Study of Properties of Al LM-25/SIC fabricated by using Stir Casting Method and Wear Analysis by RSM

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Abstract— *Aluminum MMC's are widely used in various applications because of their higher mechanical and physical properties when compared with their base Al alloy. This paper focuses on the change in mechanical properties of various Al/SiC composites fabricated by using stir casting method. Effect of SiC reinforcement in different Al alloys on mechanical properties like hardness, tensile strength, wear test, percentage elongation, residual stress measurements are discussed in detail. For this purpose various reinforcement of SiC with 0,4,8 percent weight and different particle sizes are considered along with Al alloys. Variations in process parameters of stir casting are also made and taken into consideration*.

Keywords— Al/SiC, Al LM-25, Hardness, MMCs, Tensile Strength, Wear Resistance, Response Surface Methodology.

I. INTRODUCTION

A metal matrix composite (MMC) is a composite material with a mixture of two or more constituent parts, one being a metal, other material may be a different metal such as a ceramic or organic compound. If three materials are present, it is called as hybrid composite. The unique characteristics of the composite materials for the specific requirements make these materials more popular in a variety of applications like aerospace, automotive and structural components, resulting in savings of material and energy. Metal matrix composites (MMCS) have become an important class of materials for structural, wear, thermal, transportation and electrical applications. This is due to their ability to exhibit superior strength-to-weight and strength-to-cost ratio when compared to equivalent monolithic commercial alloys. The strength of the composites depends on the amount, arrangement and type of reinforcement in the resin.

Aluminium-based particulate reinforced metal matrix composite has high class of performance material for which it is used in aerospace, automobile, chemical and transportation industries because of its improved strength, high elastic modulus and increased wear resistance over conventional base alloy. To improve different properties of the main material, such as wear resistance, hardness, fatigue resistance, friction coefficient, thermal conductivity and others, reinforcement is used. As from recent studies, MMCs have found a lot of application in automobile industry for the production of brakes and parts of engines and in aerospace industry for the production of structural components, as well as in electrical and electronic industry and in many other applications Composite materials which main constituent part is a metal are called Metal Matrix Composites (MMCs). The other compounds may be metals too, ceramics or even organics. They are well known for their excellent thermo-physical and mechanical properties.

II. EXPERIMENTAL SET UP

Work Material

In this study the AL LM-25 is used as a matrix material and SiC as a reinforcement material. The Al LM-25 + volume percentage of SiC MMC is fabricated by using a stir casting method. Chemical composition of Al LM-25 is as shown in table 1.

Table 1 Chemical composition of AL LM-25

Element	Cu	Mg	Si	Fe	Mn	Ni	Zn	Pb	Tin	Ti	Al
Wt. %	0.1 max	0.2 – 0.6	6.5 – 7.5	0.5 max	0.3 max	0.1 max	0.1 max	0.1 max	0.05 max	0.2 max	Remainder

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Fabrication of Al MMC (AL LM-25 + Vol. % of SiC) by Stir Casting

In this study the matrix material used is Al LM-25 and SiC is used as reinforcement material. The liquid metallurgy technique i.e. Stir Casting is used to prepare composite specimens, because it is most economical to fabricate composites. In this process, matrix alloy was firstly super heated over its melting temperature (800ºC) and then temperature was lowered gradually below the liquidus temperature to keep the matrix alloy in the semi- solid state at this temperature, the preheated SiC particles were introduced into the slurry and mixed. The temperature of the composite slurry was increased to fully liquid state and automatic stirring was continued for 12 min at an average stirring speed of 400 rpm. Alloys were melted in an electrical furnace and poured at a temperature of 750ºC in to a steel mould at room temperature and finally poured into the cast iron permanent mould of 18 mm in diameter and 200 mm in height.

