ISSN : 2455-9679
Impact Factor : 3.340

IJRTSM

INTERNATIONAL JOURNAL OF RECENT TECHNOLOGYSCIENCE& MANAGEMENT

"TRIBOLOGICAL STUDY OF SILICON NITRIDE EMBEDDED ALUMINIUM MMC THROUGH PM ROUTE"

***Sharad Saxena*[1], *P. K. Sharma*[2]**

[1]*M. Tech. Scholar, Department of Mechanical Engineering,NIIST, Bhopal*

[2]*Professor, Department of Mechanical Engineering N IIST, Bhopal*

ABSTRACT

The present paper deals with the study of tribological behavior of Aluminum metal powder composite reinforced with Si3N4 particles prepared by Powder Metallurgy route. Four number Cylindrical preforms (Si3N4-0 wt. %, 3wt. %, 5 wt. % and 7 wt. %) at a compaction pressure of 120 KN were prepared using a die and punch assembly on a Universal Testing Machine. Sintering at different temperatures of 450°C, 470°C and 490°C has been carried out using Electrical Muffle Furnace. The sliding wear behaviour of cylindrical sample diameter 10 mm was performed on a pin-on-disc wear tester against an EN- 32 steel disc (10 N applied the load, distance 4000 m at 300 rpm, 1200 seconds) under dry ambient conditions. The microstructural characterization done by Scanning Electron Microscopy (SEM) to investigate the grain structure. Wear decreases with the increase of Si3N4 contents and sintering temperature when experimented. SEM test confirm uniformly distribution of Si3N4 particles in Al matrix.

Keyword: *Aluminum (Al); Silicon Nitride (Si3N4); wear properties; sintering temperature; hardness, density, porosity, SEM analysis.*

I. INTRODUCTION

Powder Metallurgy is a process where metallic shapes are manufactured from metallic powders. In powder metallurgy, the metal or alloy is solid at the start and remains solid at the end of the process. Now-a-days powder metallurgy becomes an important aspect in fabrication industry. Powder Metallurgy helps us to deals with the materials like refractory materials which are difficult to machine like *sintered carbides* etc.

Powder metallurgy is the way toward mixing fine powdered materials, compacting the same into a coveted shape or frame inside a form taken after by warming of the compacted powder in a controlled environment, alluded to as sintering to encourage the arrangement of holding of the powder particles to shape the required part.

Composites are the materials having superior mechanical properties and light in weight. Epoxies and polyester commonly serve as a matrix material. The reinforcing fibers are usually graphite, glass, boron, etc. New developments concerns are in metal matrix and ceramic composite materials. Ceramics-matrix cutting tools are being developed, made of silicon carbide reinforced alumina, with greatly improved tool life.A composite material contains more than one component. The compound materials are amalgamated into the composites so as to take the advantage of their attributes, thus providing an improved version of the material.

ISSN : 2455-9679
Impact Factor : 3.340

II. LITERATUREREVIEW

M. A. Salem et al. (2017) analyzed the impact of the Al lattice, SiC sizes and the SiC volume part on the microstructure development, mechanical properties of the composites. They worked on Al-SiC MMCs by taking different sizes, and volume parts were manufactured using ball milling machine and powder metallurgy. Al and Al-SiC composites of various volume fractions were processed for 120 hours and then, the Al and Al-SiC composites were compact under 125 MPa and then sintered at 450 °C. Then he measured the thermal conductivity, electrical resistivity and micro hardness analysis of the prepared composite samples. He conclude as we decrease the size of Al-SiC particle and increases the volume of Al-SiC will decrease the properties of the MMC's. On the other side micro hardness was increased when we took the small particle size of Al-SiC and increases their volume fraction.
Smrutiranjan Pradhan et al. (2016) analyses the wear and friction behavior of Al-SiCMMC under three different condition i.e. dry, aqueous and alkaline medium. The pin on disc apparatus where specimen is sliding under Alumina disc and varying speed. So as the load increases; wear increases. It seems that maximum wear occurs in alkaline medium, followed by aqueous and dry conditions. The microstructural analysis and worn analysis done by SEM & EDS. And he conclude that minimum wear occurs in dry medium is dominated by adhesive and abrasive wear whereas in aqueous and alkaline medium mechanical and corrosive wear will responsible for the same.
Babalola et al. (2014), he reviewed the development of Aluminum matrix composites withSiC as an additive via fabrication through solid state and liquid state process. Then he quoted that Aluminum matrix composites can easily be prepared when combined it with non-metallic reinforcing materials like SiC, B4C, Si3N4, AIN, TiC, TiB2, TiO2 and etc. After adopting the cost effective techniques like stir casting for manufacturing the samples and comparison is done with the powder metallurgy samples and results shows that stir casting samples have high hardness then the powdered one.

