July 2019- Available at www.ijraset.com

Metallurgical and Tribological Behaviour of Al6061 with Reinforcement of E-Glass Fiber, SiC and Fly Ash by using Stir Casting

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Abstract: ***Aluminium 6061 has been used as matrix material for its excellent mechanical properties coupled with good formability. Numerous technological challenges present in casting techniques for obtaining a proper distribution of reinforcement in the matrix. In this work Al 6061 alloy act as a matrix and SiC, E glass fiber and Fly ash are used as reinforcement. Composites are fabricated by liquid metallurgy technique (stir casting) for decreasing the castings fault and to improve the proper mixing of reinforcement and matrix. Al 6061 alloy is melted at 680° C and then preheated reinforcements are added to maintaining stirrer speed around 600 rpm. This experiment deals with improving the properties of Aluminium material (Al 6061) by Reinforcing E-glass Fiber as constant proportion and SiC, Fly ash with varied proportions. The samples were prepared by stir casting equipment. Their proportions are taken as (0%,1%,2%,3%). Different tests were conducted upon the specimens and resulted that addition of reinforcement indulges the increase in Compressive strength and decrease in wear rate. Also Microstructure of the specimens have been studied.***

Keywords: E-Glass Fiber, SiC, Fly ash, Stir Casting, compressive strength, Wear rate, Microstructure

I. INTRODUCTION

Aluminium based metal matrix composites have evoked a keen interest in recent times for potential applications in marines, aerospace and automotive industries owing to their superior strength to weight ratio, good wear and corrosion resistance. Composite materials are having their desirable properties, which include high specific stiffness, low density, controlled co efficient of thermal expansion, high specific strength, and superior dimensional stability at elevated temperatures. As the dispersed phase is compared to matrix phase it is stronger. So it is called as reinforcement phase. In this work the various aspects of the wear behavior of MMC's have been investigated. Metal Matrix Composites (MMCs) have resistant with the ceramic particulates and tender to the significant performance advantages over pure metals and alloys. MMC's are adapt with the best properties of the two components, such as ductility and toughness of the matrix. Generally aluminium alloys are having low density and good adaptability, good corrosion resistance and high thermal and electrical conductivity. The objective of the present study is to investigate the wear behaviour of al 6061 reinforced with, SiC and E glass fiber and Fly ash.

II. LITERATURE REVIEW

Sidharth patel et.al.[1] described that Heat sinks made up of aluminium alloy when reinforced with E-glass Fiber and Fly ash in different weight percentage(0%,3%,6%,9%) by using stir casting method found that Tensile, compressive and yield strength increases with increase in addition of fly ash. Pujan sarkar et.al.[2] found that, Glass Fiber when it is reinforced with epoxy composites by taking aluminium powder as base metal by conventional hand layup technique. Result shows that wear rate increases with addition of aluminium powder.A.Benham et.al.[3] studied on different ratios of glass fiber (0%,5%,10%) and silicon carbide particles in different proportions. Tensile, flexural and impact strength has been increased by the addition of SiC to fiber epoxy composites. V.R.Arun prakash et.al.[4] noticed in their research that E-glass fiber when treated with Aluminium 6061 and SS-304 wire mesh lowers Tensile strength/ flexural strength, Izod impact strength due to poor adhesion of metal surfaces. Rajesh Purohith et.al.[5] made an analysis on the mechanical properties of Fiber glass, epoxy resins and fly ash by using hand layup method. The fabricated polymer matrix composites were subjected to micro-structural study, Impact strength test and tensile strength test. Tensile strength decreases with the addition of fly ash and flexural strength increases with the addition of fly ash. H.T.Gao et.al.[6] described in their article that Blast furnace slag was chosen as the main material with glass fiber and aluminium powder as reinforcement. Results suggested that glass fiber has a better reinforcement effect of aluminium powder as it exhibits high mechanical strength.Gajendra Dixit et.al.[7] in his work described that Hardness have been improved by the reinforcement of SiC

