International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-8 Issue-11, September 2019

Fabrication of Silicon Carbide and Graphite Reinforced Aluminium MMC by Stir Casting and Characterization by Wear Test

K. Srividya, P. Anusha, E. Kavitha, M. Nagaswapnasri

Abstract: Aluminum metal matrix composites with various reinforcements had pronounced prospective of meeting the criteria of recent engineering applications like aerospace, automobile, breakpads, sports, this is due to their enhancement of some mechanical properties by some addition of matrix in to decide material. The present study focuses on the fabrication of 6351 aluminum MMC hybrid composites reinforced with silicon carbide and graphite powder, followed by a wear test for characterization of the material. Although several methods are available for the fabrication of Al-Sic MMC, we have employed stir casting technique due to its simplicity and economical. In this work aluminum metal matrix composites reinforced with different weight fractions of 2%, 4%, 6% and 8% graphite and silicon carbide in equal proportion characteristics were compared with Al6351 alloy. It is found that the wear properties have been improved with increase in weight fraction of the reinforcements of silicon carbide and graphite in aluminum matrix.

Index Terms: *Al6351 alloy, Al-Sic MMC, Stir casting, Wear Test*

I. INTRODUCTION

The developments that were happened in composite material after they have meeting the challenges of the aerospace sector have cascaded to domestic and industrial applications. Composites which were the marvel material having light-weight, high strength to weight ratio and stiffness properties have come a long way by replacing the traditional materials like metals, wood, etc.. The composites had an unique feature that the properties of the final product can be altered to a specific engineering requirement by the careful section of matrix and the reinforcement kind. Neelimadevi. C [1] analyzed Aluminum silicon carbide alloy composite material is two times less in weight than the aluminum of the same dimensions. Mahendraboopathi.M [2] presented various composites of Al-SiC, Al-fly ash, Al-SiC-fly ash were successfully fabricated by two-step stir casting process. Sankar.L [3] studied Lightweight materials have been proven good in weight reduction in automobile industry in clutch plates and other in weight reduction. Manojsingla [4] revealed that with an increment of composition of Si-C there is increment in mechanical properties namely impact strength, hardness, normalized displacement. Jayashree.p [5] performed micro structural test on Al-SiC metal matrix composites after subjecting them to two kinds of treatment i.e heat treatment and precipitation hardening and an untreated sample. Among three tests above the sample treated with precipitation hardening exposed promising physical and mechanical properties. Ravindran.P [6] concluded that the value of coefficient of friction roses up with increasing concentration of SiC content. S.Balasivanandha prabhu [7] stated that Al-SiC metal matrix composite has been Stir-casted with different stirring speeds and stirring times with 10% Si-C concentration…

Manuscript published on 30 September 2019.
***Correspondence Author(s)
Dr. K. Srividya, Associate Professor, Mechanical Engineering Department, P V P Siddhartha Institute of Technology, Vijayawada, India.
P. Anusha, Assistant Professor, Mechanical Engineering Department, P V P Siddhartha Institute of Technology, Vijayawada, India.
E. Kavitha, Assistant Professor, Mechanical Engineering Department, P V P Siddhartha Institute of Technology, Vijayawada, India.
M. Nagaswapnasri, Assistant Professor, Mechanical Engineering Department, P V P Siddhartha Institute of Technology, Vijayawada, India.

II. PROCEDURE FOR PAPER SUBMISSION

A. Materials and their properties

The materials used in this present work are: 1. Al6351 alloy 2. Graphite powder 3. Silicon carbide

Al6351 alloy: Alloys composed of aluminium lose their strength when they are subjected to temperatures from 200 to 250 degree Celsius. They also possess a character of high strength when exposed at subzero temperatures, moreover they show higher resistance to corrosion.

Graphite: Graphein is the Greek word for graphite. Graphite is a greyish black carbon form which is opaque in nature moreover having lustrous black sheen. It possesses both metallic and non-metallic properties making it a unique substance. It is not elastic but has flexibilities, also high thermal and electrical conductivity moreover it is highly refractory and chemically inert. In the nuclear domain graphite is preferred substance because of its low adsorption rates of x-rays and also neutrons.

