Mechanical Properties and Tribological Behaviour of Reinforced Aluminium Metal Matrix Composites

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***Abstract:** This paper focuses the Mechanical properties and tribological behaviour of aluminium (6063) metal which are reinforced with silicon carbide and graphite. Different percentages like7 %, 10%, 12% of silicon carbide and 3%, 5%, 8% of Graphite were added for reinforcement. The manufacturing of components is made by using stir casting method. Mechanical properties like (fatigue, impact, micro structure) and wear test are carried out in this paper. The result concluded that there is an increase in the mechanical and tribological properties with increase in weight percentage of reinforcement.*

***Key Words**: Al6063, SiC, graphite, reinforced material matrix, stir casting.*

I. INTRODUCTION

Metal matrix composites are the materials which are combined of at least two unique materials, which improve their properties. This paper deals the Al-4.5% Cu combination were utilized as the Matrix and fly ash and silicon carbide (SiC) as reinforcement. The hybrid metal matrix composite was produced using conventional foundry techniques. The fly ash and SiC were included 5%, 10%, and 15% by weight (equivalent extent) to the molten metal (K. V. MAHENDRA, 2010)**.** In this present study, A356.2 Al/Rice hush ash (RHA) metal matrix composites (MMCs) were fabricated by vortex method. Different weight fractions of reinforcement were used to fabricate the composites. Scanning electron microscope equipped with energy dispersive Xray analyzer is used for micro structural characterization. The properties like density, hardness, and ultimate tensile strength were investigated (D. SIVA PRASAD, 2011). Aluminium based metal matrix composite containing up to 15% weight percentage of flyash particulates were successfully synthesized using vortex method. The properties like density, hardness, micro hardness, ductility and ultimate tensile strength were investigated. The MMC produced was also subjected to corrosion, dry sliding wear and slurry erosive wear test to investigate its behavior under different material wearing conditions. The results of micro hardness revealed higher hardness of the matrix material in the immediate vicinity of flyash particle. The addition of flyash particles reduces the density of composite while increasing some of their mechanical properties(M. RAMACHANDRA,2005). The paper deals with the fabrication of aluminium based hybrid metal matrix composite and then characterized their chemical properties which are recently developed modification of stir casting has been used in the present investigation to produce aluminium (6063) alloy reinforced with Silicon carbide (Sic).Here Aluminium (6063) alloy is used as a base metal and Silicon carbide (SIC)is been used as are in forced material with the hybrid rein for cement as Rice husk ash (HARIDASS.R,2018). This study focuses on the Mechanical properties of Al6061 with reinforcement of coconut shell ash and boron carbide particulates are prepared by stir casting techniques. In this experimental, reinforcement boron carbide has various altitude of 5,8&3 wt% and other one coconut shell ash has1,1 & 2 wt% for all specimens. The result concludes that the tensile strength and fracture toughness would be improved in reinforcement material compared to pure aluminum alloy. (T.NITHYANANDHAN, 2017).Metal matrix composites represent a new generation of engineering materials which combine metallic properties of matrix alloys with the properties of reinforcements, which is desired for the industries today. Among various particulate reinforcements like SiC, Al2O3, B4C, SiC, TiC, AlN, fly ash etc, fly ash presents as a natural source, low cost, toxic industrial waste particulate reinforcement. Reinforcement of fly ash particles in the aluminium melt diminishes the cost of the composites, incorporation of hybrid particle reinforcement shows couple the properties of primary and secondary reinforcements (K. KAVIYARASAN, 2018). This study focuses on the Mechanical properties of Al7075with reinforcement of alumina and boron carbide particulates prepared by stir casting techniques. In this experimental, reinforcement alumina has various altitude of 2,4,6,8 and 10 wt% and other one boron carbide has 5 wt% kept as constant for all specimens. The result concludes that the properties would be improved in reinforcement materials (T. PRIDHAR, 2016). This study focuses on the microstructure and mechanical properties while incorporating zirconium oxide and coconut shell ash particles in Al 6082 matrix composites. Zirconium oxide and coconut shell ash particles were varied from 0 to 10% and fabricated by stir casting process (T.PRIDHAR, 2018). The effects of friction stir welding parameters were examined by mechanical and microstructural characterizations. The composites microstructure and dispersion of particle reinforcements were analyzed through optical microscope and also the mechanical properties of

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yield strength, ultimate strength and elongation were analyzed using universal testing machine. The optimized friction stir weld parameters were identified for 20% weight fraction reinforced hybrid composites (B.SURESHBABU, 2018).