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and Fly ash to Al6061 and resulted that Hardness is improved while the tensile strength is reduced but it exhibits better wear resistance. Vijaykumar H.K. et.al.[8] studied on different ratios of epoxy and fly ash sandwiched composite material for finding the flexural strength. Three different ratios of epoxy and fly ash were used for the analyses, which were 65%-35% (65% fly ash and 35% epoxy resin by weight), 60%-40% and 55%-45%. They found that 60%-40% sample demonstrated better results in bending and compression tests. That improvement was accredited to hollowness of fly ash particles and strong interfacial energy between resin and fly ash. Based on the observation, they suggested that this composite can be used and replaced to areas where it needs a good compressive strength like wood applications, flooring, ceiling and other constructions. Pichi Reddy et.al.[9] analyzed the impact of fly ash particle on tensile strength and flexural strength of 10% fiber glass epoxy composites. The fly ash amount was changed from 0 to 10 grams in steps of 2 grams. The highest tensile strength was obtained for composite with 6 gram fly ash, the highest modulus of elasticity for composite with 8 gram fly ash and the highest flexural strength for composite with 4 gram fly ash. V. Pradeep et.al.[10] fabricated fiber glass reinforced polymer composites with fly ash in different weight percentage (0%, 5%, 10% and 15%) using hand lay-up method. They found that mechanical properties were improved when fly ash was reinforced with the fiber glass; furthermore the sample having 15% (highest amount of fly ash percent among all the samples) was having superior tensile strength, impact strength and hardness. Nikhil Gupta et.al. [11] found that addition of filler particles in lesser volume portions prompted the reduction in compressive strength of the fiber glass epoxy composite samples with fly ash filler. On the other hand, impact strength was improved by such addition significantly. Impact of aspect ratio of the sample on the compressive strength of the material is substantial and can't be ignored. Sample behavior was found to change significantly with the alteration in aspect ratio; it also influenced the values of compressive strength. In event of short fiber composites, fiber length ought to be taken into account while choosing sample dimensions and aspect ratio. In event of impact mode of fracture, it incredibly relies on the interfacial strength of the filler and matrix material.

III. EXPERIMENTAL WORK

A. Materials

In this study, Al 6061 with density 2.71 g/cm^3 is used as Matrix material. It is one of the most popular in its series. Chemical composition of Aluminium alloy is given in the below tabular form.

Material	Alloy	Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti	Al
% of constituents	6061	0.65	0.70	0.25	0.15	0.9	0.07	0.25	0.15	Remainder

B. Reinforcement Material

1) *E-Glass Fiber:* Among all types of fibers, E-glass fiber is more advantageous and has some special charactres E-Glass or electrical grade glass are used as insulators for electrical wiring. Later found that the e-glass is having excellent fiber forming capabilities and is now used almost solely as the reinforcing phase in the material commonly known as e-glass fiber. E-Glass fibers have a nominal composition of SiO_2, Al_2O_3, CaO, MgO, B_2O_3, Na_2 and K_2O.



fig2. E-glass fiber

Fiber reinforced composite materials consist of fibers embedded and bonded to a matrix material. In this form, both fibers and matrix retain their physical and chemical properties individually. Optimal strength and desirable properties are gain when the fibers are continuously aligned straight and parallel in a single direction. To support strength in other directions, construction of laminate structure can be done, with continuous fibers aligned in other directions. E-glass fiber, is low cost, high strength, good reinforcement and easily available in the market.

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2) *Fly Ash:* Fly ash is a ravage product produced from the combustion of pulverized coal in electricity power plants, and contains fine particles that rise with the flue gases. Ash which collects at the bottom of the burning chamber is termed as bottom ash. Ash produced during the combustion of coal is generally referred as Fly ash. It can be generally collected by electrostatic precipitators or other particle filtration equipment. Flue gases reach the chimneys of coal fired power plants the ash is collected by electrostatic precipitators and other particle filtration equipment. Fly ash is classified into two types that is Class F fly ash and Class C fly ash. Class F fly ash contains calcium oxide more than 20% whereas Class C class Fly ash contains less than 20% of CaO. 75 micron grain size was used for the preparation of composite.

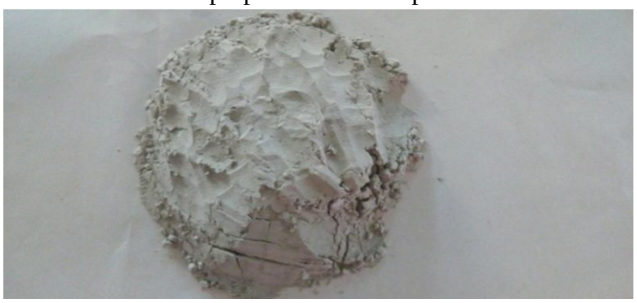


Fig3. fly ash

3) *Silicon carbide (SiC):* Silicon carbide is also known as carbondium which contains silicon and carbon. Grains of the silicon carbide can be bonded together by sintering to form very hard ceramics which are used in wide applications requiring high endurance, such as car brakes, car clutches and ceramic plates.

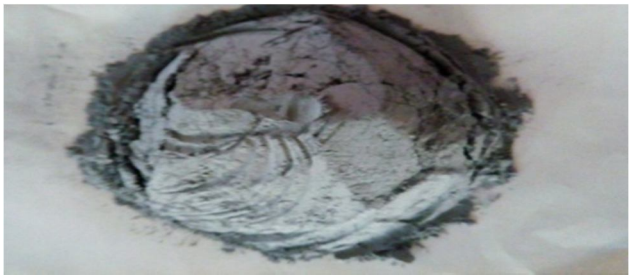


Fig4. Silicon carbide(SiC)

C. Preparation of Samples of Hybrid Composites

Firstly, E-glass fiber, a short, continuous fibers is made into discontinuous pieces by chopping them into small pieces of same size. Fly ash, an Industrial wastage was collected near Thermal power plant and was sieved to attain a grain size of 75 microns. They are pre heated upto 200^0c in Muffle furnace in order to remove moisture content, absorbed gases and agglomeration present in the powder. Also, silicon carbide on an average of 30 microns is preheated upto a temperature of 200^0c. E-glass fiber is chopped into pieces. Stir casting is a liquid metallurgical method of composite material fabrication, in which a dispersed phase like ceramic particles, short fibers etc. is mixed with molten metal by means of a stirrer attached to it.



Fig.5. Bottom type Stir casting equipment

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A stir casting machine has a chamber in which Al 6061 is dropped. It is made to heat upto a temperature of 750^0c. When temperature reaches at 650^0c, Al 6061 starts melting and gets liquified. SiC and Fly ash is mixed with different proportions keeping the weight percentage of the E-glass Fiber as constant. All the three reinforcements is mixed and stirred well at 600 rpm. To obtain a definite shape, Molten metal is poured into dye to obtain a required shape. After removing the material from the dye, it is made to cool in air for about half an hour. For obtaining a proper finish, it was machined on Lathe. The composition of the material is mentioned below.

Casting	Al6061	E-glass fiber	Silicon Carbide	Fly ash
0	100%	-	-	-
1	99%	0.5%	0.25%	0.25%
2	98%	0.5%	0.75%	0.75%
3	97%	0.5%	1.25%	1.25%

IV. RESULTS AND DISCUSSION

A. Compression Test

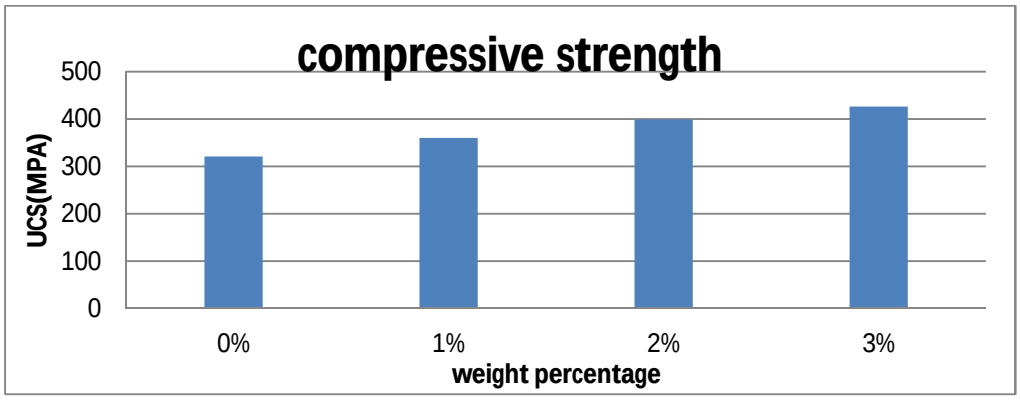
Compressive strength is the capacity of a material or structure to withstand loads tending to reduce size. It is used to analyze the compressibility of the materials. The compressive load is applied on the specimen and the resistance of the specimen to deform is called compressive strength of the materials



Specimens are confined according to ASTM standards. The length to diameter ratio (L/D) of the specimens is taken as 26mm and 13mm respectively. They are placed under UTM in which two forces acts in opposite direction which means compressing. After compressing , the values are tabulated and compared in the following graph.

S.no		Compression value(MPa)
1	Al 6061(pure)	322
2	Al 6061+E-Glass Fiber(0.5%)+SiC(0.25%)+Fly ash(0.25%)	369
3	Al 6061+E-Glass Fiber(0.5%)+SiC(0.75%)+Fly ash(0.75%)	399
4	Al 6061+E-Glass Fiber(0.5%)+SiC(1.25%)+Fly ash(1.25%)	427

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B. Wear Test

The specimens of the metal matrix composites are tested with pin on disc wear test apparatues to find the wear charecteristics with the following operating conditions.

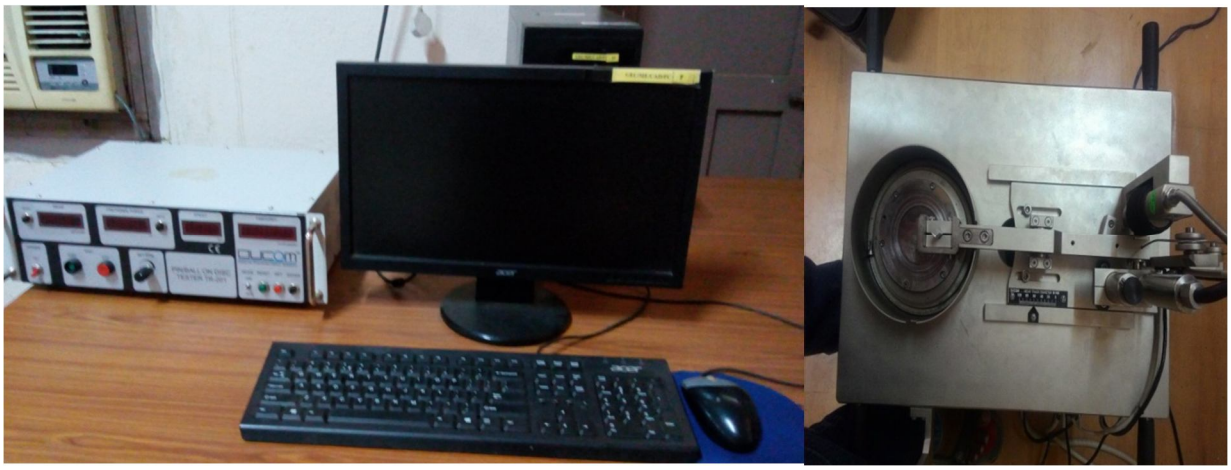


Table 4.2.3 Wear test with pin on disc apparatues

Parameter	Magnitude
Size	8 mm diameter
Load	10 N,15N,20N
Track diameter	60 mm
Speed	159rpm, 318rpm, 477rpm
Duration	10min

Wear evaluation and friction force at velocity=0.5m/s

Weight percentage	Load (N)	Wear(micro meter)	Friction force(N)
0%	10N	28	3.8
	15N	36	5.6
1%	10N	24	3.7
	15N	34	5.6
2%	10N	59	3.3
	15N	73	4.8
3%	10N	44	3.5
	15N	60	5.3

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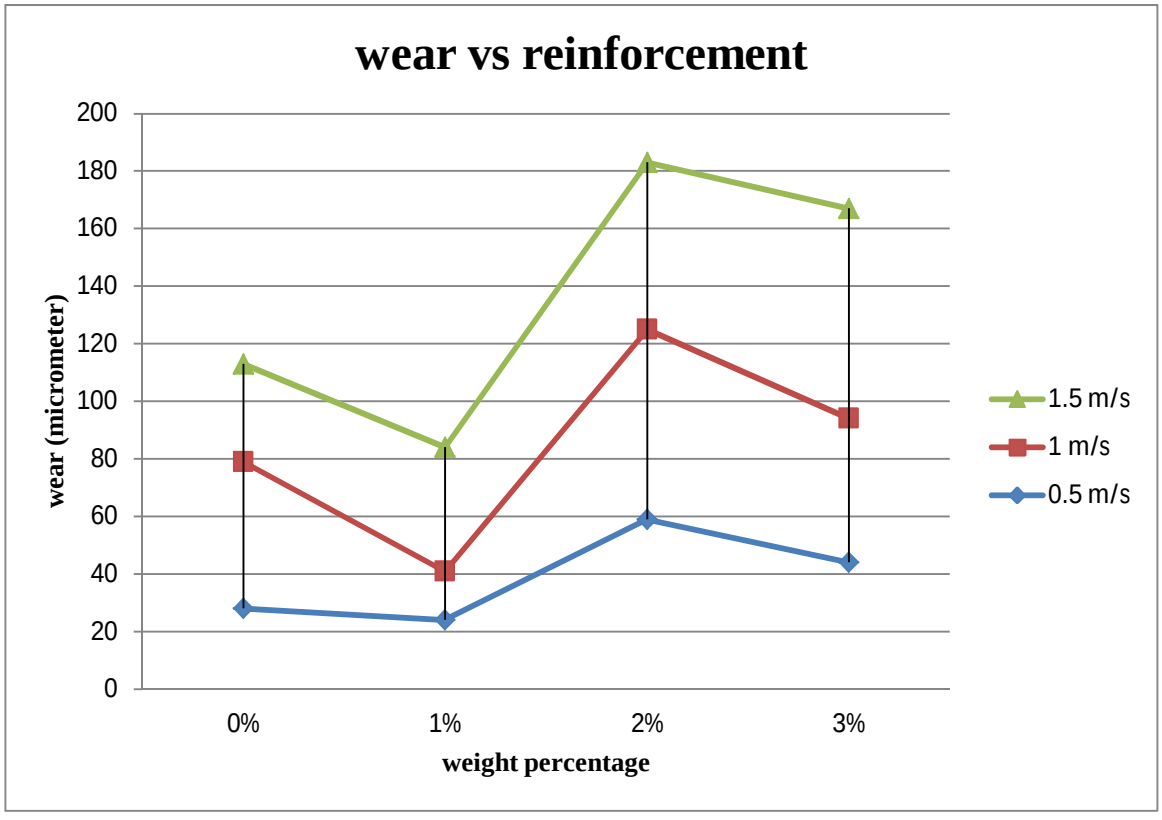
Wear evaluation and friction force at velocity=1m/s

