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An Experimental Study on Effect of Mechanical Properties of Aluminium Composite Reinforced With Silicon Carbide

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ABSTRACT

Tremendous research is going on Aluminium Metal Matrix composite material due to wide applications Automobile, Aerospace, Ship etc. In current industrial scenario composite material has lot of scope due to its improved mechanical properties like hardness, toughness, compressive strength & tensile strength. Conventional monolithic materials have limitations with respect to composite material in terms tribological properties. The composite contents two inherent phases as matrix and reinforcement. The aluminium alloy A356 has good potential to work as matrix material because of its low melting point, good weldability, castability, as well as corrosion resistance.In the present investigation, it is found that Intribological properties, when the reinforcement % increases wear of composite material decreases. When the load increases wear in micron of composite material increases. When the speed increases wear in micron of composite material increases.
Keywords— Metal Matrix composite,A356,reinforcement,matrix, wear ..

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I. Introduction

In recent trends many researchers encouraged to many scientists to search new engineering materials. Among the many engineering material composite material is attractive one for future research due to its mechanical and wear properties[1]. AMC has low density, high specific strength, working at high elevated temperature. Aluminium and its alloys are extensively used as the materials in transportation (aerospace and automobiles), engine components and structural applications [1].Thus it becomes all the more vital to study the tribological characteristics of Aluminium and its alloys. Addition of Silicon to Aluminium gives high strength to weight ratio, low thermal expansion coefficient, and high wear resistance. These alloys also show improved strength and wear properties as the silicon content is increased beyond eutectic composition. Such properties warrant the use of these materials as structural components in automotive industries [2].

The results of an present experimental investigation of the mechanical properties of SiC reinforced aluminium alloy (A356) composites samples, processed by stir casting route are reported in this project. Three sets of composites with constant weight fraction of silicon Carbide (particle size of 3-100 µm) with different wt% were used. Composite samples have the reinforcement weight fractions of constant 3% ,6%,9% Silicon carbide .As advanced engineering materials, composites are usedin many applications where high wear resistance is required, these include electrical contact brushes, cylinder liners, artificial joints, and helicopter blades. Indeed, compared to monolithic materials, wear resistance can generally be enhanced by introducing a secondary phase(s) into the matrix material [3]. In this fashion, the wear properties can be varied substantially through changes in the microstructure, the morphology, volume fraction and mechanical properties of the reinforcing phase, and the nature of the interface between matrix and reinforcement. In order to obtain optimal wear properties without compromising the beneficial properties of the matrix material, an accurate prediction of the wear of composites is essential.

II. TAGUCHI'S TECHNIQUE

The main trust of Taguchi's technique was the use of parameter design that determines the parameter settings which produces the best levels of a quality characteristic with minimum variation. Taguchi's technique was best suited for manufacturing problems. This methodology acquires data in a controlled way through limited number of experiments which gives the accurate nature of the process. Further depending on the number of factors, interactions and their level, an orthogonal array was selected. Taguchi method follows Signal-to-Noise (S/N) ratio as the quality characteristic of choice.

III. MATERIAL SELECTION

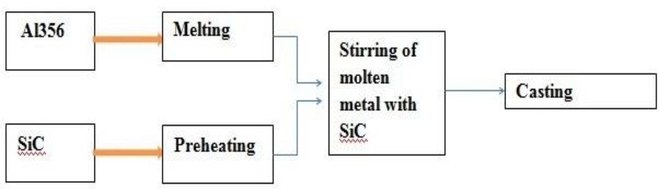
The matrix material used in the experiment investigation was commercially aluminium alloy A356 .The particle size of the SiC as received condition lies in the range from (3-100 μm).A356 aluminium alloy having density of 2.72 gm/cm^3 and prominent properties like weight, toughness, heat conduction etc.

Table 1.
Chemical composition (in % wt) of A356 aluminium alloy

Cu	Mg	Si	Fe	Mn	Zn	Sn	Ti	Al
.20	.25 to .45	6.5 to 7.5	.20 max	.35Max	.10 max	.1	.20 max	Balance

IV. SYNTHESIS OF COMPOSITE

Composite material is manufactured by stir casting technique.In this the A356 melted into the graphite crucible till 760 degree centigrade. Temperature of furnace kept steady still 30 minutes .Simultaneously Silicon carbide reinforcement also preheated at 400^{0}C because to remove the moisture .To avoid the oxidization of metal hexachlorinethane tablets are mixed. To attain grain refinement powder also mixed. This mixture of A356 and SiC mixed by using turbine stirrer at 500 rpm speed of stirrer and 5 minutes timing.