II. MATERIAL SELECTION

1. ALUMINIUM 6063
2. SILICON CARBIDE (SiC)
3. GRAPHITE

2.1 ALUMINIUM 6063: Al 6063 is an alloy with magnesium and silicon metals. The Aluminum Association maintains the standard controlling and its composition. Aluminium is heat treatable and weldable, because it has good mechanical properties.Aluminium 6063 is used for making architectural applications such as window frames, door frames, roofs, and sign frames. It has a good surface completion material, high corrosion resistance mostly suited for welding. Most ordinarily accessible as T6 temper, in the T4 condition it has great form ability.

Fig 2.1 Al6063

Table 2.1 Chemical composition for aluminium alloy 6063

ELEMENTS	WEIGHT%
Aluminium(Al)	98.50%
Maganesium(Mn)	0.487%
Silicon(Si)	0.280%
Iron(Fe)	0.35%
Chromium(Cr)	0.015%
Copper(Cu)	0.07%
Tin	0.002%
Manganese(Mn)	0.055%
Zinc(Zn)	0.081%
Nickel(Ni)	0.006%
Lead(Pb)	0.001%

2.2 SILICON CARBIDE:

Silicon carbide (SiC) is a compound of silicon and carbon with chemical formula SiC also known as carborundum. It occurs in nature as the extremely rare mineral moissanite. 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. In this process the silicon carbide is preheated in muffle furnace and added to the molten metal.

Fig 2.2.1 SILICON CARBIDE

2.3 GRAPHITE:

Graphite is a crystalline type of carbon, semimetal and one of the allotropes of carbon. Under, standard condition graphite is increasingly stability. The heat formation of carbon compounds it is used in thermochemistry as the standard state. During metamorphism, reduction of sedimentary carbon compound occurs; therefore graphite is obtained from metamorphic rocks. It also occurs in igneous rocks and in meteorites. Quartz, calcite, micas and tourmaline are the minerals associated with graphite. In meteorites it occurs with troilite and silicate minerals. Meteoritic iron consist of small graphitic crystals are called cliftonite.

Fig 2.3.1 GRAPHITE

III. EXPERIMENTAL SETUP

3.1 STIR CASTING PROCESS:

Hybrid composite materials are fabricated by stir casting method (also called liquid state method). By means of mechanical stirring a dispersed phase is mixed with a molten matrix. Conventional casting methods and conventional metal forming technologies are used to cast the liquid composite material. Stir casting process is used to fabricate composite consists of an induction furnace with three mild steel stirrer blades. Mechanical stirring is used to distribute reinforcement into molten aluminium matrix. In stir casting setup the melting temperature is fixed by 650^0C to 850^0C.The aluminium is directly added to the stir cast. Whereas the reinforcement preheated in muffle furnace at 350^0C is added to the stir cast at 700^0C.And made to stirrer at constant speed of 600 rpm/sec at 3 minutes for each specimen.

Fig 3.1.1 STIR CASTING SETUP

Table 3.1.1 FURNACE SPECIFICATION

Capacity	**2 kg**
Operating Temperature	100-1200^{0}C
Operating Voltage	440 V,3Phase

Fig 3.1.2 SPECIMEN

Table 3.1.2 COMPOSITION PERCENTAGE

SPECIMEN.NO.	AL 6063 IN WT%	SILICON CARBIDE	GRAPHITE
1	90%	7%	3%
2	85%	10%	5%
3	80%	12%	8%

IV. TESTING, RESULT AND DISCUSSION

4.1 WEAR TEST:

Hardened steel is used to rub the specimen. Pins are used for dry sliding wear test on disc type wear tester. Three kinds of specimens with different composition were subjected to same speed, load and time to find the wear rate and coefficient of friction. Three specimens were prepared as per the requirements for test and the results obtained are provided below:-

Table 4.1.1 Wear rate of three specimens

INPUT FACTOR				OUTPUT FACTOR	
Specimens	**Speed (m/s)**	**Load (N)**	**Time (sec)**	**Wear rate (mm^3/m)**	**Coefficient of friction**
1	1.5	10	300	0.0046170	0.370000
2	1.5	10	300	0.0046168	0.356321
3	1.5	10	300	0.0046163	0.312321

Minimum wear rate and coefficient of friction are obtained by determining the wear process with the help of combination of factor.

