Evaluation of Tribological Behavior of LM24 Reinforced With Nano Alumina

Kathervel A [1], Surendran R [2]
[1, 2] Dept of Manufacturing Engineering
[2] Assistant Professor, Dept of Manufacturing Engineering
[1, 2] Government College of Technoloy,Coimbatore-13

Abstract- *Metal Matrix Nano composite material differs from the conventional composite material for offering high surface to volume ratio of the reinforcing phase. In this research work, liquid metallurgy route says, stir casting technique employed to fabricate the nano composite material. The fabrication of nano composite material was conducted with the distribution of 1.5 wt% of nano aluminium oxide powder in the molten aluminium alloy of LM24. Wear behavior of the nano composite was evaluated using the pin on disc wear testing machine based on Design of Experiments approach. Experimental parameters such as applied load (10,20and30N), speed (300,400,500 rpm) and track diameter (60,70,80cm) were varied for three levels. Signal to noise ratio and Analysis of variance were also performed. Wear plots of the experiments revealed that wear was increased with increase in load and decrease with increase in speed. Signal to noise ratio plot showed that load was the significance over the wear rate followed by the speed and track diameter. Inverted microscopy was adopted to analyze the worn surface and from micrograph, it showed that the abrasive wear mechanism subjected to the wear experiment which was performed.*

Keywords- Wear, Nano Alumina, Taguchi method, Nano composite material.

I. INTRODUCTION

Aluminium metal matrix composites are the materials whose properties such as light weight, high strength to weight ratio are the prime reason for utilizing such materials on the fields of aerospace, automotive and defence industries. Tailoring the property of the material for the particular application is always an ingenious task for most of the researchers, for such cases reinforcements plays a vital role in enhancing the properties of the materials. The reinforcements are ceramics, generally Al2O3, TiC, SiC and graphite. Although the incorporating reinforcement materials may be either in the particles form or in the whisker form.

The new category of materials which meets the recent trends are metal matrix nano composite materials, here the nano particles are reinforcement, which are in the nanometer scale. Increased surface area offered by nano scale reinforcements at the matrix interface leads to superior properties in composites such as increased mechanical properties, higher fatigue life and creep resistance at elevated temperature without much compromise the ductility of the base material. However, the end properties of MMNCs are greatly influenced by the size, shape and grain distribution. Ahmed Y. Shash et.al.,(2015) studies revealed that using nano particle ceramic powders as reinforcement to gain improved performance of A356 Al Cast alloy. The result showed that higher strength values with improved ductility has been obtained, wear resistance has been positively enhanced as the amount of the nano alumina particles increases and the weight loss ranging also reduced from 5.5 to 4.0 mg. R.Surendran et al., (2015), investigated wear behavior of LM25 reinforced with nano alumina. From the dry sliding wear test, it is revealed that wear resistant of the nano composite material is improved and the wear reduction is obtained with the addition of nano alumina upto weigth percentage of 2.5 %. A.El-Ghazaly et.al.,(2016), fabricated nano structured AA2124 with graphene by a combination of ball milling and hot extrusion processes. Investigation of mechanical properties and tribological analysis were made, from the result it was concluded that with varying weight percentage of the graphene properties influences both the mechanical, tribological properties and the properties has been improved. Amit Raturi et.al (2016) investigated mechanical, tribological and microstructural behavior of Al7075 metal matrix composites reinforced with nano alumina in different weight proportions using stir casting process. It was revealed from the result thus increasing the weight percentage of nano alumina upto 7% decreases the mechanical property of the composite material. It is also revealed that increasing the weight percentage of the nano alumina also improves wear resistant considerably at high speed. R.Ambigai.et.al., (2016), compared, optimized the wear properties and microstructural analysis made on the single nano composite material and hybrid metal matrix composite material. From the result it is revealed that single nano composite material shows lower wear rate than the hybrid metal matrix composite material. And hence only abrasive wear mechanism seems to occur in

the single nano composite material. Cesar A. Isaza Merino et.al., (2014) fabricated the metal matrix composite with carbon nano tube and observed that improved mechanical properties was obtained in the composite material thus produced. Guobin Li et.al., (2014) fabricated Copper Alumina metal matrix composite materials with varying weight proportions by powder metallurgy technique. The wear and friction performance improved with the addition of nano alumina powder and also the hardness of the composite material is also improved compared to its base matrix material.

Aluminium nano composite materials are lighter in weight than the aluminum alloys for applications in aerospace and automotive industries. Fabrication of Aluminium matrix composites reinforced with nano sized ceramic particles with higher weight proportion degrades its properties. Most of the researchers had done Nano particle reinforcement on various Aluminium alloy only few made their reinforcement in LM24.

II. EXPERIMENTAL PROCEDURE

Material Selection

The material chosen for this research work is LM24, whose known for its excellent castability, and its strength. Nano Aluminium oxide powder with the average size of 40nm of purity 99.5% obtained from MKImpex corp, Canada. The Samples has been fabricated through liquid metallurgy route says, stir casting method. The sample that has fabricated with the reinforcement weight percentage of 1.5 nano aluminium oxide, remaining LM24.

