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Experimental Analysis of Nano Aluminium Metal Matrix Composite a Tribological Studies

R.Yuvaraj , N.Alagirisamy , R.Kandhasamy

Abstract— The Aluminum 6061 alloys are mainly used in the application of automobile and aeronautical applications. An attempt has been made to investigation of Tribological property of Al6061 alloy by adding SiC and Al2O3. The ratio of particulates based on weight percentage such as (85%, & 5to10%) both SiC and Al2O3. The composite is developed by stir casting method. The particle size of SiC between 40 to 50μm. The optical microscopic test is conducted to examine the distribution of reinforcement particulates. Thermal corrosion test, fatigue test and Izard test also included calculating the Friction and wear constituents present in the composite samples. The investigation results that Al6061 hybrid composite with good Tribological properties has been plotted with graphical representations and curves and used in automobile components for reliable, long life and high performance.

Index Terms: AA 6061, SiC, Al2O3, Tribological, Stir Casting

I. INTRODUCTION

Aluminum alloys are widely used in aerospace and automobile industries due to their low density and good mechanical properties, better corrosion resistance and wear, low thermal coefficient of expansion as compared to conventional metals and alloys. To achieve the better performance the use of composite materials with their unique properties in engineering application is in these materials and relatively low production cost make them a very attractive candidate for a variety of applications [1-2]. Achieving uniform distribution of reinforcement is the foremost important work. A new technique of fabricating cast Aluminum matrix Composite has been proposed to improve the wet ability between alloy and reinforcement [3]. Automobile producers had just begun to employ composites in the engine parts. Several engine parts are being made using aluminum-alloy matrix reinforced with aluminum oxide and carbon fibers. These are of less weight and oppose wear and thermal deformation. Besides, metal-matrix composite has been engaged in drive shafts, extruded stabilizer bars, and forged suspension and transmission components [4].

The Aluminum alloy composite materials consist of high specific strength, high specific stiffness, more thermal stability, more corrosion and wear resistance, high fatigue life. AlSiC, pronounced 'alsick' is a metal matrix composite consisting of aluminum matrix with silicon carbide particles. A finite element model was developed to simulate the wear result [5-8]. The sliding distance of the pin is discretized in several steps according to the input velocity and was observed that temperature effect on the wear rate is more critical and the role of the reinforcement particles in the matrix increases the transition temperature from the mild to the severe wear regimes [9-10].

Composite is a mixture of two or more distinct constituent or phases Both constituents have to be present in reasonable property, say 5%. There is a growing interest worldwide in manufacturing hybrid metal matrix composites [HMMCs] which possesses combined properties of its reinforcements and exhibit improved physical, mechanical and tribological properties [11]. Aluminium matrix composites reinforced silicon carbide was developed using conventional foundry techniques. The reinforcements were varied by 10% and 15% by weight. The composite was tested for density, mechanical properties, and dry sliding wear. The results show an increasing trend in all the properties with increase in SiC content, except density which decreased with increase in reinforcements .The tribological properties of MMCs are also increased by increasing reinforcements at all applied conditions[12-15].

II. MATERIAL SELECTION

EXISTING METHOD
SILICON CARBIDE

A composite material is defined as mixture or combination of two or more nano, micro or macro constituents which are chemically and physically different, with a boundary separating them. The fabricated material would still have identity of components as the different materials constituent. Usually, composite materials will consist of two different components, one is matrix and the other is reinforcement. Silicon carbide is composed of tetrahedral of carbon and silicon atoms with strong bonds in the crystal lattice [16]. This produces a very hard and strong material. Silicon carbide is not attacked by any acids or alkalis or molten salts up to 800°C. In air, SiC forms a protective silicon oxide coating at 1200°C and is able to be used up to 1600°C. The high thermal conductivity coupled with low thermal expansion and high strength gives this material exceptional thermal shock resistant qualities. Silicon carbide ceramics with little or no grain boundary impurities maintain their

R.Yuvaraj , PG Scholar, Department of Mechanical Engineering ,Selvam College of Technology , Tamilnadu. (Email : yuvaraj8813@gmail.com)
N.Alagirisamy , Associate Professor , Department of Mechanical Engineering ,Selvam College of Technology , Tamilnadu.
R.Kandhasamy , Assistant Professor , Department of Mechanical Engineering,Selvam College of Technology, Tamilnadu.

strength to very high temperatures, approaching 1600°Cwith no strength loss [17].

III. MATRIX MATERIALS:

The primary phase of a continuous medium is known as matrix. Matrix is usually more of ductile as less hard phase of and it holds the reinforced phase. The lighter metals such as aluminium, magnesium, etc are used as metal matrix for composites (MMC), and it provided to reinforcement a compliant support in structural applications.

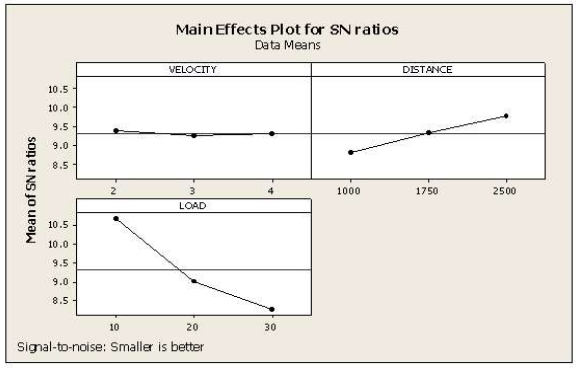

Fig.1 Main effects for plot for S/N Ratios – Coefficient of Friction

IV. PROPOSED METHODOLOGY

A. HYBRID COMPOSITES

A relatively new fiber reinforced composite is the hybrid. When two or more fibers or particulates of different properties are reinforced in single matrix then the composites is called Hybrid composites. These composites have better mechanical and tribological properties than composites containing single reinforcement. Many fiber combinations composites are used, but most common fiber combination is carbon and glass fibers in polymer resin matrix. Glass fibers have low stiffness and also inexpensive. Carbon fibers are low density reinforcement, strong and relatively stiff, but they are expensive. So the combination of glass-carbon hybrid which has good impact resistance, toughness, and having lower production cost than either all glass composites or all fibers composites [19]. Due to their improved properties the application of hybrid composites are air transport components, automotive parts, lightweight land and water.

B. RESULTS OF STATISTICAL ANALYSIS OF EXPERIMENTS

The results for various combinations of parameters were obtained by conducting the experiment as per the Orthogonal array. The measured results were analyzed using the commercial software MINITAB 15 specifically used for design of experiment applications [23]. Table 4 & Table 5 shows the experimental results average of two repetitions for wear rate and coefficient of friction. To measure the quality characteristics, the experimental values are transformed into signal to noise ratio [19]. The influence of control parameters such as load, sliding speed, and sliding distance on wear rate and coefficient of friction has been analyzed using signal to noise response table. The ranking of process parameters using signal to noise ratios obtained for different parameter levels for wear rate and coefficient of friction are given in Table (4.1-4.2) and Table (5.1-5.2) respectively for 10% &15% reinforced SiC MMCs. The control factors are statistically significant in the signal to noise ratio and it could be observed that the sliding distance is a dominant parameter on the wear rate and coefficient of friction followed by applied load and sliding speed [20].

C. MACHINE SELECTION

CNC is computerized technology by controlling the relative movements between the tool and the work piece geometrical shapes are machined. Control of these relative movements through coded letters numbers is known as Numerical Control of machine tools.

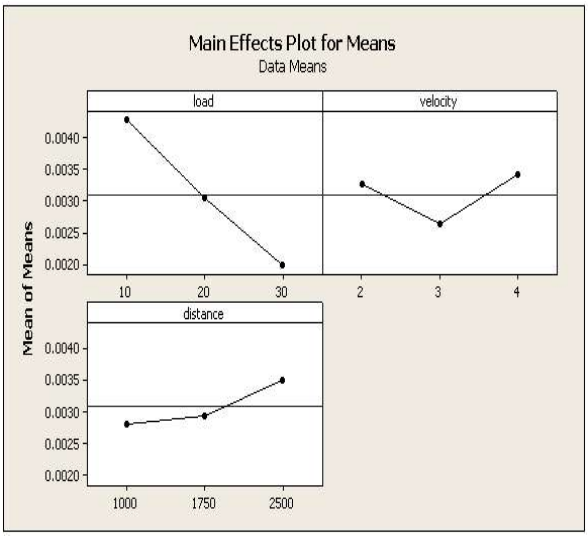

Fig.2 Main effects plot for Means – Wear Rate

V. CASTING EXPERIMENTAL PROCEDURE

A. CORROSION TEST

Thermal corrosion is a mechanism of corrosion that takes place in gas turbines, diesel engines, furnaces or other machinery coming in contact with hot gas containing certain contaminants. Fuel sometimes contains vanadium compounds or sulfates which can form compounds during combustion having a low melting point.

- Aluminum alloy (6061) was first superheated to its melting point in graphite crucible.
- Powder SiC preheated in the different temperatures and then was wrapped into aluminum foils and added to the molten metal in the two different compositions like 1%
- Stirring was carried out at constant rate of 420 rpm for 14min.

Fig.3 General Corrosion testing

B. WEAR TESTING

The dry sliding wear behavior of the Al-Sic + various leaf ashes composite at room temperature, a pin-on-disc wear testing machine was used as shown in fig In this method two different sets (as-casted in 1 and 1.5% composition) of pins were fabricated from composites viz. The pin dimension was 8 mm in diameter and 30 mm in length. The counterpart disc with 70 mm in outside diameter and 10 mm in thickness was fabricated using high carbon high chromium steel. The each test pin was loaded against the disc with a dead weight. The tests were carried out at the room temperature with the fixed sliding wear parameters, namely, the load as 9.8 N, the sliding speed as m/s for 20 min.

