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# Studies on High Temperature Wear Behaviour of Magnesium Metal Matrix Composites

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**ABSTRACT:** Magnesium and its composites were utilised in the aerospace, marine, and automobile industries due to their lower density. The present study examines wear behaviour of magnesium metal matrix composites reinforced with silicon carbide and alumina particles under temperature of 50°C, 75°C, 100°C, 125°C and 150°C. The hybrid composites were fabricated through powder metallurgy process. The dry sliding wear test was carried out using a pin-on-disc apparatus. The result shows that when the load increases, the volumetric wear rate of matrix and hybrid composites increases significantly. For all applied loads, the volumetric wear rate of hybrid composites was lower than that of pure magnesium matrix. In addition, studies show that increasing the proportion of reinforcement in magnesium metal matrix composites improves the transition load.

**KEYWORDS:** Magnesium, Hybrid MMC's, Powder metallurgy, dry sliding wear, volumetric wear rate.

## I. INTRODUCTION

A composite material has been shaped by combining two or more materials that have very distinctive properties on a micro or macroscopic level to prepare a functional materials. In engineering applications, composite materials are used extensively due to their higher specific strength and stiffness properties compared to metals. The metal matrix composites is a material, when the matrix is a metal or alloy. The MMCs were developed to overcome the problems associated with conventional materials especially in high temperature performance and lower load carrying capacity. Various types of reinforcements included to the matrices are particle, continuous fiber, short fiber and laminates. The particulate-reinforced MMCs are commonly used among the various types because of the uniform distribution of hard ceramic particles embedded in the matrix. MMCs have the properties such as light in weight, high strength to density ratio and better wear resistance are the necessity for aircraft as well as in automobile industries [4]. In recent years, MMCs have been studied extensively, because of their promising advanced properties. Close attention has been paid to aluminum and magnesium as matrices that are commonly used in composites of metallic matrix [5].

In the present study, pure magnesium has been selected as the matrix material because it is more compatible with the reinforcement and have great mechanical properties. Alumina and Silicon carbide have selected as reinforcement in the form of particle size. Alumina is an oxide ceramic having low affinity for the oxygen to form oxides and withstands elevated temperature. The particulate type of the reinforcement has better distribution in the matrix to give isotropic property to the composite.

## II. METHODOLOGY

The Magnesium metal matrix composites reinforced with alumina and silicon carbide particles were fabricated by powder metallurgy process. To ensure consistent mixing of powders, the silicon carbide and alumina powders were extensively blended with magnesium powder in a ball mill equipment. Powders were compacted after blending with the help of dies and punches with tight tolerances as shown in Figure 1. To make green compacts, the blended powder is put into a die cavity and compressed with a punch using a Universal Testing Machine. To make the composite

specimen, the green compacts are sintered in a vacuum furnace at a temperature of 550°C. The wear test was carried out for pure magnesium, Mg-5%SiC-5%Al<sub>2</sub>O<sub>3</sub>, and Mg-10%SiC-10%Al<sub>2</sub>O<sub>3</sub> composites using pin-on-disc apparatus as shown in Figure 2.



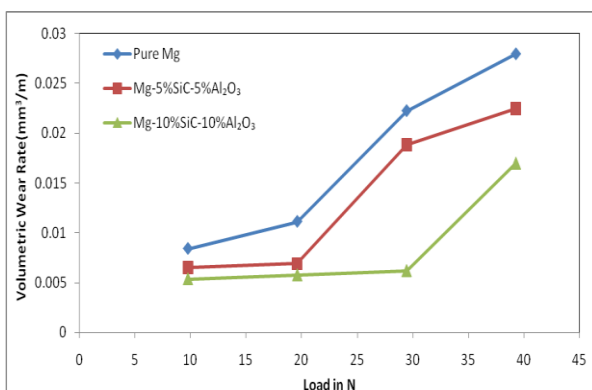
Figure 1 : Die and Punch



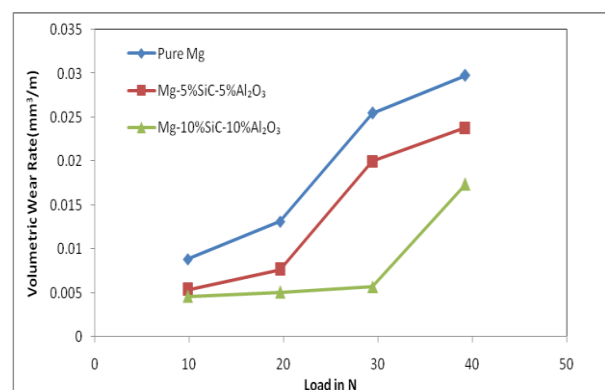
Figure 2: Wear test by pin-on-disc machine