Silicon Carbide: It is a chemical product composed by silicon and carbon. It was made by electro chemical reaction of sand and carbon at high temperatures. Being one of the renowned abrasive materials for more than century, it is used as grinding wheel manufacturing.

B. Engineering of Metal Matrix Composite (MMC)

Stir casting method:

MMC when demanded to get manufactured in liquid state requires involvement of dispersed phase into molten metal. Subsequently its solidification when high levels of mechanical properties are desired interfacial bonding between liquid matrix and dispersed phase must be engineered.

By applying a layer of dispersed phase particles, interfacial bonding might get improvised. Interfacial bonding and chemical bonding will get affected by layers of coating i.e chemical reactions between dispersed phase and matrix can be prevented by coating, moreover without proper coating, interfacial energy reduces. One of the economical methods at a time simple methods for preparing liquid state engineered composites is Stir casting processes. In this process of producing metal matrix composites by liquid state engineering, by continuous stirring of composite and liquid metal by using stirrers at different speeds. Later composites are processed out by conventional casting procedures. The experimental setup for stir casting method is shown in figure1.

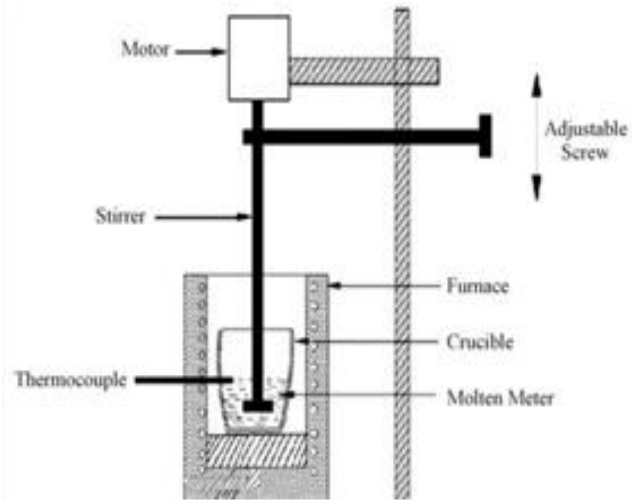


Figure1. Stir casting experimental setup

Experimental procedure of wear test:

Pin- on- disk machine has been employed for performing dry sliding wear test for numerous specimens of different compositions (this machine was prepared by DUCOM, has a friction monitor TR20). The rotating disc EN31 steel) having a face is countered by a pin where the track diameter is 60mm.With a dead weight against the loading disc , the pin was placed, then all the specimens were wear tested under normal loads of 20,40N and sliding velocity of 2 and 4m per sec, wear test was carried out of total sliding distance of 3000 m tentatively. Initially the samples of pill were 40*10 in diameter and length. Then the pin surfaces of the sample were rubbed using emery paper in order to get the information regarding effective contact of fresh and flat surface corresponding to steel disc. Simultaneously the wear track and the sample too were cleaned with acetone and weighed (up to an accuracy of 0.0001 gram using micro balance) prior to and after each test.

Employing high class techniques wear rate was calculated and expressed interms of wear volume loss per unit sliding distance.

Figure 2.Pin-on-Disc Experimental setup

III. RESULTS AND DISCUSSION

Wear test carried on Pin-on-Disc wear test machine, by using this machine the wear rate of aluminium 6351 alloy composites which is reinforced with graphite and silicon carbide are examined. This test was conducted on 40 specimens as which are fabricated at different compositions (pure, 2% ,4% ,6% and 8%), with graphite and silicon carbide respectively.