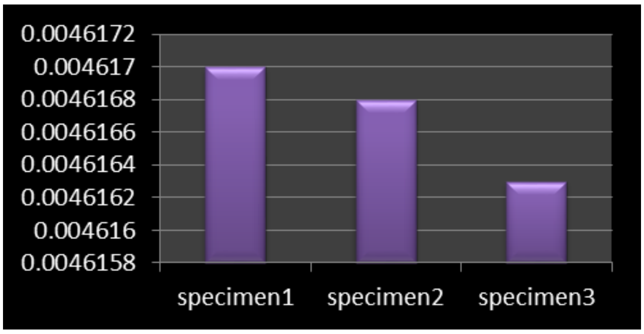

Fig.4.1.2 wear rate of three specimens

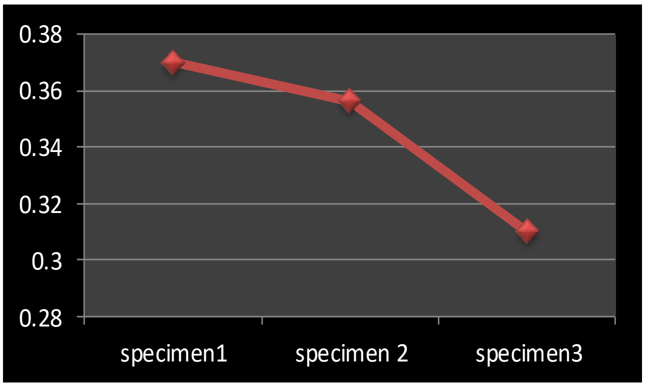

Fig.4.1.3 Coefficient of friction three specimens

While comparing the wear rate and coefficient of friction, the range of three specimens were varied.Specimen1 having wear rate greater than the 2 and 3.Whereas specimen 2 exhibit wear rate less than 1.But wear rate of specimen 3 is very less than other two specimen on the same parameter. It is concluded that the composition on specimen 3 having increased wear reducing characteristics.

4.2 FATIGUE TEST:

The procedure listed within the ASTM E606 was followed in accordance with ISO 1143 and BS 3518 part2.To determine the effect of fluctuating stress normally encountered in the cyclic loading of material. Polish the sample surface as smooth as possible and observe for any surface defects and deep scratch/machining marks.

Three specimens were prepared as per the requirements for test and the results obtained are provided below.

Table 4.2.1: Fatigue strength of three specimens

Specimen	1	2	3
Fatigue Strength	129 MPa	131 MPa	134 MPa

During the experiment there was a noticeable difference in fatigue strength of the three specimens.

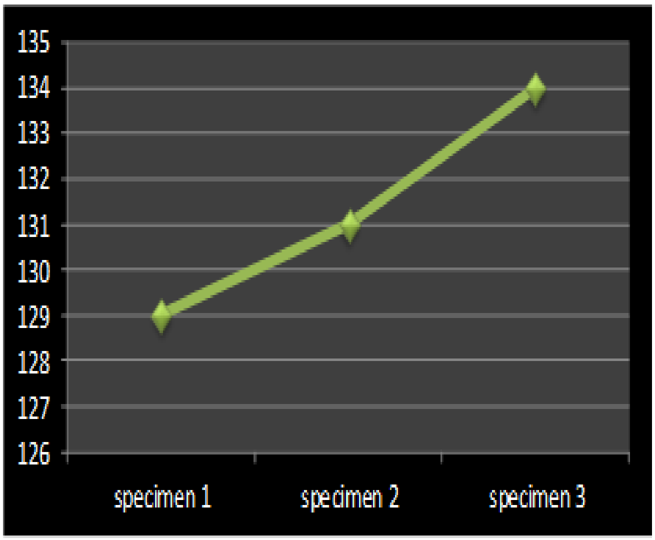

Fig.4.2.1 fatigue strength of three specimens

The specimen3 is found to be having the higher fatigue strength to withstand, without failure.

4.3 IMPACT TEST:

The procedure listed within the ASTM E2298 was followed. The impact test signifies toughness of materials. The ability of the material to absorb energy and deform plastically before fracture is called impact test. It is usually measured by the energy absorbed in a notched impact test.

Three specimens were prepared for impact test and the results obtained are:

Table 4.3.1: Impact strength of three specimens

	Observed Values		
Test Parameter	1	2	3
Absorbed energy in joules	12	15	17

The test measures the notch toughness of material under shock loading.

