Tribological evaluation of LM26 Aluminum Metal Matrix Composites.

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Abstract— *Material development is a vital part for any design process. In this field, metal matrix composites are extensively researched because of their ability to be produced in a unique manner. There are vast number of application areas of these materials which include automobile, aerospace, energy, biomedical fields. The current research work deals with the possible development of a new material with Aluminum LM26 as the base metal. The reinforcement particles used are Silicon Carbide (SiC) and Tungsten Disulphide is used as a lubricating medium. In this research work, LM26 metal matrix composite is fabricated by the procedure of stir casting and reinforced with Silicon Carbide powder by infusing the reinforcement into 5%, 10%, 15% weight percentage respectively. The aim of the research work is friction testing of Aluminum LM26 metal matrix composite material on a pin-on-disk apparatus (For determining wear rate). The substantial conclusions include how load & reinforcements affect the wear characteristics of LM26 metal matrix composite.*

Keywords— Metal matrix composites, Aluminum LM26, Silicon Carbide, Tungsten Disulphide.

I. INTRODUCTION

Engineering field has seen material advancements throughout the different periods of technological evolution. Over the years, different materials like alloys, fiber reinforced composites, nano fibers, metal matrix composites, nanotubes have been used to alter the physical properties of pure base metals in order to produce a tailor made material for fulfilling increasing requirements in different conditions. Metal matrix composites are in demand because they can be manufactured in a specific way to meet the required conditions. Metal matrix composites are comparatively less costly than nanotubes. Hence, these materials can be used widely for specific application areas due to their exceptional properties.

A decent amount of research is under progress for finding a suitable material for replacement of the conventional materials used. Due to the need of having less mass in modern day applications, Aluminum metal matrix composites are under development to meet specific conditions and get the desired results. Aluminum LM26 alloy can be utilized in place of the conventional Aluminum alloys for certain applications if the proper reinforcements are applied to it.

Because of the naturally excellent wear resisting properties, LM26 alloy can be properly manufactured as a metal matrix composite by proper reinforcements and the resulting material can give minimum wear rate under the specific loading conditions.

Aluminum LM26 is known for its wear resistant properties. Mostly, the previous metal matrix composite works deal with lighter loads of the order 10N-30N. This work aims at the consideration of loads i.e. 40N, 50N and 60N and thus finds out the wear rates of the LM26 metal matrix composite.

II. LITERATURE REVIEW

S. Seshan, A. Guruprasad, M. Prabha and A. Sudhakar [1] in their paper, "Fibre-reinforced metal matrix composites-a review" outlined the production techniques and mechanical properties of MMCs in general. They depicted that Al and Zn-based composites exhibit tremendous improvement in all mechanical properties as compared to the unreinforced base alloys.

Dunia Abdul Saheb [2] in his paper, “Aluminum silicon carbide and aluminum graphite particulate composites” attempted to develop aluminum based silicon carbide particulate MMCs, graphite particulate MMCs with an objective to develop a conventional low cost method of producing MMCs to obtain homogenous dispersion of ceramic material. Experiments were conducted by varying weight fraction of SiC, graphite and alumina & while graphite weight fraction keeping all other parameters constant. The results indicated that the ‘developed method’ was successful to obtain uniform dispersion of reinforcement in the matrix. An increasing of hardness and with increase in weight percentage of ceramic materials was observed.

Vinoth M.A, Arun L.R, Bhimagoud Patil [3] in their paper, “The Fabrication Process and Mechanical Characterization of Pure Al-Si Mmc’s for Engine Applications” investigated the fabrication of aluminium-silicon based hybrid metal matrix composites reinforced with silicon carbide and cenosphere particulates for engine applications. Pure Al-12.5 weight % Si alloy reinforced SiC & cenosphere particulates were produced by using stir casting technique. These materials were developed for piston, cylinder sleeve and engine blocks.

Z. F. Zhang, C. Zhang, Y.W. Mai [4] in their paper, “Particle effects on friction and wear of aluminium matrix composites” investigated the effects of different particles on friction and wear of 6061 aluminium (6061 AI) reinforced with silicon carbide and alumina (AI203) particles by means of Vickers hardness measurements and scratch tests. They concluded that increase of hardness by larger volume fraction of particles or different ageing conditions increases the friction coefficient and reduces the wear rate. Compared to other ageing conditions, peak-aged composites have the best wear resistance but the largest friction coefficient.

III. MAUNFACTURING PROCEDURE

Stir casting method was implemented for the manufacturing of the LM26 Aluminum metal matrix composite. The LM26 ingot was melted in an electrical furnace under atmospheric conditions. The molten metal was then allowed to solidify in a mold. Preheated Silicon Carbide particles in powder form were added in the molten metal through the use of a funnel.

Silicon carbide particles were preheated and added 5%, 10%, 15% by weight percentage in molten Aluminum LM26 to form different compositions.

Solid Lubricant in the form of Tungsten Disulphide was used as another reinforcing material in order to develop the self-lubricating property.

The Dimensions of the prepared specimen are as follows:

Aluminum (Pins): ϕ10x 100 mm

The samples were finalized by machining the prepared specimen on a conventional lathe machine.