Calculations for wear test:

Formulae: V= (πdR)/60
S=V*T
N Load=N (Newtons)
Speed=R (R.P.M)
Velocity=V (m/s)
Sliding Distance=S (meters)
Track Diameter (d)=100mm=0.1m
Time =T(sec)
Sample Calculation:
Load=10N
Speed=150 rpm
Sliding Distance=1500m
Then,
V=πdR/60(3.14*0.1*300)/60 =1.57 m/sec
S=V*T

T=S/V
T=1500/1.57 =955.41 sec= 15.92 min.
Formula:
Wear Rate=Weight Loss/ (Density*Sliding Distance)
Weight Loss=ΔW=W1-W2
W1=Weight of specimen before wear
W2=Weight of specimen after wear
ῥ = Density of specimen
W=Δw/(ῥ*S)
Sample Calculations:
W= (0.01)/ (2.7*10^-3*1000)
W=0.0037 mm^3/m
Formula:
Frictional Force = F (Newtons)
Coefficient of friction = µ
µ = F/N

Retrieval Number: K14780981119/19©BEIESP
DOI: 10.35940/ijitee.K1478.0981119
Journal Website: www.ijitee.org

Published By:
Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP)

Sample Calculation:
F=7.5 (N)
N=1 Kgf=1*9.81N = 9.81N
μ = 7.5/9.81=0.76

Al ALLOY 6351 PURE:

Table4. Al alloy 6351 pure calculations

Samples	Load (Kgf)	Sliding velocity (m/s)	Sliding speed (R.P.M)	Sliding distance (m)	Wear (mm)^3	Wear rate (mm)^3/m	Frictional force (N)	COF (μ)	Time (min)
1	1	0.785	150	1000	100	0.003	2.1	0.21	21.23
2	1	1.57	300	1500	121	0.0032	2.1	0.21	16.32
3	1	2.355	450	2000	168	0.0033	2.2	0.22	14.15
4	2	0.785	150	1500	111	0.0032	7.3	0.24	21.23
5	2	1.57	300	2000	139	0.0033	5	0.25	16.32
6	2	2.355	450	1000	168	0.003	4.8	0.24	14.15
7	3	0.75	150	2000	187	0.0037	8	0.27	21.23
8	3	1.57	300	1000	202	0.0033	2.7	0.27	16.32
9	3	2.355	450	1500	205	0.0037	2.7	0.27	14.15

The following tables 4-8 represent the calculation of Time verses wear

Al ALLOY 6351+2% GRAPHITE+2% SILICON CARBIDE:

Table5. Al alloy 6351+2% graphite+2% silicon carbide calculations

Samples	Load (Kgf)	Sliding velocity (m/s)	Sliding speed (R.P.M)	Sliding distance (m)	Wear (mm)^3	Wear rate (mm)^3/m	Fricti-onal force (N)	C O F (μ)	Time (min)
1	1	0.785	150	1000	230	0.0041	2.6	0.27	21.23
2	1	1.57	300	1500	234	0.0041	2.6	0.27	16.32
3	1	2.355	450	2000	247	0.0041	2.6	0.27	14.15
4	2	0.785	150	1500	312	0.005	5.4	0.28	21.23
5	2	1.57	300	2000	276	0.0056	5.4	0.28	16.32
6	2	2.355	450	1000	279	0.0055	5.2	0.27	14.15
7	3	0.75	150	2000	312	0.006	8.8	0.3	21.23
8	3	1.57	300	1000	315	0.0056	8.8	0.3	16.32
9	3	2.355	450	1500	340	0.0059	8.5	0.29	14.15

Retrieval Number: K14780981119/19©BEIESP
DOI: 10.35940/ijitee.K1478.0981119
Journal Website: www.ijitee.org

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

Al ALLOY 6351+ 4% GRAPHITE+4% SILICON CARBIDE:

Table6. Al alloy 6351+4% graphite+4% silicon carbide calculations

Sam ples	Load (Kgf)	Sliding velocity (m/s)	Sliding speed (R.P.M)	Sliding distance (m)	Wear (mm)^3	Wear rate (mm)^3/m	Frictio-nal force (N)	COF (µ)	Time (min)
1	1	0.785	150	1000	276	0.87	7.5	0.76	21.23
2	1	1.57	300	1500	280	0.9	7	0.71	16.32
3	1	2.355	450	2000	281	0.98	5.7	0.58	14.15
4	2	0.785	150	1500	340	0.97	9.9	0.5	21.23
5	2	1.57	300	2000	365	0.99	5.7	0.29	16.32
6	2	2.355	450	1000	399	0.9	10.8	0.55	14.15
7	3	0.75	150	2000	414	0.9	5.9	0.2	21.23
8	3	1.57	300	1000	433	0.87	10.2	0.34	16.32
9	3	2.355	450	1500	447	0.97	4	0.13	14.15