III. EXPERIMENTATION

Die & Punch Preparation

For preparing the samples of the composite material, first the well-defined combination of powder preforms a die and punch has been manufactured by turning the die steel on lathe then tempered the punch for withstanding the high load applications. The pin on disc machine has a pin holder of capacity varying from 6 mm to 12 mm. As the powder preforms should have sufficient contact area with the disc the pin diameter was decided as 10 mm. The figure below shows the photograph of the die and punch.

Table 1 Sample selection

T1 (450°C)	T2 (470°C)	T3 (490°C)
T1 (0% Si3N4)	T2 (0% Si3N4)	T3 (0% Si3N4)
T1 (3% Si3N4)	T2 (3% Si3N4)	T3 (3% Si3N4)
T1 (5% Si3N4)	T2 (5% Si3N4)	T3 (5% Si3N4)
T1 (7% Si3N4)	T2 (7% Si3N4)	T3 (7% Si3N4)

IV. RESULTS & DISCUSSION

Effect of 450°C sintering temperature on wear:

ISSN : 2455-9679
Impact Factor : 3.340

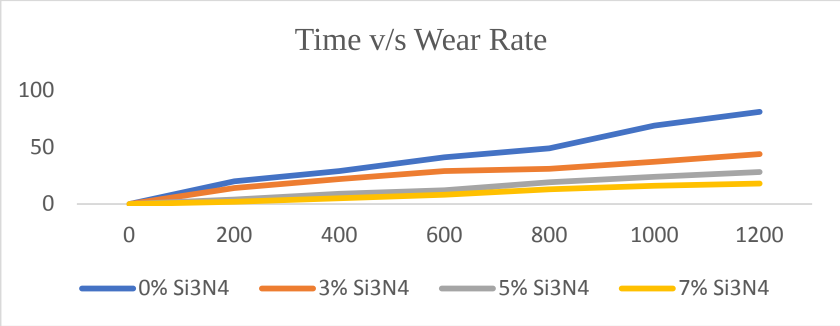

Figure 1 Average wear (in micron) with Silicon Nitride (Si3N4) at 450°C sintered specimen

Figure 1 shows that variation of wear with respect to time. It was seen that at the sintering temperature 450°C sample at 0% Si3N4 (Silicon Nitride) shows the maximum wear rates and followed by the 3% Si3N4, 5% Si3N4 and 7% Si3N4 shows at minimum wear (micron) it is evident in the SEM. This experimental work is performed with 10N applied load and sliding distance of 4000 meter selected for test.

Effect of 470°C sintering temperature on wear

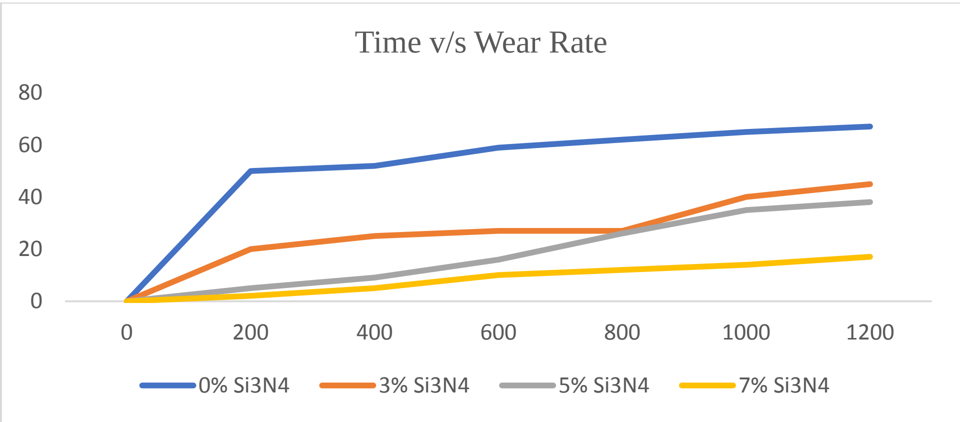

Figure 2 Average wear (in micron) with Silicon Nitride (Si3N4) at 470°C sintered specimen