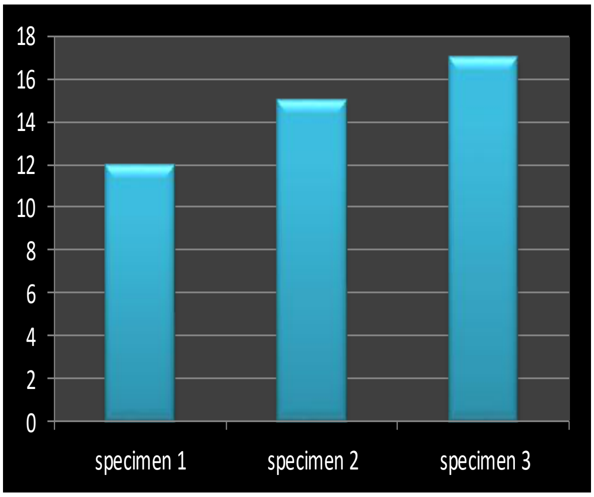

Fig.3.1 notch toughness of material under shock loading of three specimens

The energy required to break the specimen is obtained directly from the test. Specimens shown in fig.3.1is varied range of impact strength due to difference in their composition.

4.4 MICROSTRUCTURE TEST:

The procedure listed within the ASTM E766 was followed. For metallographic examination samples were prepared. On Selvyt cloth with 'Brasso' metal polish a final hand polishes was performed. This final polishing stage also served to etched with Keller's reagent Particle size, distribution, and shape were investigated by image analysis techniques. IMAGETOOL program are used for analyzing in PC.

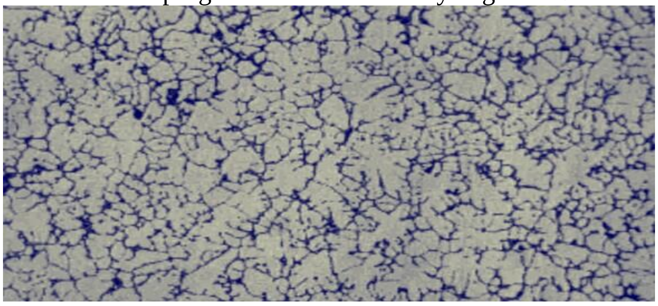

Fig.4.4.1 SPECIMEN A

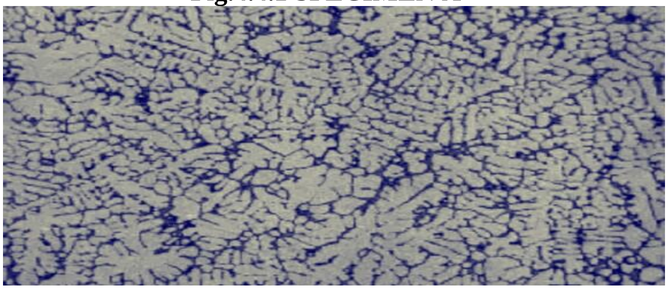

Fig.4.4.1 SPECIMEN B

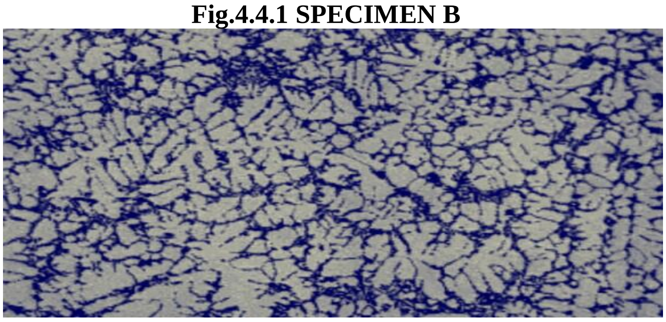

Fig.4.4.1 SPECIMEN C

The characteristics appearance and physical arrangement of metal molecules as observed with a microscope to determine the grain size and shape, distribution of various phases and inclusion. Micro examination reveals homogenous dispersion of silicon carbide particles and graphite in the aluminium matrix and ensures that the material possess desired mechanical properties. The SiC reinforced Al-SiC matrix composite have rarely pore, compact structure, and good interfacial bonding. Presence of equated grains with fine intermetallic precipitates is seen in the matrix of aluminium.

V. CONCLUSION

The mechanical properties and tribological behaviour of AL-SiC-Graphite composite containing like7 %, 10%, 12% of silicon carbide and 3%, 5%, 8% of Graphite as reinforcement were investigated.

The result shows that:

1. Wear rate are improved in maximum percentage of sic (12%) and graphite (8%) added with aluminium metal.

2. Fatigue strength are also improved in maximum

percentage of sic (12%) and graphite (8%) added with aluminium metal.