Al ALLOY 6351+ 6% GRAPHITE+6% SILICON CARBIDE:

Table7. Al alloy 6351+6% graphite+6% silicon carbide calculations

Samples	Load (Kgf)	Sliding velocity (m/s)	Sliding speed (R.P.M)	Sliding distance (m)	Wear (mm)^3	Wear rate (mm)^3/m	Frictional force (N)	C O F (µ)	Time (min)
1	1	0.785	150	1000	59	0.002	0.09	0.01	21.23
2	1	1.57	300	1500	76	0.0022	0.294	0.03	16.32
3	1	2.355	450	2000	79	0.0024	0.294	0.03	14.15
4	2	0.785	150	1500	60	0.0025	2.74	0.14	21.23
5	2	1.57	300	2000	81	0.0027	2.74	0.14	16.32
6	2	2.355	450	1000	106	0.002	1.07	0.11	14.15
7	3	0.75	150	2000	96	0.0027	5.59	0.19	21.23
8	3	1.57	300	1000	100	0.002	5.59	0.19	16.32
9	3	2.355	450	1500	110	0.0024	4.7	0.16	14.15

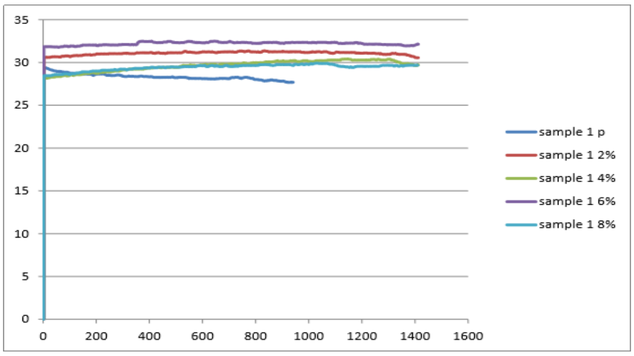
Retrieval Number: K14780981119/19©BEIESP
DOI: 10.35940/ijitee.K1478.0981119
Journal Website: www.ijitee.org

Published By:
Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP)

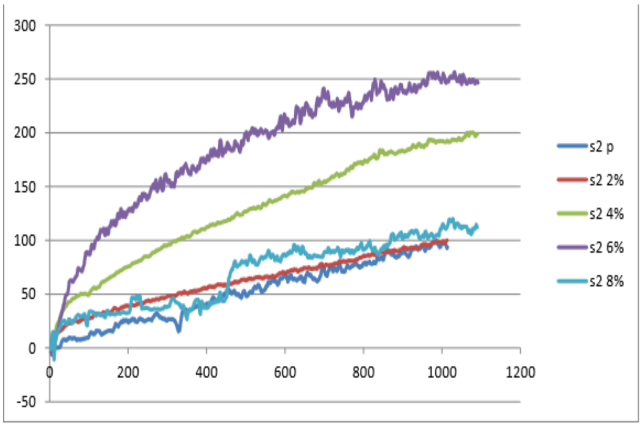
Al ALLOY 6351+ 8% GRAPHITE+8% SILICON CARBIDE:

Table8. Al alloy 6351+8% graphite+8% silicon carbide calculations

Samples	Load (Kgf)	Sliding velocity (m/s)	Sliding speed (R.P.M)	Sliding distance (m)	Wear (mm)^3	Wear rate (mm)^3/m	Frictional force (N)	C O F (μ)	Time (min)
1	1	0.785	150	1000	122	0.056	2.06	0.21	21.23
2	1	1.57	300	1500	160	0.06	2.06	0.21	16.32
3	1	2.355	450	2000	194	0.0062	2.15	0.22	14.15
4	2	0.785	150	1500	137	0.0083	4.12	0.21	21.23
5	2	1.57	300	2000	181	0.0083	4.31	0.22	16.32
6	2	2.355	450	1000	202	0.0074	4.12	0.21	14.15
7	3	0.75	150	2000	205	0.06	8.53	0.29	21.23
8	3	1.57	300	1000	243	0.012	8.24	0.28	16.32
9	3	2.355	450	1500	247	0.0187	7.06	0.24	14.15



