Analysis of Dry Sliding Wear Behaviour of Stir Casted Lm25-Al_2O_3-Gr Composite

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Abstract- *The Mechanical properties and machinability of composites not only depend on the volume of reinforcements, but also on the distribution of these reinforcements. Aluminium LM25 alloy has high corrosion resistance; however, its hardness is lower which limits its applications. This project aims at fabricating a composite material using LM25 as matrix which has high hardness. Composite material with different proportions of Al_2O_3 and graphite were fabricated using stir casting process. Samples were prepared usingLM25 reinforced with Aluminium oxide Al_2O_3 (8%, 12%) and Graphite (5%) by volume at 725°Cmelting temperatures and stiring speed at 250rpm and 300rpm , and reinforcement pre-heat temperatures as 850°C. Experiments were conducted using Taguchi L_4 orthogonal design of experiments. Hardness and wear tests were conducted using micro hardness testing machine and pin-on-disc apparatus respectively. The evaluation of mechanical properties reveals that, hardness and wear resistance vary with the composite combinations. The results show that the incorporation of reinforcement vary the hardness and the wear resistance of the material.*

Keywords- LM25,stircasting,wear,hardness.

I. INTRODUCTION

Aluminium is among the most interesting model materials for processing because of its unique micro structural and mechanical features and the main cause of this is the low density and wear resistance of aluminium. Aluminium alloys have been used as a matrix alloy in producing metal matrix composites.The reason of very good usage in the advanced industries such as aerospace as well as mechanical is because of its increased properties such as low density, high strength and stiffness, high specific modulus, very good wear resistance, low coefficient of thermal expansion, high damping capacity and excellent high temperature properties. Wear Behavior of aluminium matrix composites depends on the strength of the interface between the matrix and reinforcement particle.

In this study the Composite having 8% Al_2O_3 and 5% Gr and 87% LM25 combination fabricated at stirring speed 300rpm has improved in hardness . The wear test is performed by a pin-on-disk wear-testing apparatus. The pins used for testingare in the form of a cylinder of diameter 10 mm and height 30 mm. The disk against which the cylinder slides is made of steel.

The wear test was performed in increasing load condition. After each step, the surfaces of the samples were cleaned with ethanol. The Reinforced composite materials exhibited improved wear resistance with increasing weight fraction of reinforcement.The composite having 12% Al_2O_3 and 5% Gr and 83% LM25 composition fabricated at stirring speed 250rpm has superior wear resistance compared to other combinations.Hence it is clear that the increase in the amount of reinforcement increases wear resistance of the Aluminium LM 25 alloy.

II. EXPERIMENTAL PROCEDURE

The matrix material is aluminium alloy LM25. Samples are to be prepared using LM25 reinforced with Aluminium oxide Al_2O_3 (8%, 12%) and Graphite (5%) by volume at Stirring speed of 250rpm and 300rpm, at melting temperatures of 725°C and reinforcement pre-heat temperatures as 700°C. Experiments were conducted using Taguchi L_4 orthogonal design of experiments . The chemical composition of LM25 is shown in Table 1.The samples are made by stir casting method by various constituents levels of composite elements which was shown in Table 2.

Table 1: Composition of LM 25

Materials	%
Copper	0.2 max.
Magnesium	0.20-0.60
Silicon	6.5-7.5
Iron	0.5 max.
Manganese	0.3 max.
Nickel	0.1 max.
Zinc	0.1 max.
Lead	0.1 max.
Tin	0.05 max.
Titanium	0.2 max.
Aluminium	Remainder

Table 2 :various constituents levels of composites

Experiment No	Sample No	Stirring speed	Reinforcement %	
			Al_2O_3	Graphite
1	1	250	12	5
2	2	300	12	5
3	3	250	8	5
4	4	300	8	5

2.1Preparation of samples using stir casting process

The experimental setup of stir casting essentially consists of an electric furnace and a mechanical stirrer. The electric furnace carries a crucible of capacity 2kg. The maximum operating temperature of the furnace is 1000°C. The current rating of furnace is single phase 230V AC, 50Hz. The stir casting machine set up at GCT, Coimbatore is shown in Figure 4.1.