V. DESIGN OF EXPERIMENTS

Plan of experiments was done using Taguchi's technique and L9 orthogonal array was opted for getting the best results with minimum number of experiments (Table 2). Wear rate of the specimen and the average coefficient of friction were the two responses evaluated using S/N ratio and Analysis of Variance (ANOVA). Experiments were conducted by considering three parameters; applied load, Speed of disk and reinforcement percentage, each of these varied for three levels (Table 2).

Table 2.
Process parameters and their levels.

Sr.No	Applied load (N)	Speed of Disk (rpm)	Reinforcement
1.	10	150	3
2.	20	300	6
3.	30	450	9

The cast component was machined into rectangular specimen of 5mmX30mm dimensions by milling. Drysliding wear tests on those specimens were conducted using a DUCOM make pin-on-disc tester (Fig.2) as per L9 orthogonal array. Test pins (5X30mm) (Fig. 3) were held against a rotating steel disc (EN-32) ofhardness HRC65. Track radius22.5 of mm was made constant for all the experiments. Load was applied on thecantilever beam that exerts equal amount of force on the specimen for contact with the counter face. The wear of thespecimen was monitored using a Linear Variable Differential Transducer (LVDT) which was attached to the lever ofthe machine. The applied load forces the pin to be in contact with the disc. Wear mechanism of the surface leads tothe minor change in the dimensions of the pin, thus displacing the lever arm. This displacement of the lever armgives input to LVDT for measuring the respective wear. Before and after the experiment, specimen was cleanedproperly and weighed using a microbalance of least count 0.1mg. The mass loss of the specimen was calculated andconverted into volume loss and thereby to wear rate respectively. The coefficient of friction between the pin and therotating disc was measured using friction sensors under regular intervals and was recorded by the WINDUCOMsoftware. Taking the average of those values gives average coefficient of friction.

Fig. 2.Pin on Disc Tester

Fig.3 Specimens of Wear test

1. Wear test

Tribologicalbehaviour of the composite, i.e. wear rate and coefficient of friction was evaluated.

Table 3.Table of Experiments

Sr. No	% reinforcement	Load (N)	Speed of Disc rpm	Wear in micron	COF
1.	**3**	**10**	**150**	**81**	**0.386**
2.	**3**	**20**	**300**	**120**	**0.375**
3.	**3**	**30**	**450**	**160**	**0.350**
4.	**6**	**10**	**300**	**97**	**0.462**
5.	**6**	**20**	**450**	**168**	**0.422**
6.	**6**	**30**	**150**	**88**	**0.559**
7.	**9**	**10**	**450**	**96**	**0.490**
8.	**9**	**20**	**150**	**94**	**0.524**
9.	**9**	**30**	**300**	**140**	**0.498**

ANOVA investigates which of the process parameters and their interactions significantly affect the performance characteristics. ANOVA for wear rate and coefficient of friction was indicated in Table 4&5 respectively. Thisanalysis was carried out for a level of significance 5%, i.e., for a level of confidence 95%. 'P' value, less than 0.05for a particular parameter, indicates that it has the major effect on the responses.

Table 4.
ANOVA for wear rate.

Sr. No	Reinforcement	Load	Speed of Disc rpm	Wear in Micron
1	3	10	150	81
2	3	20	300	120
3	3	30	450	160
4	6	10	300	97
5	6	20	450	168
6	6	30	150	88
7	9	10	450	96
8	9	20	150	94
9	9	30	300	140

It can be observed from the Table 6 that the speed of disc (S) and applied load has the highest influence on Wear. as the value of P for speed of disc (sliding distance) P= 0.019 and for applied load P=0.06. Other value are above the confidence level of 0.05, therefore those source value can be neglected.

Table 5
Analysis of Variance for Wear

Source	DF	Seq SS	P	Regression coefficient
				34.7
R	**1**	**160.2**	**.539**	**-1.29**
L	**1**	**2166**	**.06**	**1.9**
S	**1**	**4320.2**	**0.019**	**.17889**
Residual error	**5**	**5486**		
Total	**8**			

S = 19.181 R-Sq = 78.3% R-Sq(adj) = 65.3%

The adequacy of developed models were tested using analysis of variance (ANOVA) technique and the results of first-order response model fitting in the form of ANOVA is given in Table 7. The determination coefficient (R2) indicates the goodness of fit for the model. In this case, R2 value for wear is 78.3 % percent after considering significant factors. The value of adjusted determination coefficient, adjusted R2 = 65.3 % is also high, which indicates a high significance of the model.