Wear Testing (PIN-on-Disc Wear Testing TR-20 Standard)

A single pin type pin-on-disc apparatus was used to carry out dry sliding wear characteristics of the composite material as per ASTM G99-95 standards. The tests were carried out at the room temperature under dry operating conditions. Wear specimen (pin) of size 12 mm diameter and 25 mm length was cut from as cast samples machined and then polished metallographically. A single pan electronic weighing machine with least count of 0.0001 g was used to measure the initial weight of the specimen. The cylindrical pin flat ended specimens of size 12 mm diameter and 25 mm length were tested against EN31 steel disc by applying the load. After running through a fixed sliding distance, the specimens were removed, cleaned with acetone, dried and weighed to determine the weight loss due to wear.

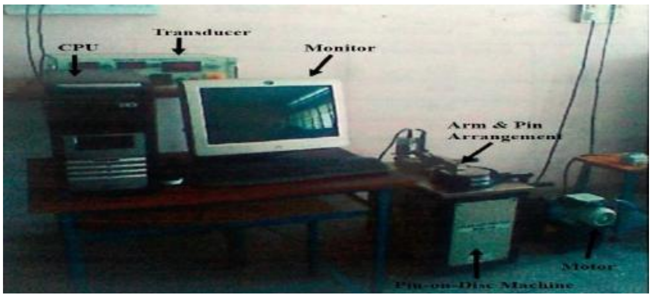

Fig.1: Pin On Disc Apparatus

The difference in the weight of the material measured before and after test gave the sliding wear of the composite specimen and then the weight loss was calculated. The sliding wear of the composite was studied as a function of the weight percentage of the SiC composite, Sliding distance, applied load and rpm.

Plan of Experiments using Orthogonal Array

Tribological behaviors of the samples were studied by conducting the dry sliding wear test as per the standard orthogonal array. The wear parameters chosen for the experiment were: Sliding Velocity (m/sec), Pressure (mpa) and time (Min). The non-linear behavior of the process parameters if exists can only be revealed if more than two levels of the parameters are investigated. Therefore, each parameter was analyzed at three levels. The process parameters along with their values at three levels are given in Table 2.

Table.2: Levels and Values of input parameters

Level	**Low**	**Medium**	**High**
Pressure (mpa)	0.3747	0.7494	1.1242
Time (Sec)	30	60	90
Sliding Velocity (m/s)	1.0472	2.0944	3.1416

III. RESULTS ANALYSIS AND DISCUSSION

The tests were conducted with the aim of relating the influence of Time, Pressure, Sliding Velocity and percentage of SiC with dry sliding wear of the composite material. On conducting the experiments as per orthogonal array the following results were obtained for the wear of various combinations of parameters

Experimental Results and Analysis by Taguchi Method for AL LM-25 & 0% SiC Composite

Analysis of Variance

This analysis was carried out for a level of significance of 5%, i.e. the level of confidence 95%. Table 4 shows the result of ANOVA analysis. One can observe from the ANOVA analysis that the value of P is less than 0.05 in all three parametric sources. Therefore it is clear that sliding distance is most influential followed by sliding speed and load.

Table.3: Wear for AL LM-25 0% SiC Composite

Sr. No.	**Sliding Velocity (m/s)**	**Pressure (Mpa)**	**Time (min)**	**Actual Value**	**Design Expert Predicted Value**
1	1.0472	0.3747	30	22	22.317
2	1.0472	0.7494	60	52	50.222
3	1.0472	1.1242	90	96	96.126
4	2.0944	0.3747	60	42	42.507
5	2.0944	0.7494	90	84	85.269
6	2.0944	101242	30	30	30.888
7	3.1416	0.3774	90	72	71.555

8	3.1416	0.7494	30	28	27.746
9	3.1416	1.1242	60	77	76.365

Table.4: Analysis of variance table using quadratic approach

Std. Dev.	2.47	R-Squared	0.9990
Mean	55.89	Adj R-Squared	0.9917

Experimental Results and Analysis by Taguchi Method for AL LM-25 & 4% SiC Composite