Taguchi Method

Table.1
Design of Experiments

S.No	WEIGHT (Kg)	SPEED (rpm)	TRACK DIAMETER (mm)
1.	1	300	60
2.	1	400	70
3.	1	500	80
4.	2	300	60
5.	2	400	70
6.	2	500	80
7.	3	300	60
8.	3	400	70
9.	3	500	80

Taguchi method is used to optimize the result that has been obtained from the wear test. L9 method is adopted to perform the experiment by setting the test parameters and their levels.

S/N Ratio is taken for the wear result that obtained from the experimentation. The suitable parameters and conditions in which wear obtained is also obtained.

The dispersion of reinforcement particles in the matrix alloy is analyzed by means of inverted microscope. An inverted microscope is a kind of microscope with its light source and condenser on the top, above the stage pointing down, while the objectives and turret are below the stage pointing up. The focus mechanism typically has a dual concentric knob for coarse and fine adjustment.

III. RESULT

Wear Test

In the wear test the pin is pressed against EN32 steel disc with hardness 65HRC by applying the load as per the design of experiments. The wear graph that was obtained from the winducom software through the data acquisition method. The wear result thus obtained is tabulated below.

Table2. Wear Result

S.No	WEIGHT (Kg)	SPEED (rpm)	TRACK DIAMETER (mm)	WEAR RATE (µm)
1.	1	300	60	40
2.	1	400	70	182
3.	1	500	80	146
4.	2	300	60	180
5.	2	400	70	176
6.	2	500	80	163
7.	3	300	60	236
8.	3	400	70	215
9.	3	500	80	181

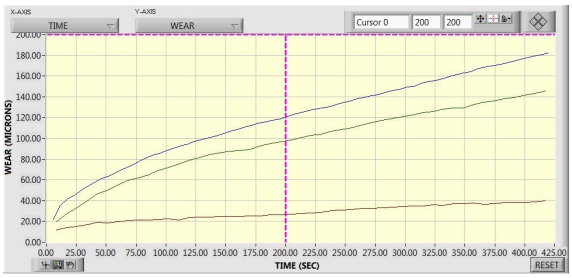

Fig.1 Wear Vs Time graph for the first three samples

From the Fig.1, the graph has been plotted between wear and time. The above fig also compare th 3 ion of the wear with the different speed and the same load condition.

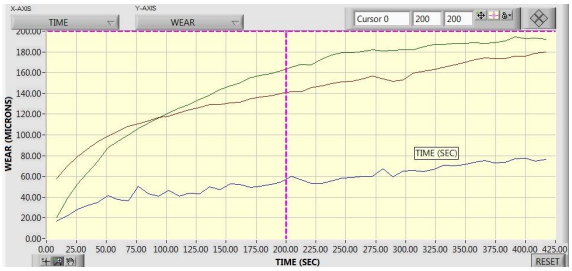

Fig.2 Wear Vs Time graph for 4th, 5th, 6th samples

From the Fig.2, the graph has been plotted between wear and time. The above fig also compare the variation of the wear with the different speed and the same load condition.

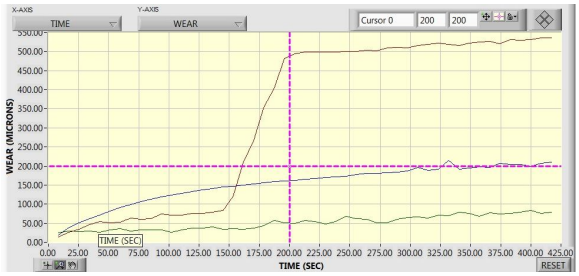

Fig.3 Wear Vs Time graph for 7th, 8th, 9th samples

From the Fig.3, the graph has been plotted between wear and time. The above fig also compare the variation of the wear with the different speed and the same load condition.

From the morphological data obtained from inverted microscope reveals that the predominant wear mechanism are occurred during the wear test. From the wear morphology of the specimens, the mechanism from which wear occurred is abrasive wear mechanism.

The S/N ratio for the wear test was plotted to find the effect in which the wear parameter contributed to the wear. The contribution and their levels of contribution has been found and the predominant parameters which contributes the wear has also been found.

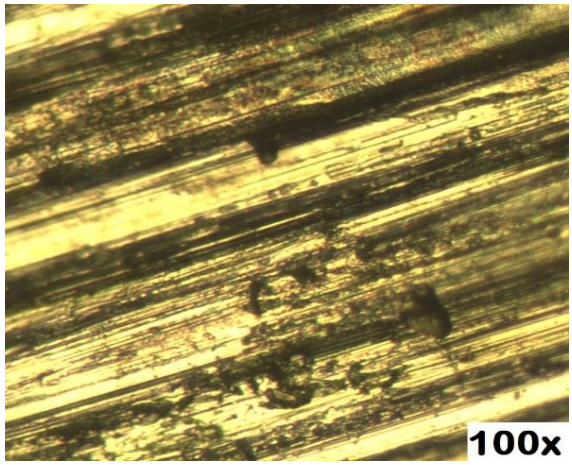

Fig 4. Wear morphology

Fig 5. S/N Ratio

From the Fig 5, we can conclude that the weight is the predominant and most crucial parameters than the other parameters.

