IJRAME

INTERNATIONAL JOURNAL OF RESEARCH IN AERONAUTICAL AND MECHANICAL ENGINEERING
WWW.IJRAME.COM
ISSN (ONLINE): 2321-3051

Emerging Trends in Mechanical Engineering Proceedings of the International Conference, ETME-2017, 27 & 28 December, 2017, Pg: -246-255

TRIBOLOGICAL CHARACTERIZATION OF MICROWAVE PROCESSED AL-SIC METAL MATRIX COMPOSITES

Honnaiah C[1], Amaresh Murari[2], S L Ajit Prasad[3], Srinath M S[4]

[1]Asst. Professor, APS College of Engineering, [2]PG Student, PES College of Engineering, [3]Professor, PES College of Engineering. [4]Professor, Malnad College of Engineering
1.honna.me031@gmail.com, 3. palspesce@gmail.com, 4. srinadme@gmail.com

Abstract

Particulate reinforced metal matrix composites are finding wider acceptance in many industrial applications because of their isotropic properties and ease of manufacture. Uniform distribution of reinforcement particulates and good bonding between matrix and reinforcement phases are essential features in order to obtain metal matrix composites with improved properties. Even though stir casting is the most commonly adopted technique for processing MMCs, because of its simplicity, it has got its own limitations in terms of non-uniform distribution of reinforcement particulates, agglomerate formation and porosity levels. Conventional powder metallurgy technique can successfully overcome the limitation of stir casting techniques, but it is time consuming and not cost effective. Use of microwave technology for processing particulate reinforced MMCs through powder metallurgy technique is being increasingly explored in recent times because of its cost effectiveness and speed of processing.

Metal matrix composites are used in many industrial applications, where components are subjected to relative sliding motion with respect to their mating components. Pistons, cylinder liners, brake calipers, clutch and brake discs are some of the examples, where components are subjected to relative sliding motion. Tribological characteristics play important role in such applications for efficient performance of the mechanical system.

The present work is a small attempt to process Al-SiCp metal matrix composites using microwave technology. Some of the Tribological characteristics of the processed composites have been studied. The results of the study indicate effectiveness of microwave technology in processing metal matrix composites and improved tribological characteristics of the composite materials.

Key words: *MMC's, Aluminium, Silicon Carbide, Microwave technology, Tribology etc.*

1. Introduction

A composite material is a material composed of two or more distinct materials or constituents, with one constituent acting as the reinforcing phase and the other as the matrix. A composite material will have different macroscopic behaviours, or chemical and physical properties than its constituent materials, and has a distinct interface boundary at the microscopic level. The main advantage of a composite material over conventional material is the combination of different properties which are not often found in the conventional materials. The extraordinary combination of properties includes high strength to weight ratio, higher stiffness to weight ratio, improved fatigue resistance, improved corrosion resistance, higher wear resistance and fracture toughness [1].

Among many types of MMCs, Aluminium alloy based composites are known as very promising light materials with enhanced mechanical properties. In fact, by introducing a hard reinforcement phase, the properties such as hardness, stiffness, wear and corrosion resistance, fatigue resistance of aluminium alloys could be significantly improved. Aluminium Metal Matrix composites (AMC) were identified as good materials for automobile and space application [2, 3].

Metal Matrix Composites are produced by different methods such as stir casting, liquid infiltration, spray deposition and powder metallurgy technique. Among these, powder metallurgy processing is one of the effective methods of manufacturing MMCs with high volume of reinforcement with fairly uniform distribution. Powder metallurgy technique consists of three major processing stages. First, the primary material is physically divided into many small individual particles. Next, the powder is passed through a die to produce weakly cohesive structure (Compaction) very close to the dimension of the object to be manufactured followed by subsequent heating or sintering of compacted objects in the mould with temperature below melting point under non oxidizing atmosphere. MMC's which are processed by some of the traditional methods resulted in some defects like irregular grain shapes, non uniform distribution of reinforcement, blow holes etc. Also the time required for this process is very large [4, 5]. In order to minimize these drawbacks, suitability of advanced Microwave processing technique is being investigated in recent times.

Microwave processing of metals is a fast-developing technology. Microwaves have been found to be extremely useful in material processing. In conventional heating processes, initially, surface heating of the bulk material takes place, with the rate of heat flow depending on the temperature gradient and physical properties of the material like thermal diffusivity and thermal conductivity [6]. In microwave processing, on the other hand, electromagnetic energy is used to heat the material and volumetric heating takes place throughout the material body. The application of microwaves yields very fast and clean processing of materials [7, 8].

IJRAME

INTERNATIONAL JOURNAL OF RESEARCH IN AERONAUTICAL AND MECHANICAL ENGINEERING
WWW.IJRAME.COM
ISSN (ONLINE): 2321-3051

Emerging Trends in Mechanical Engineering Proceedings of the International Conference, ETME-2017, 27 & 28 December, 2017, Pg: -246-255

2. Materials and Methodology

In the present work aluminium powder Al 1100 with an average particle size of 40μm is used as the base material and silicon carbide powder with an average particle size of 23 μm is used as reinforcement material. Chemical composition of Al and properties of Al & SiC powders used are listed in table 1, 2 and 3 respectively.

Table 1: Chemical Composition of Al 1100

Elements	Percentage of contents
Al	91.1-93.3
Cu	≤0.2
Iron	≤0.2
Mg	0.25-0.45
Mn	≤0.1
Silicon	<0.05
Titanium	6.5-7.5
Zinc	≤0.2
Others	≤0.1

Table 2: Properties of Al 1100

Property	Value
Elastic Modulus (GPa)	70-80
Density (gm/cc)	2.8
Poisson's Ratio	0.33

Hardness (HB500)	28
Tensile Strength (MPa)	110
Melting Temperature (^oC)	640

Table 3: Properties of SiC

Property	**Value**
Elastic Modulus (GPa)	410
Density (gm/cc)	3.1
Poisson's Ratio	0.14
Hardness (HB500)	2800
Compressive Strength (MPa)	3900
Melting Temperature (^oC)	3100

Synthesizing of Al-SiC Metal Matrix Composites

- Initially, aluminium powder is mixed with 4% of SiC by using bi-axial powder blender at 150 rpm for 30 min by adding 20% of ethanol to the powder sample.
- Blended powders are compacted inside the compaction die of 35mm diameter by applying load of 150KN using UTM.
- The compacted aluminium - SiC MMC is placed above the silicon carbide susceptor in microwave furnace, such that initial coupling of susceptor with microwaves allows heating of MMC billet.
- The billet along with the susceptor is placed inside alumina casket which will not allow the microwaves to escape out of the chamber. The MMC sample is heated at 550℃ for 10 min at 900W.
- Microwave processed MMC is subjected to secondary processing of extrusion, with an extrusion ratio of 12.25 at 320℃ temperature by using extrusion die setup.

Tribological Characterization

In the present study, Pin-on-Disc testing method was used for investigating wear as well as frictional behaviour of materials. The pin is loaded against a flat hardened steel rotating disc such that a circular wear path is described. The machine can be used to evaluate wear and friction properties under pure sliding condition. Figure 1 shows schematic diagram of Pin-on-Disc setup. The specifications of the equipment are listed in the Table 4.

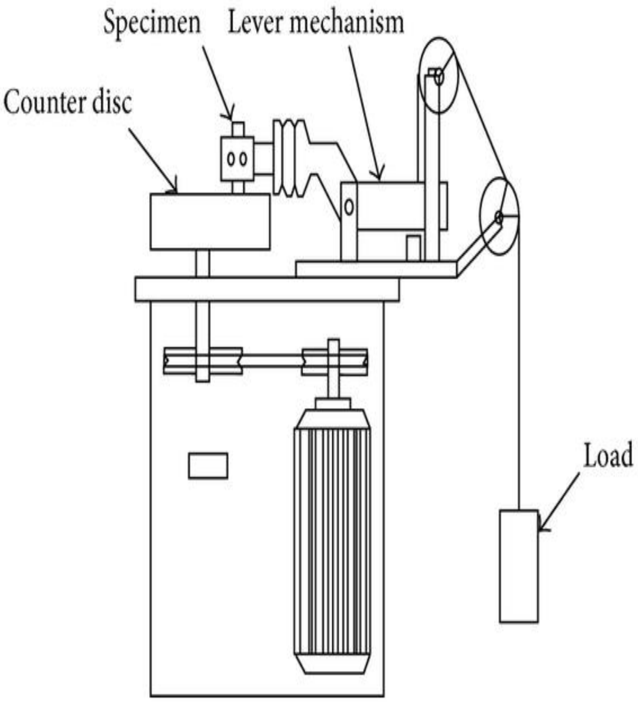

Figure 1: Schematic diagram of Pin-on-Disc setup

Table 4: Technical Specifications of Wear and Friction Test rig

Rotational Speed	Up to 2000 rpm
Track Diameter	20mm -118 mm
Load Range	Up to 200 N
Disc Size	Diameter 120 mm x Thickness 8mm
Pin Size	Diameter 10mm x Length 30mm
Wear or Displacement	Up to 2000 Microns
Frictional Force	Up to 200 N