Weight percentage	Load (N)	Wear(micro meter)	Friction force(N)
0%	10N	51	3.5
	15N	52	5.6
1%	10N	17	3.3
	15N	41	5.2
2%	10N	66	3.1
	15N	71	5.0
3%	10N	50	3.3
	15N	53	5.4

Wear evaluation and friction force at velocity=1.5m/s

Weight percentage	Load (N)	Wear(micro meter)	Friction force(N)
0%	10N	34	3.4
	15N	43	5.7
1%	10N	43	3.3
	15N	62	5.6
2%	10N	58	3.3
	15N	94	5.9
3%	10N	53	3.4
	15N	73	5.2

Fig: 4.16 Effect Of Friction Force OfAl 6063/ (CSA: SICp) Hybrid Composite At Velocity 1 m/s



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Fig: 4.16 Effect Of Friction Force OfAl 6063/ (CSA: SICp) Hybrid Composite At Velocity 1 m/s

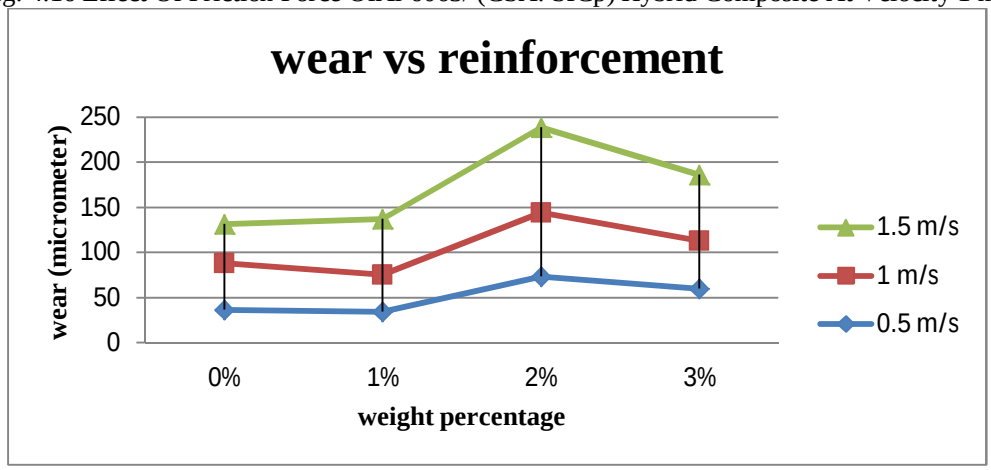
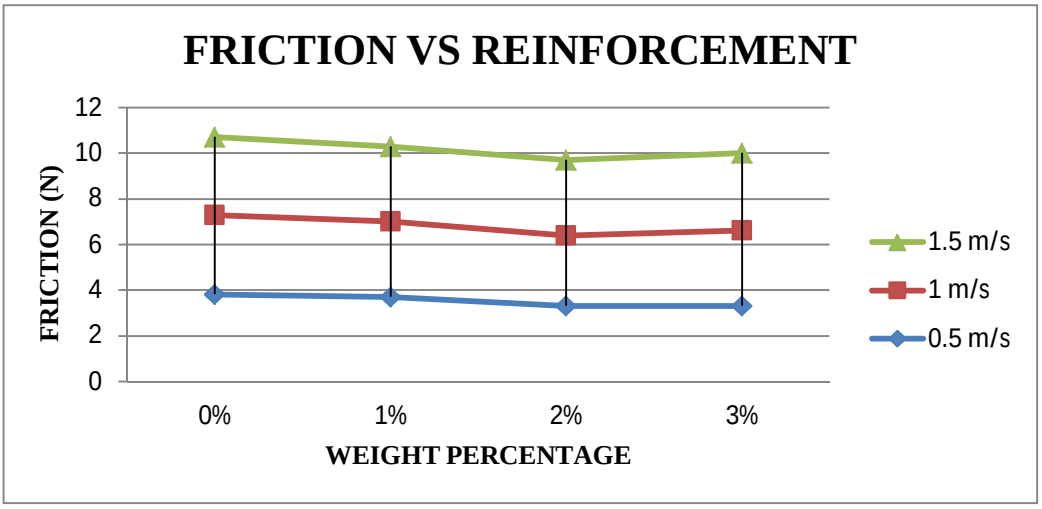
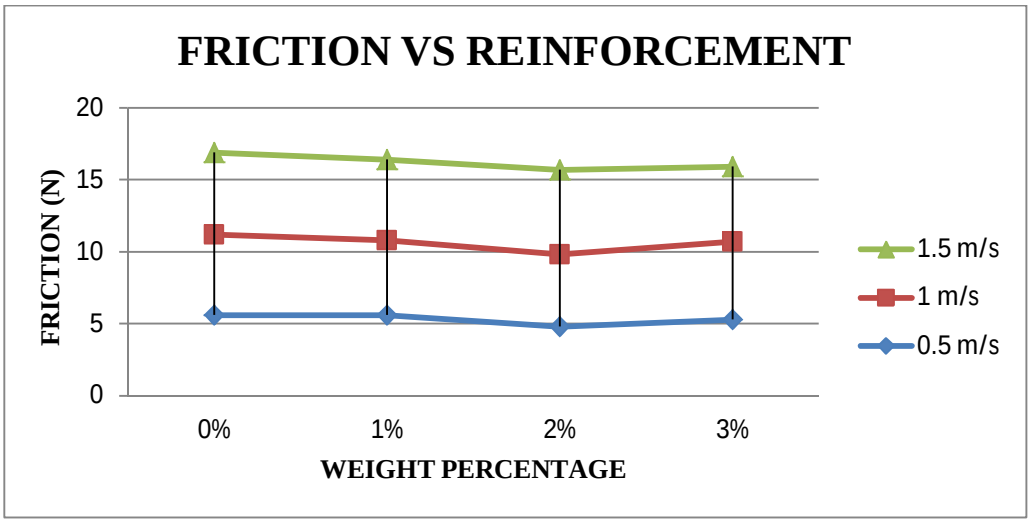