IV. CONCLUSION

The Nano composite samples of LM24 as matrix, and nano Al2O3 powder as reinforcements were fabricated using stir casting process. The wear behaviour and microstructure were investigated for the fabricated samples. From the results it is observed that the microstructure of the particulate reinforcement has shown an impact in the wear resistance of the composite. The microstructure analysis shows fairly even distribution of particles.

- The Nano composite exhibited superior wear resistance when compared with the base aluminium LM24 matrix alloy and the wear resistance increased by 66%.
- It is clear from the S/N ratio that Load is the most significant factor followed by Speed and Time.
- From the comparison charts we can conclude that when the load increases the wear rate increases tremendously at low speed. And also the wear rate decreases with increases in the speed.

REFERENCE

[1] El-Ghazaly, et al., "Effects of squeeze casting parameters on density, macrostructure and hardness of LM13 alloy" Materials Science and Engineering A 428 (2006) 135–140.

[2] Ali MAZAHERY& Mohsen Ostad SHABANI, "Microstructural and abrasive wear properties of SiC reinforced aluminium-based composite produced by compocasting" Trans. Nonferrous Met. Soc. China 23(2013) 1905−1914.

[3] Mobasherpour, A.A. Tofigh, M. Ebrahimi, Effect of nano-size Al2O3 reinforcement on the mechanical behavior of synthesis 7075 aluminum alloy composites by mechanical alloying.

[4] S.M.Suresh et al., "Production and characterization of micro and nano Al2O3 particle reinforced LM25 Aluminium alloy composites" (2011).

[5] ennath Kannoy et al., "Production and mechanical Zproperties of Al2O3 particles reinforced 2024 aluminium alloy composites" (2011).

[6] Achutha M.V et al., "Fatigue life estimation of Hybrid Aluminium Matrix composites " (2008).

[7] Akilesh Jayakumar et al.,"A Study on Mechanical Properties of Silicon Carbide, E-Glass and Red Mud Reinforced Aluminium (LM25) Composite" , Volume 11, Issue 3 Ver. VIII (May- Jun. 2014).

[8] Kaveh Edalati et al.,"High-pressure torsion of aluminum with ultrahigh purity (99.9999%) and occurrence of inverse Hall-Petch relationship", Volume 7, Materials Science & Engineering A: Structural Materials: Properties, Microstructure and Processing, 2014.

[9] Dinesh kumar koli et al., A Review on Properties, Behaviour and Processing Methods for Al- Nano Al2O3 Composites, Procedia Materials Science, Volume 6, 2014, Pages 567-589.

[10] R.Surendran et al., "Tribological Behavior of LM25 Aluminium alloy Reinforced with Nano Alumina"- volume 11, Issue 3 ver.VI 2014.

[11] Dinesh Pargunde et al., "FABRICATION OF METAL MATRIX COMPOSITE BY STIR CASTING METHOD" E- ISSN2249–8974 Int. J. Adv. Engg. Res. Studies / II/ IV/July-Sept.,2013/49-51

[12] S.Suresh et al.,"Effect of graphite addition on mechanical behavior of Al6061/TiB_2 hybrid composite using acoustic emission", Materials Science and Engineering: A Volume 612, 26 August 2014, Pages 16-27

[13] Amit Raturi et al., "Analysis of mechanical and micro structural behaviour of al based metal matrix composite reinforced with ball milled nano particles: a review", Volume 6, Issue 1, January (2015), pp. 01-19.

[14] R.Ambigai et al., "Optimization of friction and wear behaviour of Al–Si3N4 nano composite and Al–Gr–Si3N4 hybrid composite under dry sliding conditions", Transactions of Nonferrous Metals Society of China, Volume 27, Issue 5, May 2015, Pages 986-997.

[15] Quanquan et al.,"Macro and nanoscale wear behaviour of Al-Al 2 O 3 nanocomposites fabricated by selective laser melting", Composites: Part B Engineering 127 , pp. 26-35, 2016.

[16] Guobin Li et al.,"Friction and Wear Behavior of Nano-Al2O3 Particles Reinforced Copper Matrix Composites", J. Tribol 137(1), 011604 (Oct 03, 2014) (7 pages).

[17] A.Miranda et al., "Study of mechanical properties of an LM24 composite alloy reinforced with Cu-CNT

nanofillers, processed using ultrasonic cavitation", Materials Science and Engineering: 2013.
[18] Keshav singh et al.," Fabrication and Mechanical properties characterization of aluminium alloy LM24/B 4 C composites" Materials Science and Engineering: 2016.
[19] C Kannan et al., "Comparative study on the mechanical and microstructural characterisation of AA 7075 nano and hybrid nanocomposites produced by stir and squeeze casting", J Adv Res. 2017 Jul; 8(4): 309–319.
[20] B. Venkataraman, G. Sundararajan "Correlation between the characteristics of the mechanically mixed layer and wear behavior of aluminium, Al-7075 alloy and Al-MMCs" Wear 245 (2000) 22-38.