C. WEAR BEHAVIOUR

The aim of the experimental plan is to find the important factors and combination of factors influencing the wear process to achieve the minimum wear rate and coefficient of friction. The experiments were developed based on an orthogonal array, with the aim of relating the influence of sliding speed, applied load and sliding distance. These design parameters are distinct and intrinsic feature of the process that influence and determine the composite performance [17]. Taguchi recommends analysing the S/N ratio using conceptual approach that involves graphing the effects and visually identifying the significant factors.

The above mentioned pin on disc test apparatus was used to determine the sliding wear characteristics of the composite.

D.IMPACT TEST & FATIGUE TEST

1) IMPACT TEST

Impact strength indicates the toughness of the material. Toughness can be defined as ability of a material to absorb energy exerted by external force before it undergoes fracture. Most of mechanical properties and product life, product safety and liability are dependent on impact strength.

The impact tests are carried out on specimens using an Impact testing machine of izod type at room temperature. And the specimens are prepared according to ASTM standard E23. The size of the specimen for the impact test was 10mm x 10mm x 55mm with a rectangle notch size of 2mm with an included angle of 120^0.

2) FATIGUE TEST

A specified mean load (which may be zero) and an alternating load are applied to a specimen and the number of cycles required to produce failure (fatigue life) is recorded. Depending on amplitude of the mean and cyclic load, net stress in the specimen may be in one direction through the loading cycle, or may reverse direction.

Fig. 4 Impact & Fatigue Testing Machine

Data from fatigue testing often are presented in an S-N diagram which is a plot of the number of cycles required to cause failure in a specimen against the amplitude of the cyclical stress developed. The cyclical stress represented may be stress amplitude, maximum stress or minimum stress. Each curve in the diagram represents a constant mean stress. Most fatigue tests are conducted in flexure, rotating beam, or vibratory type machines.

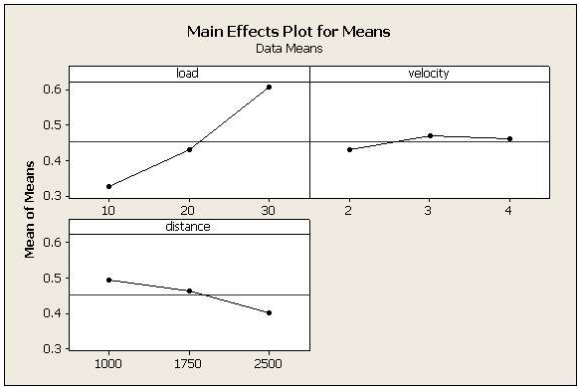

Fig. 5: Main effects plot for Means – Coefficient of Fatuge

VI. RESULTS AND DISCUSSIONS

The experimental results were analyzed with Analysis of Variance (ANOVA) which is used to investigate the influence of the considered wear parameters namely; applied load, sliding speed, and sliding distance that significantly affect the performance measures. By performing analysis of variance, it can be decided which independent factor dominates over the other and the percentage contribution of that particular independent variable. Table (6&7) and Table (8&9) shows 10% &15% SiC MMCs of the ANOVA results for wear rate and coefficient of friction for three factors varied at three levels and interactions of those factors. This analysis is carried out for a significance level of α=0.05, i.e. for a confidence level of 95%. Sources with a P-value less than 0.05 were considered to have a statistically significant contribution to the performance measures.

Table .1 Results of L9 Orthogonal array for Al – 6061 / 10% SiC MMC

S.No.	L (N)	S (m/s)	D (m)	Coefficient of friction	Wear rate (mm^3/m)	S/N ratio c.o.f	S/N ratio wear rate
1	10	2	1000	0.311	0.00481	10.1448	46.3571
2	10	3	1750	0.291	0.0036	10.7221	48.87395
3	10	4	2500	0.277	0.00178	11.1504	54.9916
4	20	2	1750	0.35	0.00422	9.1186	47.49375
5	20	3	2500	0.343	0.00222	9.2941	53.07294
6	20	4	1000	0.372	0.0037	8.5891	48.63597
7	30	2	2500	0.36	0.00296	8.8739	50.57417
8	30	3	1000	0.41	0.0037	7.7443	48.63597
9	30	4	1750	0.39	0.00254	8.1787	51.90333

To communicate the people with independent of wires and provided enhanced portability's, free motions, wearable with low power consumptions. Figure 8 shows the experimental setup.

VII. CONCLUSION

The aim of this review is to consider the research studies by different researchers in the field of tribological behavior of Al-MMCs in last one and half decades. The experimental plan and tribological test results of wear behavior of Al-MMCs are mentioned here. Most of the tribological tests were carried out by pin-on-disk and block-on-ring tribometer. The reinforcement used by researchers are mostly particle and fibre reinforcements. The wear behavior of Al-MMC is studied with varying load, sliding speed and volume fraction of reinforcement under dry sliding condition. Some studies were carried out under lubricated condition and compared to dry condition. The researchers have also studied the tribological behavior of hybrid Al-MMC. From the research studies, increase in wear resistance of alloys due to reinforcement is noticed. Wear resistance increased in general with increase in volume fraction of reinforcement. The influence of particle size and surface morphology was also studied by some researches. Adhesive wear and delaminating.

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