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Wear And Friction Behaviour Of Tial Mmc With Sic Reinforcement

Pandu Sathvik*,Mrs. Rekha .N**
**Mechanical Engineering Student, ** Assistant Professor, Department Of Mechanical Engineering, Pes University.*

Abstract
The study essentially aims at investigating the wear and friction properties of TiAl Metal Matrix Composite (MMC) with SiC reinforcement over different loading conditions. The stoichiometric ratio has been maintained by adding SiC in varying percentages of 5%, 7%, 9% and 12% on the Ti-Al base metal. As outlined in ASTM standards G99, the Pin on Disk test is used to understand the behaviour of composite material where EN31 steel is used as a counter body. Polished specimens were prepared in accordance with ASTM E18 for testing.
SEM (Scanning Electron Microscopy) analysis also helps to see microstructural features of SiC inside TiAl matrix along with its interaction. Rockwell hardness testing was used to determine the hardness characteristics of the material that gives vital data regarding its rigidity against penetration and deformation. Hence it is a better approach that aids in a detailed understanding of the TiAl MMC's mechanical performance under varying SiC reinforcement percentages, explaining its suitability for various engineering applications.
Keywords: *Composites, Aluminium, Metal alloy materials, Thin films and Powder Metallurgy.*

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I. Introduction

Friction and wear behaviour are fundamental phenomena encountered in various engineering applications, impacting the performance and longevity of materials and components. Friction refers to the resistance encountered when two surfaces move against each other, while wear encompasses the gradual loss of material due to frictional forces. Understanding these behaviours is crucial for optimizing design, minimizing energy losses, and ensuring the reliability and durability of mechanical systems. Factors such as surface roughness, lubrication, material properties, and operating conditions influence friction and wear characteristics, making their study interdisciplinary and essential in fields ranging from automotive engineering to biomechanics. Engineered materials called composites are composed of two or more constituent materials, each of which has unique chemical and physical characteristics. When these components are combined, a new material is produced that has superior qualities not found in either of the constituents, such as great strength, stiffness, and durability. The study of composite materials has become a critical field of research and development.

Composite materials are employed in many different industries nowadays, such as sports, construction, automobile, and aerospace. The field of composite materials is still undergoing study and development, which will increase the materials' usefulness and enhance their qualities, making them an essential part of contemporary technology. On the basis of matrix phase composite materials are classified as metal matrix, ceramic matrix and polymer matrix.

The advanced composites like metal matrix composites (MMCs) and ceramic matrix composites (CMCs), were developed in the 1980s and 1990s. These materials provided better mechanical and thermal qualities in addition to increased wear and corrosion resistance. Composite materials are used in many industries like sports, construction, automobile, and aerospace. A composite fibre system is implanted in a homogenous, monolithic material called a matrix. Fibers, fabric fragments, or whiskers are examples of reinforcement. These reinforcements essentially worked to improve a composite's mechanical qualities.

Composite materials known as metal matrix composites (MMCs) are made of carbon fibers, glass, ceramic, or other reinforcing components mixed with a metallic matrix. MMCs preserve the metallic matrix's electrical and thermal conductivity while providing advantageous qualities including high strength, stiffness, and wear resistance. It is possible to customize the reinforcement and matrix material selection to achieve certain qualities for various applications. MMCs can be produced using a variety of methods.