Fig: 4.16 Effect Of Friction Force OfAl 6063/ (CSA: SICp) Hybrid Composite At Velocity 1 m/s

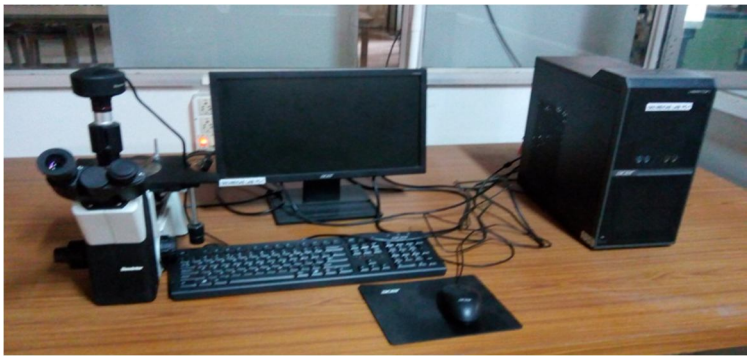




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C. Inverted Metallurgical Microscope

The metallurgical microscope micro structrure of a metal matrix composite is observed by using Trinocular metallurgical microscope.The micro structure of various metal matrix composites



1) Composite 1



V. CONCLUSION

A. The Compressive strength has been increased with increase in the percentage of reinforcement.

B. The wear rate has been decreased at 1 % of reinforcement while there is increase in 2% and 3% composites.

C. Friction has been increased at 1% composite while there is slight decrease in 2% and 3% respectively.

D. Micro structures of all the composites have been studied under inverted metallurgical microscope and noticed that reinforcement has been mixed without any agglomeration.