Dry sliding wear tests were carried out using pin-on-disc wear testing machine. The standard wear test specimens (shown in the figure 2) were prepared by machining the extruded material. The specimens were weighed accurately using electronic balance. The counter face disc was cleaned with acetone to remove any oil film present. The wear test was conducted at different loads, of 10-40N at constant velocity of 2 m/s for a sliding distance of 3000m.
Figure 3 illustrates the variation of dry sliding wear with normal load. It can be observed from the plots that the wear increases continuously with increase in load.

INTERNATIONAL JOURNAL OF RESEARCH IN AERONAUTICAL AND MECHANICAL ENGINEERING
WWW.IJRAME.COM
ISSN (ONLINE): 2321-3051

Emerging Trends in Mechanical Engineering Proceedings of the International Conference, ETME-2017, 27 & 28 December, 2017, Pg: -246-255

Figure 2: Wear Testing Specimens

3. Results and Discussions

Wear v/s Normal Load

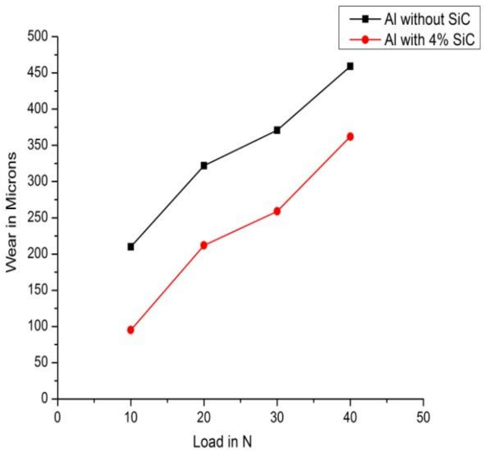

Figure 3: Wear v/s Normal Load

IJRAME

INTERNATIONAL JOURNAL OF RESEARCH IN AERONAUTICAL AND MECHANICAL ENGINEERING
WWW.IJRAME.COM
ISSN (ONLINE): 2321-3051

Emerging Trends in Mechanical Engineering Proceedings of the International Conference, ETME-2017, 27 & 28 December, 2017, Pg: -246-255

Frictional Force v/s Normal Load

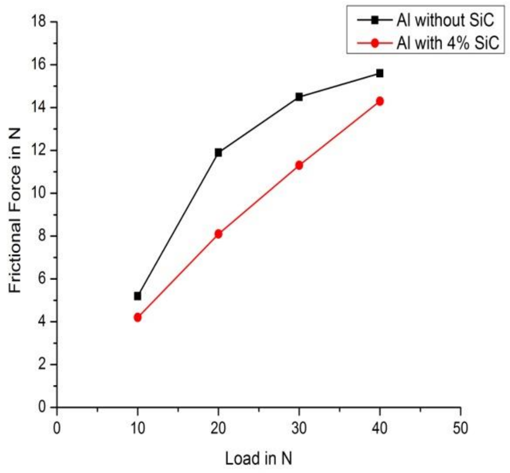

Figure 4: Frictional Force v/s Normal Load

It is observed that the aluminium matrix material is having higher wear rate compared to the Al with 4% SiC. Similarly, from figure 4, it can be observed from the plots that the frictional force increases with increase in load.

During asperity interaction between pin surface and hardened steel disc counter surface, the specimen made of Aluminium material alone, undergoes plastic deformation because of its softness. This results in increased resistance to sliding causing higher frictional force. In case of pin specimen made of Al with 4% SiC composite materials, the pin slides over the asperities of the counter surface with relatively lesser deformation, because of its higher hardness. This result in relatively lesser frictional force compared to pure aluminium specimens. At higher loads it is observed that, the slope of friction force decrease in case of pure aluminium specimens. This can be attributed to the fact that at higher loads interface temperature increases. In case of pure aluminium specimen material gets softened at higher temperature, resulting in reduced resistance to motion against asperities. This could be the reason for decreasing trend in slope of friction force curves in case of pure aluminium specimens.