Table.5: Wear for AL LM-25 - 4% SiC Composite

Sr. No.	Sliding Velocity (m/s)	Pressure (Mpa)	Time (min)	Actual Value	Design Expert Predicted Value
1	1.0472	0.3747	30	18	18.063
2	1.0472	0.7494	60	50	51.015
3	1.0472	1.1242	90	94	93.682
4	2.0944	0.3747	60	38	36.730
Sr. No.	**Sliding Velocity (m/s)**	**Pressure (Mpa)**	**Time (min)**	**Actual Value**	**Design Expert Predicted Value**
5	2.0944	0.7494	90	82	82.253
6	2.0944	101242	30	32	31.492
7	3.1416	0.3774	90	68	68.253
8	3.1416	0.7494	30	15	15.634
9	3.1416	1.1242	60	69	68.873

Table.6:25 Analysis of variance table using Quadratic Approach

Std. Dev.	0.62	R-Squared	0.9990
Mean	51.56	Adj R-Squared	0.9995

Experimental Results and Analysis by Taguchi Method for AL LM-25 & 8% SiC Composite

Table.7: Wear for AL LM-25 & 8% SiC Composite

Sr. No.	Sliding Velocity (m/s)	Pressure (Mpa)	Time (min)	Actual Value	Design Expert Predicted Value
1	1.0472	0.3747	30	11	10.111
2	1.0472	0.7494	60	58	58.634
3	1.0472	1.1242	90	97	97.730
4	2.0944	0.3747	60	49	51.920
5	2.0944	0.7494	90	102	98.444
6	2.0944	101242	30	28	27.982
7	3.1416	0.3774	90	69	69.158
8	3.1416	0.7494	30	30	28.539
9	3.1416	1.1242	60	76	77.777

Table.8:38 Analysis of variance table using quadratic approach

Std. Dev.	3.39	R-Squared	0.9985
Mean	57.78	Adj R-squared	0.9883

Hardness

Table.9: Hardness of the Samples

Sr. No.	Sample	Wt. %	Hardness (BHN)
1	A	4	112
2	B	8	115
3	C	12	116

Tensile Test

Table.10: Tensile strengths

Sr. No.	wt. %	Tensile strength (N/mm^2)
1	4	160.33
2	8	161.73
3	12	180.43

IV. CONCLUSIONS AND EFFECTS OF WT. % OF SIC ON AL LM-25

It was found that Pressure, sliding Velocity, time are most influencing parameters on wear. The highest wear resistance can be found out with the Al/ SiC alloy composite. From wear test, it is observed that the sliding velocity is the wear factor that has the highest physical properties as well as statistical influence on the dry sliding wear of the composites. For dry sliding wear of Al SiC alloy metal matrix composites, the time has moderate influence on the wear. The pressure has least influence on dry sliding wear of the composites. It is observed that the uniform distribution of SiC in all samples is not possible by Stir Casting technique, so that some of the properties and results are almost same. Wear resistance of tested alloy increased with increasing SiC weight percentage. Hardness of alloy decreased with SiC content. Tensile strength increases with increase in weight percentage of SiC same for 117ehav strength and percentage elongation.

REFERENCES

[1] N. S. Kalyankar, R. D. Shelke, D. D. Barkul, A review on effect on properties of AL SiC composites fabricated by stir casting method, eISSN: 2319-1163 | pISSN: 2321-7308, Volume: 05 Issue: 02 | Feb- 2016

[2] Balasubramanian, R. Maheswaran, Effect of inclusion of SiC particulates on the mechanical resistance behavior of stir-cast AA6063SiC composites, Materials and Design 65 (2015) 511–520.

[1] J. Jobeen Moses, I. Dinaharan, S. Joseph Sekhar, Characterization of SiC particulate reinforced AL6061 produced via stir casting, Procedia Materials Science 5 (2014) 106 – 112.

[2] Md. Habibur Rahman, H. M. Mamun Al, Rashed, Characterization of silicon carbide reinforced 118ehaviour matrix Composites, Procedia Engineering 90 (2014) 103 – 109.

[3] M.Vamsi Krishna, Anthony M. Xavior, An Investigation on the Mechanical Properties of Hybrid Metal Matrix Composites, Procedia Engineering 97 (2014) 918 – 924.