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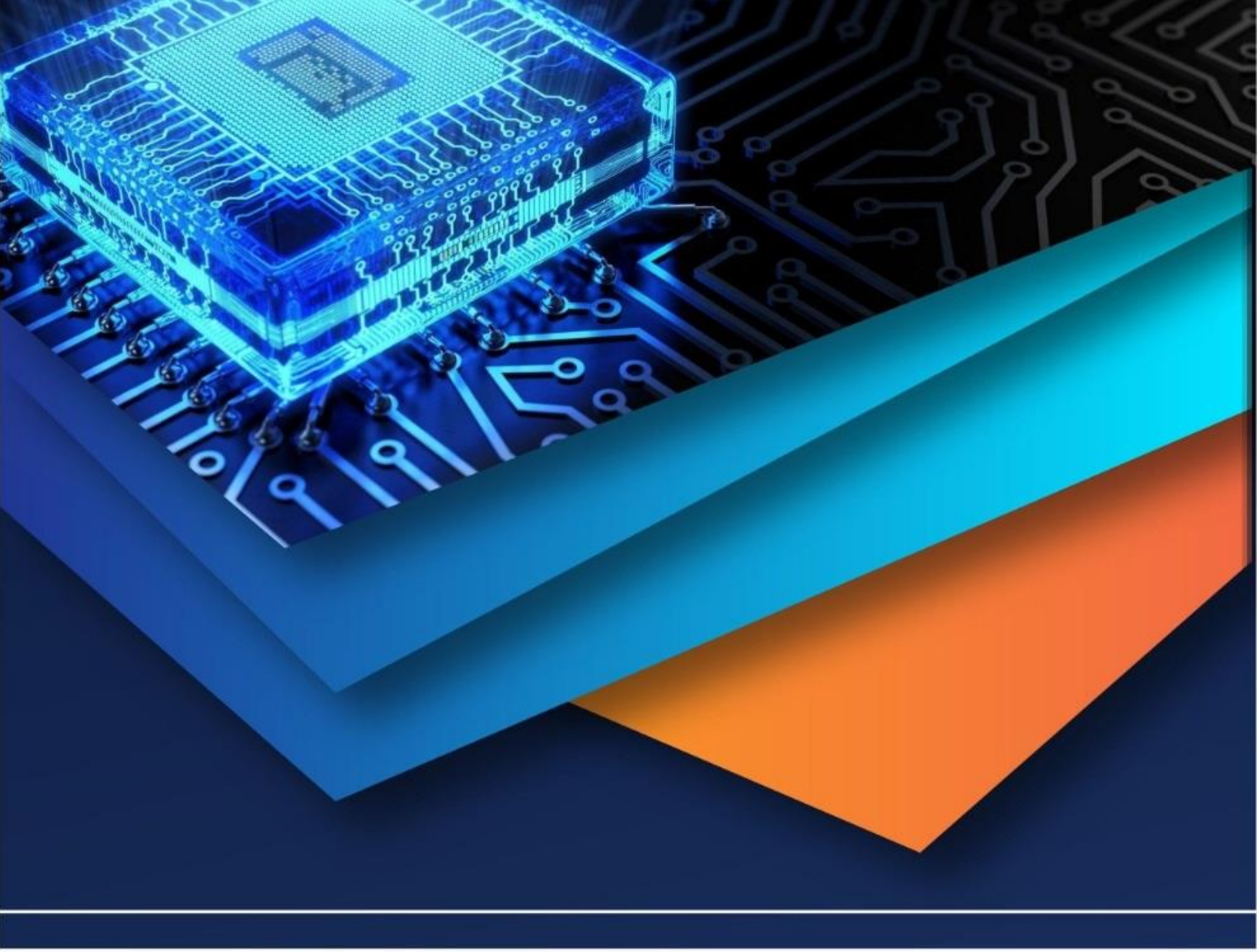
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