3. Impact strength are improved in hybrid composite with maximum percentage sic (12%) and graphite (8%) as reinforcement.

4. From microstructural studies, it was observed the the reinforcement are uniformly distributed in the aluminium matrix which influences the mechanical properties.

REFERENCES:

1. MahendraKV, RadhaKrishnaK. "Characterization of Stir Cast AlCu (flyash+SiC) hybrid metal matrix composites". Journal of Composite Materials 2010;44 (8):989–1005.
2. SivaPrasadD,RamaKrishnaA."ProductionandmechanicalpropertiesofA 356.2/RHAcomposites".International Journal of Advanced ScienceandTechnology2011;33:51–7.
3. RamachandraM, RadhakrishnaK. "Synthesis-microstructure-mechanical properties wear and corrosion Behaviour of an Al–Si(12%)–Fly ash metal matrix composite". Journal of Materials Science2005; 40:5989–97.
4. Mr.Haridass.R "Determination of corrosion behaviour of al6063-sic-rha metal matrix composites", International Journal of Pure and Applied Mathematics, ISSN: 1311-8080, Volume 118 No. 20 2018, 907-915
5. Christy TV, Murugan N, Kumar S. "A comparative study on the microstructures and mechanical properties of Al 6063 alloy and the MMC Al 6063/TiB2/12p". JMMCE 2010;9:57–65.
6. Macke A, Schultz BF, Rohatgi P. "Metal matrix composites offer the automotive industry an opportunity to reduce vehicle weight, improve performance". Adv Mater Processes2012;170:19–23.
7. Alaneme KK, Aluko AO. "Fracture toughness (K1C) and tensile properties of as-cast and age-hardened aluminium(6063)—silicon carbide particulate composites". Sci Iran TransA 2012;19:992–6.
8. Mr.K.Kaviyarasan, "Extensive Review On Properties Of Metal Matrix Composites Reinforced With Fly Ash", International Journal of Mechanical Engineering and Technology (IJMET), ISSN 0976-6340, Vol9, Issue 9, September 2018.
9. .Nithyanandhan. "Investigation of Mechanical Properties on Aluminium Based Hybrid Composites". International Journal of Innovative Research in Science, Engineering and Technology 2017 ISSN (Print): 2347 -6710 Volume 6, Special Issue 7, April 2017:118-126.
10. K Kaviyarasan, T Pridhar, B Sureshbabu, C Boopathi and R Srinivasan. Fabrication of Al6061-Al_2O_3 composite through liquid metallurgy technique IOP Conf. Series: Materials Science and Engineering, Volume 402, No 99 (2018)
11. Dr.P.Prathap, "Performance Analysis of Abrasive Water Jet Cutting Process in Carbon Fiber Epoxy Polymer Composite", IOP Conference Series: Materials Science and Engineering, ISSN 1757-898, Proceedings 2019-12-19
12. Mr.B.Suresh babu, Mr.C.Boopathi, Mr.T.Pridhar, Dr.R.Srinivasan, "Production and characterization of mechanical and microstructural behaviour of friction stir welded Al6063 composites reinforced with Gr/B4C/SiC particles", Journal of Ceramic Processing Research, ISSN 1229 – 9162, Vol.19, No.1, pp.69-74 2018.
13. Mr.T.Pridhar, C.Boopathi. "The effect of particle hybridization on micro structure analysis and mechanical behavior of metal matrix composites: an experimental approach" Digest Journal of Nanomaterials and Biostructures, Vol. 11, No. 3, July - September 2016, p. 845 – 852.
14. [14] Mr.Nelson,"Effect of tool material, profile and D/d ratio in friction stir welding of aluminium metal matrix composites" Materials Research Express, Volume 6, Issue 9, article id. 096590 (September 2019).
15. Mr.T.Pridhar, **"**Mechanical properties and characterization of zirconium oxide (ZrO_2) and coconut shell ash(CSA) reinforced aluminium (Al 6082) matrix hybrid composite" Journal of Alloys and Compounds, Volume 765, 15 October 2018, Pages 171-179.
16. Mr.T.Pridhar "Evaluation on properties and characterization of asbestos free palm kernel shell fibre (PKSF)/polymer composites for brake pads" Materials Research Express, Volume 6, Number 11, Published 1 November2019.
17. Mr.Justin Maria Hillary.J "A study on microstructural effect and mechanical behaviour of al6061-5%sic-tib2 particulates reinforced hybrid metal matrix composites" journals of composite materials, December 5, 2019.

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