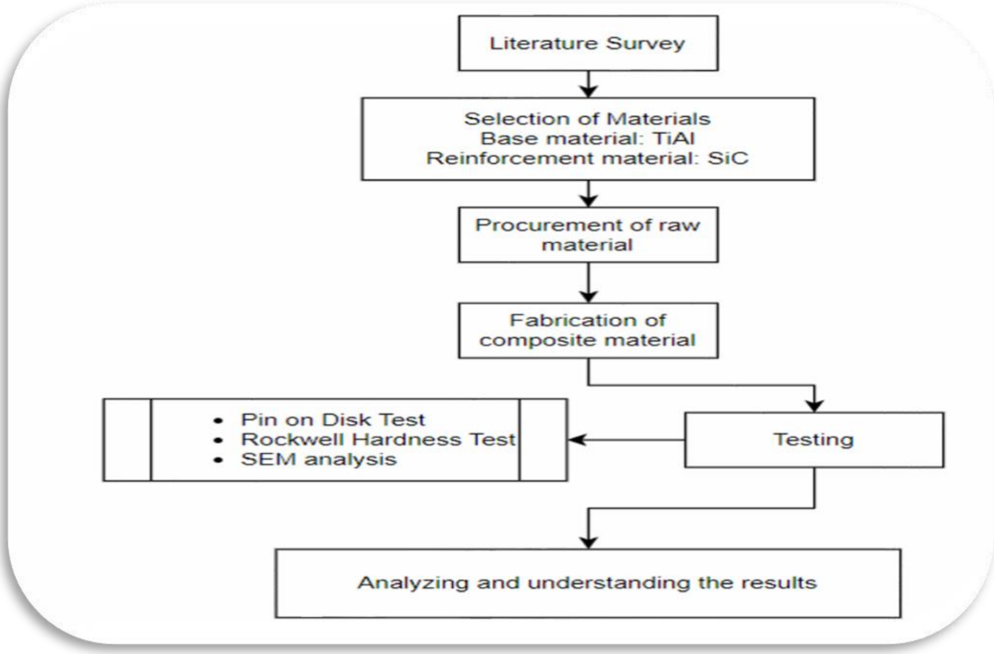
II. Objectives

The objective and methodology of the study is as follows:

Objective 1: To investigate the wear mechanisms of TiAl MMC with SiC reinforcement under different loading conditions.

Objective 2: To determine the optimal content of the reinforcement to achieve best wear and friction properties.

Objective 3: To understand microstructural features using SEM Analysis. Objective 4: To determine the hardness of the TiAl MMC with SiC reinforcement.



In the initial phase, high-purity titanium, and aluminium powders, along with silicon carbide particles, are meticulously prepared. The blending process aims for a precise composition and a homogeneous distribution of SiC within the metal matrix. Subsequent mechanical alloying via high-energy ball milling reduces particle sizes and ensures a fine dispersion of SiC throughout the material. The powders are then compacted using ceramic injection moulding where the precise pressure and temperature parameters affect the form and densification of the material.

Through solid-state reactions and diffusion, sintering—which is done at high temperatures in a regulated environment—allows metal particles and SiC reinforcements to join. The Pin samples were then machined according to the ASTM standards in line with the requirements of the Pin on Disk test specification. To perform the Pin on Disk test for the composite, a suitable counter body had to be chosen. Upon research, EN31 steel was found as a reliable disk material to perform the test against Ti based composites. EN31 Steel was purchased and machined according to the ASTM standards in line with the pin on disk test requirements.

III. Results

Wear and friction analysis is done on Pin on disk Tester according to ASTM standards G-99-05. According to the results, on adding the SiC reinforcement to base metal TiAl wear rate was less. It is shown that 2kgs load and 400 rpm also resulted in lower wear rates and friction forces. Tests on 9% reinforced samples also revealed lower wear rates and friction coefficients. By increasing the load to 6kgs for all three reinforcements it is observed that wear rate, frictional force was higher as compared to 2kgs loads.

The Rockwell Hardness Test is a method use d to find out how hard a material is by seeing how much it re sists being pressed into. An applied load of 100 kgs is put on using an indenter. The load remains in place for a set duration of 30 seconds before being released, allowing the material to exert some resistance.