[4] Satyanarayen, Dominic Roystan, M.Shreesaravanan-Balaguru, C.Devanathan, A Study on Mechanical Properties of Aluminum LM25- SiC Composites Fabricated Using Stir Casting Technique, ISSN 2394- 3777 (Print) ISSN 2394-3785 (Online) Vol. II, Special Issue XXII, February 2015.

[5] Ajay Anand, S.S Chikkadeve Gowda, Characterization of Aluminium-Silicon Carbide Composite using Stir Casting Technique, IJSRD – International Journal for Scientific Research & Development| Vol. 3, Issue 08, 2015 | ISSN (online): 2321-0613.

[6] Srinivasa.K, Devaraj.M.R, Yathisha.N, Manjunath.H.S., Microstructure analysis and wear 118ehaviour of al based metal matrix composite reinforced with ceramic particles, IJRET: International Journal of Research in Engineering and Technology eISSN: 2319-1163 | pISSN: 2321-7308

[7] Akhilesh Jayakumar –Mahesh Rangaraj, Property Analysis of Aluminium (LM-25) Metal Matrix Composite, International Journal of Emerging Technology and Advanced Engineering (ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 4, Issue 2, February 2014)

[8] C. Saravanan K Subramanian D B Sivakumar M. Sathyanandhan R Sankara Narayanan, Fabrication of aluminium metal matrix composite –a review, National Conference on Recent Trends and Developments in Sustainable Green Technologies Journal of Chemical and Pharmaceutical Sciences, ISSN: 0974-2115

[9] A. R. Sivaram, K. Krishnakumar, Dr. R. Rajavel and R. Sabarish, Experimental Investigation of Creep Behaviour of Aluminium Alloy (LM25) and Zirconium DI-Oxide (ZR02) Particulate MMC. *International Journal of Mechanical Engineering and Technology (IJMET)*, 6(8), 2015, pp.126–138.

[10] B. Vijaya Ramnath, C. Elanchezhian, RM. Annamalai, S.Aravind,T. Sri Ananda Atreya, V. Vignesh and C.Subramanian, ALUMINIUM METAL MATRIX COMPOSITES – A REVIE, Aluminium metal matrix composites

[11] Tabish Qamar Hashmi, Liquid State Methods of Producing Metal Matrix Composites: A Review Article, IJRMET Vol. 5, Issue 1, November 2014 – April 2015 ISSN: 2249-5762 (Online) | ISSN : 2249-5770[

[12] Bhaskar Chandra Kandpal, Jatinder Kumar, Hari Singh, Production Technologies of Metal Matrix Composite: A Review, IJRMET Vol. 4, Issue 2, Spl – 2 May – October 2014 ISSN: 2249-5762 (Online) | ISSN : 2249-577014Vol.2 Issue.4.

[13] M.V. Niranjan Reddy, M. Nikhil Reddy, K. Vijay Kumar and Parthasarathy Garre, Experimental Investigation of Tensile Strength on AL 6351 to the Aerospace Structural Applications. *International Journal of Mechanical Engineering and Technology (IJMET)*, 5(2), 2014, pp.110–114.

[14] Hemanth Kumar.T.R. Swamy.R.P. and Chandrashekar T.K., An experimental investigation on wear test parameters of metal matrix composites using taguchi technique. Indian journal of engineering and material science vol. 20 august 2013.

[15] Ashok Kr. Mishra, Rakesh Sheokand , Dr. R K Srivastava, Tribological Behaviour of Al-6061 / SiC Metal Matrix Composite by Taguchi's Techniques International Journal of Scientific and Research Publications,
Volume 2, Issue 10, October 2012 1 ISSN 2250-3153

[16] H. B. Bhaskar1,Abdul Sharief,Dry Sliding Wear Behaviour of aluminium/Be3Al2(SiO3)6 Composite Using Taguchi Method Journal of Minerals and Materials Characterization and Engineering, 2012, 11, 679-684 Published Online (http://www.SciRP.org/journal/jmmce).