Figure 2 shows that variation of wear with respect to time. It was seen that at the sintering temperature 470°C sample at 0% Si3N4 (Silicon Nitride) shows the maximum wear rates and followed by the 3% Si3N4, 5% Si3N4 and 7% Si3N4 shows at minimum wear (micron) it is evident in the SEM. This experimental work is performed with 10N applied load and sliding distance 4000mtere selected for test. As experiment starts specimen rubbing in wear tester disk it prevented noise sound.

Effect of 490°C sintering temperature on wear:

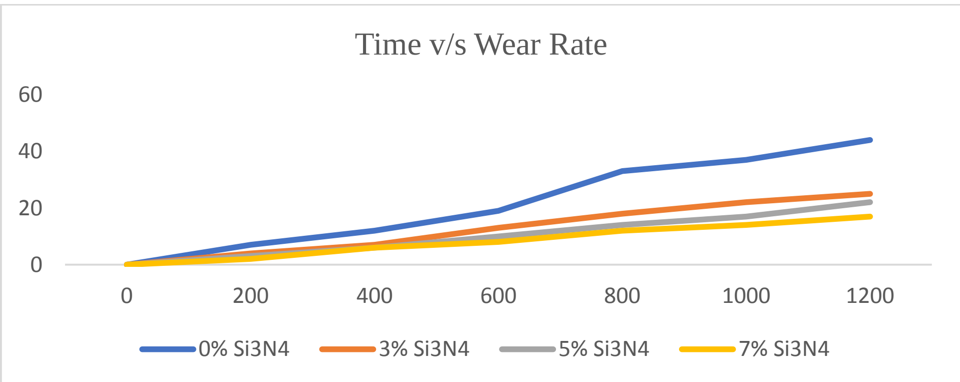

Figure 3 Average wear (in micron) with Silicon Nitride (Si3N4) at 490°C sintered specimen

ISSN : 2455-9679
Impact Factor : 3.340

Figure 3 shows that variation of wear with respect to time. It was seen that at the sintering temperature 490°C sample at 0% Si3N4 (Silicon Nitride) shows the maximum wear rates and followed by the 3% Si3N4, 5% Si3N4 and 7% Si3N4 shows at minimum wear (micron) it is evident in the SEM. This experimental work is performed with 10N applied load and sliding distance 4000mtere selected for test. As experiment starts specimen rubbing in wear tester disk it prevented noise sound.

SEM Analysis

SEM analysis shows the Microstructure of Al- Silicon Nitride composites (a) Al-3% SiliconNitride (b) Al-5% Silicon Nitride and (c) Al-7% Silicon Nitride composition of Al matrix and Silicon Nitride reinforcement of Silicon Nitride are clear visible in SEM images. Micro cracks and porous microstructure was seen in Al-3% Silicon Nitride composite, but porous structure and micro cracks reduces in Al-5% Silicon Nitride. Black region represent Al matrix and white color represent Dispersion of Silicon Nitride particle. Silicon Nitride particle are dispersed uniformly. In Al-3% Silicon Nitride and Al-5 % Silicon Nitride matrix, there is no porosity was observed in Al-7 % Silicon Nitride matrix.

For 3% Si3N4 Composite

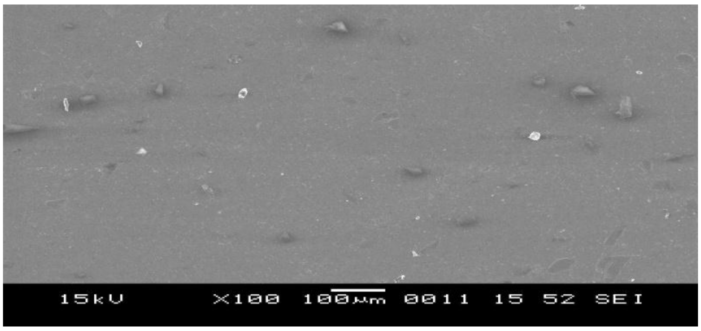

Figure 4. 3% Si3N4 Composite

Figure 4shows the Microstructure of Al- Si3N4 composites (3% Si3N4) which shows that silicon nitride particles are distributed over the surface of substrate but are lesser in quantity as visible.