### III. EXPERIMENTAL RESULTS

Dry sliding wear tests were carried out for different compositions of specimens using a pin-on-disc (Ducom TR-20-PHM-400) type wear testing machine. After being machined and polished, the pin samples measured 35 mm in length and 10 mm in diameter. The surfaces of the pin samples were polished with emery paper before to testing to ensure effective contact of a fresh and smooth surface with the steel disc. Before and after each test, the wear track was cleaned with acetone, and samples were weighed. Figure 3 shows the change in volumetric wear rate with load applied of 9.81N, 19.62N, 29.43N, and 39.24N for varying wear testing temperatures of 50°C, 75°C, 100°C, 125°C, and 150°C of unreinforced magnesium and reinforced (Mg-5%Al<sub>2</sub>O<sub>3</sub>-5%SiC, Mg-10%Al<sub>2</sub>O<sub>3</sub>-10%SiC) magnesium MMCs. It's worth noting that the volumetric wear rate of matrix and hybrid composites increases considerably as the load increases. At higher loads, the increase in volumetric wear rate of all the samples tested has been linked to a greater amount of plastic deformation and a higher degree of delamination wear. The volumetric wear rate of hybrid composites was lower than that of pure magnesium matrix for all applied loads. The composites with hard reinforcement particles shows lesser volumetric wear rate than matrix. At the wear testing temperatures of 50°, 75°, 100°, 125°, and 150° for each specimen of unreinforced and reinforced magnesium metal matrix composites, a transition from lower to greater volumetric wear rate occurred at a given applied load, as shown in Figure 3. All testing temperatures from 50°C to 150°C shows a significant increase in volumetric wear rate, indicating a transition from mild to severe wear. With an increase in the percentage of reinforcement in the magnesium metal matrix composites, the transition load (Load at which transition from moderate to excessive wear occurs) was improved. This is due to the increasing weight proportion of reinforcement (Al<sub>2</sub>O<sub>3</sub> and SiC) in the composites results in greater hardness and strength.



(a)



(b)

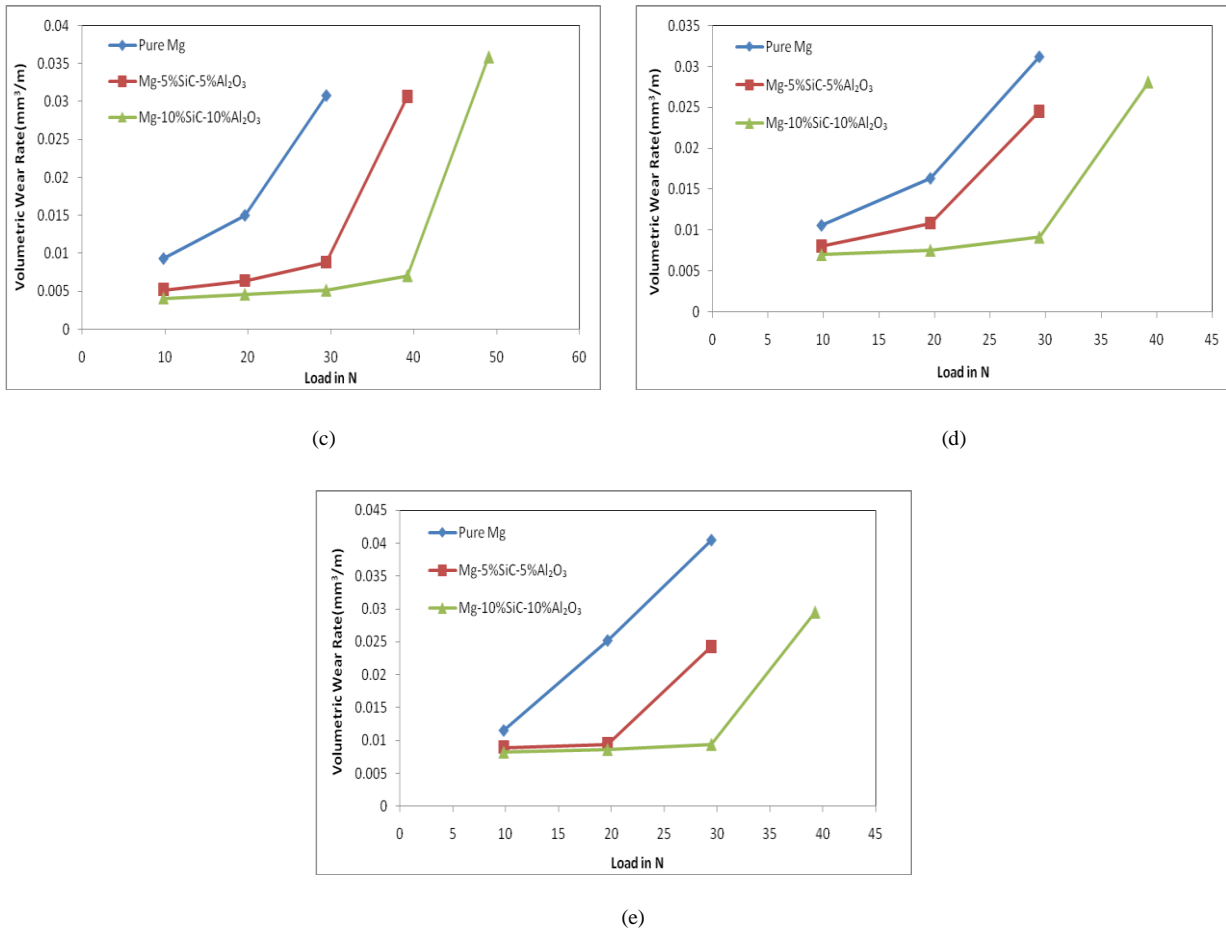


Figure 3: Volumetric wear rate v/s Applied load at a wear testing temperature of a) 50°C, b) 75°C, c) 100°C, d) 125°C, e) 150°C

#### IV. CONCLUSION

Magnesium metal matrix composites reinforced with Silicon carbide and alumina particles were successfully developed using a powder metallurgy process. Wear test was successfully performed on test ready specimens. The results reveals that the volumetric wear rate of matrix and hybrid composites increases significantly as the load increases. The volumetric wear rate of hybrid composites was lesser than that of pure magnesium matrix for all applied loads. Also, results indicates that the transition load was improved with an increase in the percentage of reinforcement in the magnesium metal matrix composites.

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