One pin of ϕ10x 100 mm was cut and machined on the lathe in order to get the standard required dimensions of ϕ10x 30mm pin. In this way, the pins were manufactured.

Fig. 1 Aluminum LM26 pin specimen

Table 1: Chemical composition of Aluminum LM26

Element	% content
Cu	3
Mg	1
Si	9
Fe	1.1
Mn	0.5
Ni	1
Zn	1
Pb	0.2
Sn	0.1
Ti	0.2

IV. DESIGN OF EXPERIMENT

The Taguchi method designs the combination of experiments which can be performed for obtaining the best possible results.

It is difficult and time consuming to decide the operating parameters and the combinations without the use of a statistical tool. Hence, the importance of Taguchi becomes vital.

Taguchi Design (Design Summary)

Taguchi Array L9(3^3)

Factors: 3

Runs: 9

Columns of L9(3^4) array: 1 2 3

Parameter	Notation	Units	Value 1	Value 2	Value 3
Load	L	N	40	50	60
% reinforcement	r	%	5	10	15
Sliding velocity	v	m/s	2	4	6

The experiments on pin on disk tribometer were performed by considering the above factors and forming an L9 array as shown:

Table 2 : L9 orthogonal array

Load (L)	% Reinforcement (r)	Sliding speed (v)
40	5	2
40	10	4
40	15	6
50	5	4
50	10	6
50	15	2
60	5	6
60	10	2
60	15	4

V. EXPERIMENTATION

The prepared samples were used for tribological test on a pin-on-disk apparatus. The pin on disc apparatus is used to determine the wear rate of the manufactured composite material. The specimen pin was located in a holder and was prone to area contact on a rotating disc spinning at a variable angular speed. The tangential force and the frictional coefficient were measured.

The basic aim of the wear test was to establish the different wear rates of the manufactured material in order to get the results of the wear rate in microns under the mentioned loads and sliding velocities. The specimen pins were run against the disc of grade EN-31 steel which is available as a standard disc material at the laboratory.

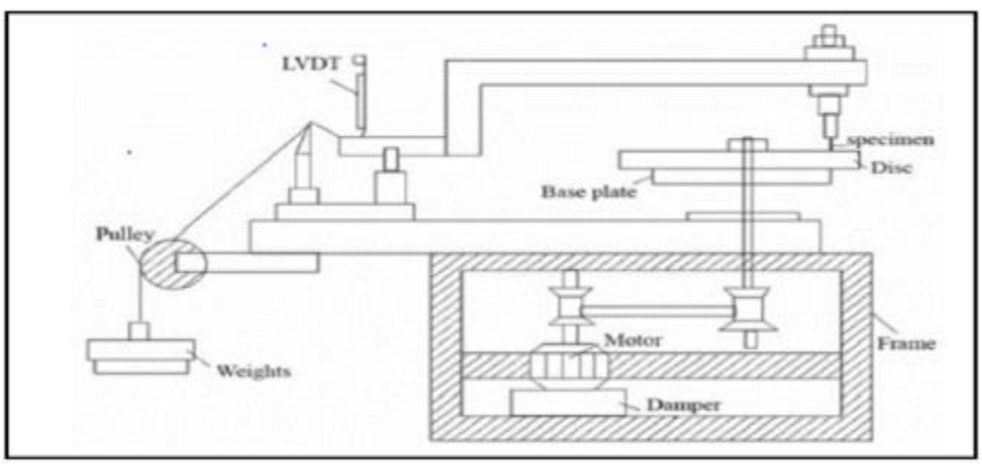

Fig. 2: Schematic image of Pin-on-disk apparatus

The tests were conducted at room temperature under dry sliding conditions. The following parameters were kept constant:

Sliding distance= 400mm

Wear Track Diameter= 100mm. The experiment time was set to be 180 seconds for testing of each reinforced specimen.

VI. RESULTS

Table 3: Pin on disk tribometer results

Load	% Reinforcement	Sliding velocity	Wear rate (Microns)	Coefficient of friction (f)
40	5	2	13	0.46
40	10	4	9	0.36
40	15	6	8	0.23
50	5	4	14	0.41
50	10	6	11	0.30
50	15	2	7	0.25
60	5	6	14	0.38
60	10	2	12	0.31
60	15	4	10	0.28

CONCLUSION

The design of experiments were performed by the virtue of Taguchi analysis.

As the load increases, the wear rate increases. However, with the increase in reinforcing material in the form of Silicon Carbide content, the resistance to wear improves as compared with the low levels of Silicon Carbide reinforcement. The effect of sliding velocity is not a major factor in the wear characteristics of the LM26 Aluminum metal matrix composite.

However, it must be noted that more tests must be performed by increasing the quantity of specimen for higher loads and higher reinforcement percentages in order to utilize the developed material for different loading conditions.

Also, the work mainly focuses on the reinforcing effect and load effect. In this work, the effect of sliding velocity has been found negligible. However, there may arise cases wherein sliding velocity may have a significant impact on the wear properties of LM26 Metal matrix composite.

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