Table 1: Rockwell Hardness Test

% of SiC sample	Value per trial	Average value
5%	Trial-1 - 83 Trial-2 - 66 Trial-3 - 55	68
7%	Trial-1 - 44 Trial-2 - 63 Trial-3 - 57	54.67
9%	Trial-1 - 53 Trial-2 - 59.5 Trial-3 - 42	51.5
12%	Trial-1 - 78 Trial-2 - 73.5 Trial-3 - 64.5	72

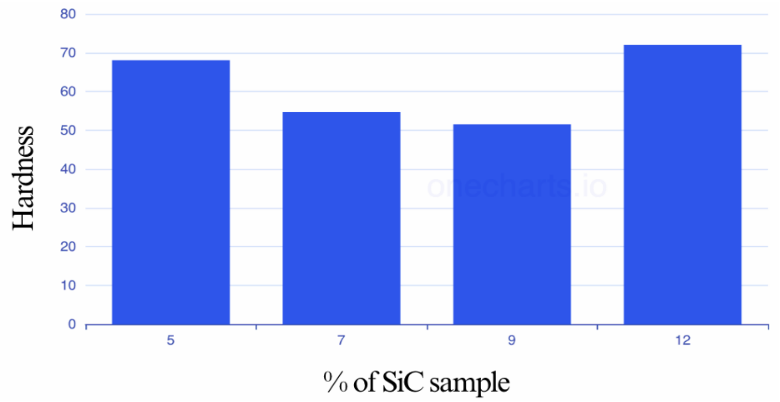


Figure 1: Bar graph of Average Hardness Value

SEM analysis uses electrons to produce high-resolution images of surfaces, aiding research in various fields by examining topography, composition, and morphology. SEM analysis on TiAl MMC with SiC was performed by coating the sample and image it in the SEM chamber. Data includes SEM micrographs revealing SiC particle morphology within the matrix. This analysis aids in understanding composite microstructure and properties.

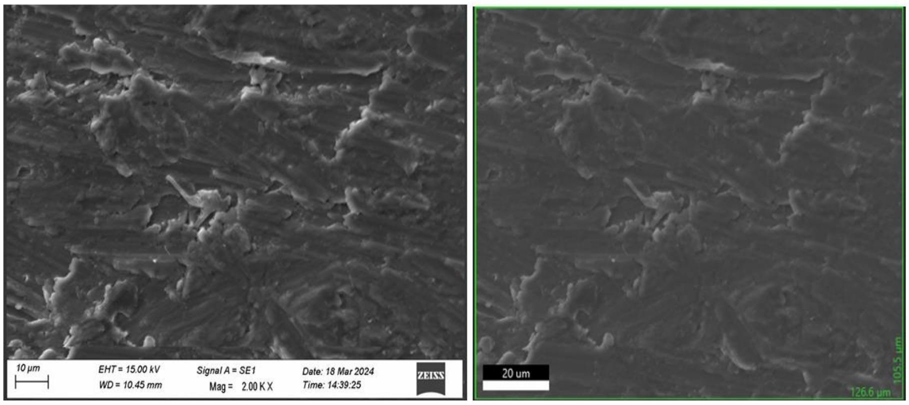


Figure 2: SEM image of SiC Sample

Table 2- Element Analysis Overview

Element	Line	Weight %	MDL	Error %	Net Int.
Si K	K	21.7	0.89	13.1	259.5
O K	K	3.9	0.21	10.3	327.7
Ti K	K	0.6	0.10	8.3	142.3
Al K	K	60.5	0.36	3.2	12088.5
C K	K	0.6	0.13	15.6	78.4
Zn L	L	0.6	0.25	14.4	52.8

The table presents elemental analysis data, featuring weight percentages, error rates, and net intensities. Aluminium dominates the composition at 60.5%, signifying its quantity. Silicon has a notable net intensity of 259.5, suggesting its significant presence and reliable measurement. Lower error rates imply higher measurement precision. Each element's characteristics offer insights into their abundance, significance, and reliability within the sample.

IV. Conclusion

The wear and frictional behaviour of TiAl MMC reinforced with SiC reinforcement have been examined in the current study.

● The metal matrix composite's wear resistance improved as the SiC reinforcement increased.

● 9%reinforcement MMC samples exhibited stable friction coefficient, but in 5% reinforcement has demonstrated an unstable and reduced friction coefficient when applied load and speed are changed.

● From the results of the Pin on Disk test operations, it is observed that the specimen with 9% reinforcement shows the maximum wear and friction resistance.

● From the results of the Rockwell Hardness Test, it is observed that the specimen with 12% reinforcement shows the maximum hardness sample.

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