Main Effects plot for Means –Wear

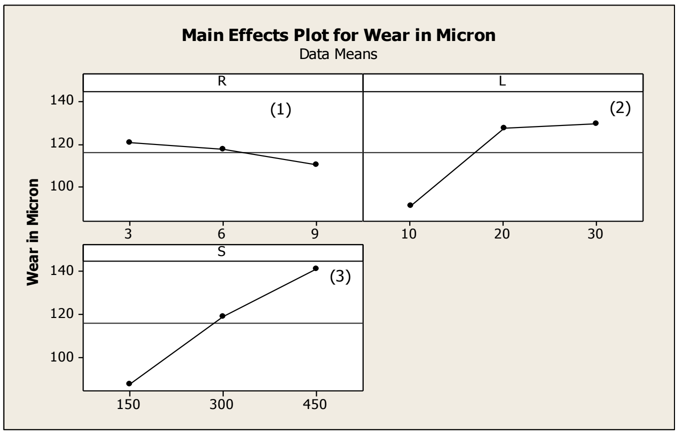


Fig.Main Effects plot for Means –Wear

It can be observed from Fig, that the speed of disc (S) and applied load has the highest influence on Wear. First graph shows that when the reinforcement increases wearof Composite material decreases .second graph shows that when the load increases wearof Composite material increases. Third graph shows that when the speed increases wearof Composite material increases.

Table 6

Coefficient of Friction

Sr.	Reinfor	load	Speed of	Coefficient
1	3	10	150	0.3859
2	3	20	300	0.37487
3	3	30	450	0.350123
4	6	10	300	0.4621
5	6	20	450	0.4215
6	6	30	150	0.5585
7	9	10	450	0.49
8	9	20	150	0.5244
9	9	30	300	0.498

Table 7.

Analysis of Variance for Co-efficient of friction

Source	DF	Seq SS	P	Regression coefficient
Constant	-	-	0.001	0.36406
R	1	0.026868	0.007	0.016729
L	1	0.000785	0.490	0.001144
S	1	0.007154	0.074	-0.0002302
Residual error	5	0.007066		
Total	8			

S = 0.0375929 R-Sq = 83.1% R-Sq(adj) = 73.0%

it can be observed from above table that reinforcement factor has significant effect on Coefficient of friction because Value of P is .007 as per Confidence level value should be .05 or less than that. And second factor Speed of disc has little effect on co-efficient of friction.

The adequacy of developed models were tested using analysis of variance (ANOVA) technique and the results of second-order response model fitting in the form of ANOVA is given in Table7. The determination coefficient (R^2) indicates the goodness of fit for the model. In this case, R^2 value for Co-efficient of friction is 83.1% percent after considering significant factors. The value of adjusted determination coefficient, adjusted R2 = 0.73 is also high, which indicates a high significance of the model. Lack of fit is insignificant and therefore indicates that these models fit well with the experimental data.

Main Effects plot for Means –coefficient of friction

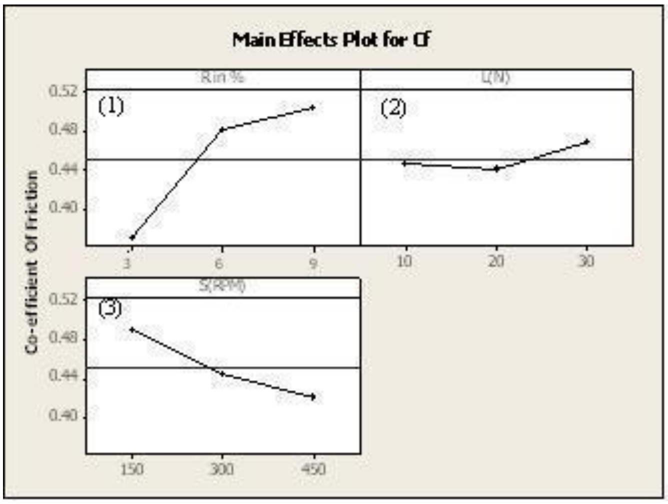


Fig. Main Effects plot for Means –Coefficients of Frictions

It can be observed from Fig 5.40**,** that the speed of disc (S) and applied load has the highest influence on COF. First graph shows that when the reinforcement increases COF of composite material increases .second graph shows that when the load increases COF of composite material increases. Third graph shows that when the speed increases COF of composite material decreases.

VI. CONCLUSIONS

- The stir casting method is found to be suitable to fabricate theAluminium-SiCreinforcedmetal matrix Nano composites.
- Aluminium reinforced with SiCexhibits better dry abrasive wear resistance.
- For all values of the applied load, specific wear rate decreases with the increase of the % of MWCNT

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