IJRAME

INTERNATIONAL JOURNAL OF RESEARCH IN AERONAUTICAL AND MECHANICAL ENGINEERING
WWW.IJRAME.COM
ISSN (ONLINE): 2321-3051

Emerging Trends in Mechanical Engineering Proceedings of the International Conference, ETME-2017, 27 & 28 December, 2017, Pg: -246-255

Specific Wear Rate v/s Normal load

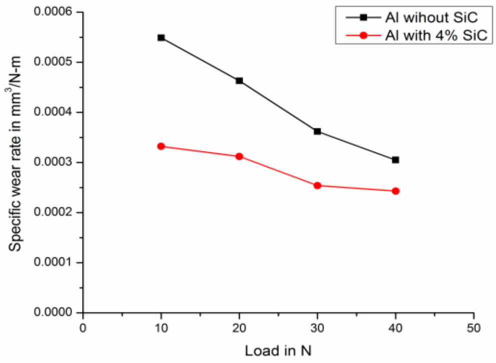

Figure 5: Specific wear rate v/s Normal load

Figure 5 shows that specific wear rate decreases with increasing load. At lower loads there will be higher levels of asperity interaction between the sliding surfaces, resulting in higher specific wear rate. At higher loads, interface temperature increases causing flattening of asperities resulting in increased contact area between sliding surfaces. Increased contact area between the mating surface causes reduced contact pressure at local areas of contact. This results in reduced wear loss rate of the material. Hence the specific wear rate decreases with increase in normal load.

4. Conclusions

Following conclusions are drawn from the investigations of present work:

- Aluminium-SiC Metal matrix composite is successfully fabricated by using microwave processing technique.
- The processing of MMC by using microwave technique is relatively faster compared to the conventional processing technique.
- Wear properties of the Aluminium alloy were considerably improved by the addition of SiC particulates and the wear resistance of the composites was much higher than that of unreinforced Aluminium alloy.

INTERNATIONAL JOURNAL OF RESEARCH IN AERONAUTICAL AND MECHANICAL ENGINEERING
WWW.IJRAME.COM
ISSN (ONLINE): 2321-3051

Emerging Trends in Mechanical Engineering Proceedings of the International Conference, ETME-2017, 27 & 28 December, 2017, Pg: -246-255

References

1. Aqida,N. Ghazali,M.I. Hashim,J.- "Effects of Porosity on Mechanical Properties of Metal Matrix Composite: An Overview" Jurnal Teknologi, 40(A) Jun. 2004: 17–32.
2. Manoj Singla, D. Deepak Dwivedi, Lakhvir Singh, Vikas Chawla "Development of Aluminium Based Silicon Carbide Particulate Metal Matrix Composite" Journal of Minerals & Materials Characterization & Engineering, Vol. 8, No.6, pp 455-467, 2009.
3. Das S, Behera R, A. Datta, G. Majumdar, B. Oraon, G. Sutradhar, "Experimental Investigation on the Effect of Reinforcement Particles on the Forgeability and the Mechanical Properties of Aluminium Metal Matrix Composites", Materials Sciences and Applications, 2010, pp.310-316.
4. Nasir Ehsani, Nader Parvin, Mehdi Rahimion, Hamid reza Baharvandi-"The effect of particle size, sintering temperature & sintering time on the properties of Al-Al2O3 composites made by powder metallurgy". Journal of material processing technology. Vol.209, Issue 14, 19 July 2009, page: 5387-5393.
5. Sreenivasan K S, S.Kathiresan, Krishna, C. Nandakumar, "Fabrication and testing of hybridal/SiC/flyash using powder metallurgy technique through microwave sintering", Journal of Mechanical and Civil Engineering, pp 54-65.
6. Ehsan Ghasali, Amir Hossein, Maryam Agheli- "WC-Co particle reinforced aluminium matrix by an conventional & microwave sintering". Material Research.2015:18(6): 1197-1202.
7. Radha Raman Mishra, Apurbba Kumar Sharma, "Microwave–material interaction phenomena: Heating mechanisms, challenges and opportunities in material processing" Review article, pp.78–97(2016).
8. Harry S Ku, Jim A R Ball, EllasSiores, "Review-Microwave Processing of materials", Journal HKIE Transactions, Volume 8, 2013, pp.31-37.