For 5% Si3N4

Figure 5. 5% Si3N4 Composite

Figure 5 shows the Microstructure of Al- Si3N4 composites (5% Si3N4). Which shows that there's equal and continuous distribution of reinforcement material i.e.Si3N4 over the base metal Aluminum. We can observe that the scattering of Si3N4 is more than that of 3% Si3N4 samples.

For 7% Si3N4

ISSN : 2455-9679
Impact Factor : 3.340

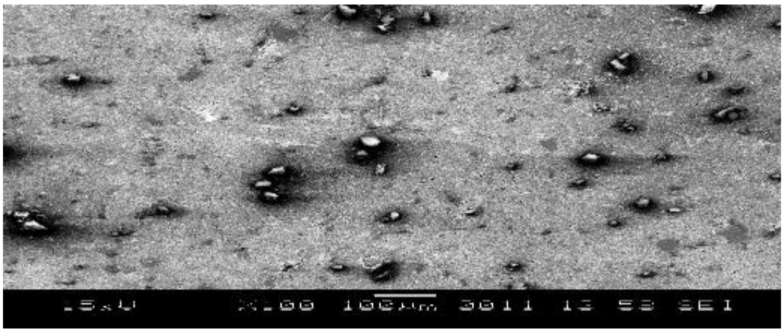

Figure 6. 7% Si3N4 Composite

Figure 6 shows the Microstructure of Al- Si3N4 composites (7% Si3N4). Which shows that there's equal and continuous distribution of reinforcement material i.e. Si3N4 over the base metal Aluminum.

V. CONCLUSION

In this work, wear of Al-Si3N4 composite is investigated at different sintering temperature and percentage incorporation of silicon nitride particles. Result shows that wear strongly depends on Si3N4 contents.

1. Specimen at 490°C confirms minimum wear as compared to 470°C and 450°C.
2. Specimen at 7% Si3N4 confirms minimum wear as compared to 0 %, 3%, and 5%.

In Micro cracks and porous microstructure was seen in Al-3% Silicon Nitride composite, but porous structure and micro cracks reduces in Al-5% Silicon Nitride. Black region represents Al matrix and white colour represent Dispersion of Silicon Nitride particle. Silicon Nitride particle are dispersed uniformly. In Al-3% Silicon Nitride and Al-5 % Silicon Nitride matrix, there is no porosity was observed in Al-7% Silicon Nitride matrix.

REFERENCES

[1] Smrutiranjan Pradhan, Shouvik Ghosh, Tapan Kumar Barman, Prasanta Sahoo, Tribological Behavior of Al-SiC Metal Matrix Composite Under Dry, Aqueous and Alkaline Medium (2016), DOI 10.1007/s12633-016-9504-y.

[2] M. Torralba, C.E. da Costa, F. Velasco, P/M aluminum matrix composites: an overview, Journal of Materials Processing Technology, 133 (2003) 203–206.

[3] M. A. Salem, I. G. El-Batanony, M. Ghanem, and Mohamed Ibrahim Abd ElAal, Effect of the Matrix and Reinforcement Sizes on the Microstructure, the Physical and Mechanical Properties of Al-SiC Composites, Journal of Engineering Materials and Technology, JANUARY 2017, Vol. 139 / 011007-7.

[4] Ashok Kumar Mishra and Rajesh Kumar Srivastava, Wear Behavior of Al-6061/SiC Metal Matrix Composites, The Institution of Engineers (India) 2016, DOI 10.1007/s40032-016-0284-3

[5] Smrutiranjan Pradhan et al. (2016), The production and application of metal matrix composite materials, Journal of Materials Processing Technology 106 (2000) 58±67.

[6] University text book on Powder Metallurgy by Katerina Skotnicova, Miroslav Kursa, Ivo Szurman, University of Ostrava, Czech Republic.