The aluminium alloy LM25 ingots were cut in power hacksaw machine to the small rods of 50 mm thickness and 25 mm diameter to feed the materials in to the crucible. The required proportion of the rods as per experimental plan is fed in to crucible and melted by heating in the induction furnace at the temperature of 725 ℃ for 1 to 2 hours and melt the rod above its liquidus temperature to make it in the form of semi liquid state (around 600°C).

The Al_2O_3 and graphite particles in the right proportion as per the experimental plan are preheated to a temperature of 700°C to make their surface oxidized. Preheated die is heated to a temperature of 200°C for proper solidification. During the reheating process of aluminium alloy at 725°C stirring is done by means of a mechanical stirrer as shown in figure 4.1 which rotates at a speed of 250rpmand 300rpm. Then the reinforcement powders are added to semi liquid aluminium alloy in the furnace. Argon gas is passed in to the molten metal to remove the soluble gases present in the liquid state metal. Stirring of molten metal is carried for 3 minutes duration.The aluminium composite material reaches completely liquid state at the temperature of about 725°C and the completely melted aluminium hybrid composite is poured in to the permanent metal die and subjected to solidification to produce the required specimen.

2.2 pin-on-disc wear test

A pin-on-disc test apparatus, which is shown in figure 4.11, was used to investigate the dry sliding wear characteristics of the aluminium alloy and its composites as per ASTM G99-95 standards. The wear specimen size of 10 mm diameter and height of 30 mm was cut from cast samples, machined and then polished metallographically. The test was conducted with constant sliding distance at constant speed and time.

All these tests were conducted at room temperature. The initial weight of the specimen was measured in a single pan electronic weighing machine with a least count of 0.0001 g during the test the pin was pressed against the counterpart rotating against EN32 steel disc with hardness 65HRC by applying the load. An approximately strain-gauged friction detecting arm holds and loads the pin specimen vertically in to a rotating hardened steel disc. After running through a fixed sliding distance at different load, the specimen was removed, cleaned and weighed to determine the weight loss due to wear

2.2.1 Wear test specification

Conforms to specifications	ASTM G99
Sliding speed range	0.26-10m/s
Disc rotation speed	100-600rpm
Maximum normal load	200N
Frictional force	0-200N
Wear measurement range	4mm
Pin size	3-12mm
Disc size	160mm diameter
Wear track diameter	10-140mm

2.3. Hardnesstest:

Hardness measurements were carried out on both the composites material using Vickers hardness testing machine.

III. RESULTS AND DISCUSSION

Wear test

The volumetric wear rates of Aluminium LM 25 and Reinforced composites are plotted. The graph is plottedtaking the wear in micrometer along Y-axisagainst the time. It is immediately apparent that there is consistent improvement in wear resistance with increasing values of reinforcement.

The wear rates were determined using the value of wear obtained by Graph. In the wear test the pin was pressed against the counterpart rotating against EN32 steel disc. An approximately strain-gauged friction detecting arm holds and loads the pin specimen vertically in to a rotating hardened steel disc.

After running through a fixed sliding distance at specific load, the specimen was removed, cleaned and the graph obtained is saved in computer for all samples.

Samples	Wear at Load 2(kg)	Wear at Load 3(kg)	Wear at Load 4(kg)
1	26	28	82
2	20	60	83
3	48	114	319
4	79	100	298

Hardness Test

Micro hardness test at various locations was carried out to know the effect of reinforced particulates on the alloy matrix. Vickers hardness measurement has been carried out on the embedded reinforcement particles as well as in the locality of particles and matrix.

Sample No.	Trial 1	Trial 2	Trial 3	Average	Indentation Depth (mm)
1	125.6	127.3	125.9	126.3	3.2
2	132.6	131.5	137.5	133.9	3.3
3	142.5	147.8	142.9	144.4	3.8
4	166.6	163.5	169.2	166.4	4.1

IV. CONCLUSION

The hybrid composite samples of LM25 as matrix, Al_2O_3 and Graphite particulates as reinforcements were fabricated using stir casting process. The mechanical properties such as hardness, wear were investigated from the fabricated samples.

Composite having 8% Al_2O_3 and 5% Gr and 87% LM25 combination fabricated at stirring speed 300rpm has higher hardness (166.4 HV) and the composite having 12% Al_2O_3 and 5% Gr and 83% LM25 composition fabricated at stirring speed 250rpm has superior wear resistance compared to other combinations.

This hybrid composite can be explored for use in applications where higher wear resistance and low hardness is required.

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