Sample1. Graph for time Vs wear



Sample2. Graph for time Vs wear

IV. CONCLUSIONS

Aluminium metal matrix composite had been reinforced with materials at different compositions (pure, 2%,4%,6% and 8%) of Si-C and graphite are fabricated by Stir-casting process. wear characteristics of the compound were studied using a wear tester named pin on disc apparatus. wear resistance of Si-C reinforced Al6351 MMC showed an increase with increment in Si-C content in aluminium MMC. In 8 wt% silicon carbide reinforced AMC showed maximum wear resistance, as there is increase in the amount of silicon carbide additional wear debris becomes smaller. With the increment in the graphite concentration in composites, the density and hardness decrease, also it is observed that there is loss of wear corresponding to the composite rises up as the concentration of graphite of increases more than 5%. This material is therefore preferred for aerospace and automotive applications, in this work we also incorporated fly ash, which is the end material to many industries, thus promoting the principles of green chemistry.

REFERENCES

1. Pradeep L. Menezes, Pradeep K. Rohatgi and Michael R. Lovell, “Green Tribology”, Green Energy and Technology , 2012.
2. Rabindra Behera and G. Sutradhar, “Journal of Engineering and Applied Sciences 7”.
3. J Singh, D Narang and NK Batra, “International Journal of Engineering Science and Technology”, 5, 2013.
4. Prakash C.H. and Pruthviraj R. D, “Research Journal of Chemical Sciences” 6, 2011.
5. Pardeep Sharma, Satpal Sharma, Dinesh Khanduja, Particulate Science and Technology 34,
6. Akhlaghi, F. and ZareBidaki, A, “Wear”, 266, 2009.
7. Zhao, H., Liu, L., Hu, W. and Shen, B, “Mater. Des.”, 28, 2007.
8. Rao, R.N. and Das, S., “Mater. Des.”, 31, 2010.

9. Rabindra Behera, S. Das, D. Chatterjee and G. Sutradhar, "Journal of Minerals & Materials Characterization & Engineering",10, 2011.
10. S. Mahdavi and F. Akhlaghi, "Tribol Lett ",44, 2011.
11. F. Akhlaghi and S. Mahdavi, "Advanced Materials Research", 264-265, 2011.
12. Adalet Zeren, "Industrial Lubrication and Tribology ",67, 2015.
13. Jinfeng Leng, Longtao Jiang, Qiang Zhang, Gaohui Wu, Dongli Sun and Qingbo Zhou, "Journal of Materials Science", 43, 2008.
14. Sulaiman, S., Sayuti, M. and Samin, R. "Mechanical properties of the as-cast quartz particulate reinforced LM6 alloy matrix composites", Journal of Materials Processing Technology , 201(1-3), 2008.
15. Yang J.B., Lin C.B., Wang T.C. and Chu H.J., "Wear", 257, 2004.
16. Umanath. K., Selvamani .S. T and Palanikumar .K., "I. J. Composite Part-B Engineering", 53, 2013.
17. J. K. M. Kwok and S. C. Lim, "High speed tribological properties of Al/SiC composites:II Frictional and wear rate characteristics", Composites Science and Technology, 1999, 59, pp.55 – 63.
18. Paul, C.J., Srividya, K., Nagaswapnasri, M., Dondapati, K.K., Camarini, L,"Effect of oil viscosity over critical frequencies in rotor bearing systems", 11(2), 2018, pp.307-317.

Retrieval Number: K14780981119/19©BEIESP
DOI: 10.35940/ijitee.K1478.0981119
Journal Website: www.ijitee.org

Published By:
Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP)