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The Dry-Sliding Wear Behavior of Aluminium Alloy/ SiC Metal Matrix Composites

Fadhil M.C.[1], B.S. Ravikiran[2]

Research Scholar[1]

Department of Mechanical Engineering

Associate Professor[2]

Department of Industrial Engineering & Management

Sri Siddhartha Institute of Technology

Tumkur, India

ABSTRACT

The present research involved the conduction of dry sliding wear tests and the study of the microstructure of aluminium AA-2618 alloy matrix composite reinforced with Silicon Carbide particulates. The composites were machined to ASTM standards. The dry sliding wear tests were conducted on a pin-on-disc test rig while the microstructure was analyzed using an optical microscope. The addition of reinforcement particulates into the matrix material increases the wear resistance properties of the composite material.

***Keywords**: Composite material, Tribology, Dry-sliding wear test, Microstructure.*

1. INTRODUCTION

Aluminium alloys have favorable physical and mechanical properties, primarily low density, but their tribological properties are unsatisfactory. One of the solutions is reinforcement of the alloy matrix and formation of composites. [1]. Y. Sahin et. al. conducted experiments on tribilogical properties and their results show that the wear resistance of SiC reinforced composites shows significant improvement in their values than the unreinforced aluminium alloy matrix [2]. G. Anil Kumar et. al. established from their literature survey that the addition of reinforcements to the matrix material which is manufactured by any desired development method resulted in composites that generally possessed better mechanical and wear properties than their monolithic metal and alloys [3]. The wear rates of the produced composites decrease with the increase of addition of the SiC reinforcements into the aluminium matrix material [4]. G. B. Veeresh Kumar et. al. concluded from their microstructure study that the dispersion of the reinforcement particles within the alloy matrices were uniform and homogeneous [5].

2. EXPERIMENTAL PROCEDURES

2.1. Material preparation

Stir casting technique of liquid metallurgy was applied for the fabrication of the composites. Metal dies were used to prepare the final castings. By varying weight percentages of SiC particulates embedded within the aluminium matrix material, three types of composites are fabricated. SiC particulate content is varied in terms of weight percentages from 2% to 6% in steps or increments of 2%. The test specimens are fabricated according to ASTM standards. The chemical composition of the aluminium AA-2618 alloy is as shown in the table below.

Table 2.1. Chemical composition of AA-2618 alloy

Component	% Composition
Aluminum	93.7
Copper	2.30
Iron	1.10
Magnesium	1.60
Silicon	0.18
Nickel	1.00
Titanium	0.07

2.2. Dry-sliding wear test

Dry-sliding wear tests were carried out on ASTM standard specimen to determine and compare their tribological properties, like wear resistance and coefficient of friction. The tests were carried out using a pin-on-disc test rig. The composite specimens were machined according to the required ASTM standards. The tests were carried out at various loads and sliding speeds and appropriate readings were recorded at definite time intervals. Graphs were drawn to compare the readings with each other in order to draw necessary inference about the tribological properties of both the base alloy as well as the composite materials.

2.3. Microstructure analysis

In the present study, microstructure analyses were carried out to analyze the distribution of SiC particulates and grain boundaries in the material system. The micrographs of the composites with different weight percentages of SiC samples are cut from each of the weight fractions of the composites and polished with different grades of emery paper using polishing machine, then polished with silky smooth diamond rolling polish and dipped in Keller's reagent. Specimens were viewed through NIKON optical microscope model LV150 with Clemex Image Analyzer and micrographs are obtained from the samples with different magnification.

3. RESULTS AND DISCUSSIONS

3.1. Dry-sliding wear test results

3.1.1. Effect of load on wear rate

Figure 4.1 shows the variation of wear rate of AA-2618 alloy and its composites at a constant sliding distance of 1232 m and a sliding speed of 1.026 m/s. As the applied load increases from 20N to 50N, there is a reduction in wear rate for both the base material and the composites. The composite with 6 % wt. of SiC shows the minimum wear rate. This indicates that the wear resistance of the composite increases with the increase in weight percentage of SiC reinforcement particulates.

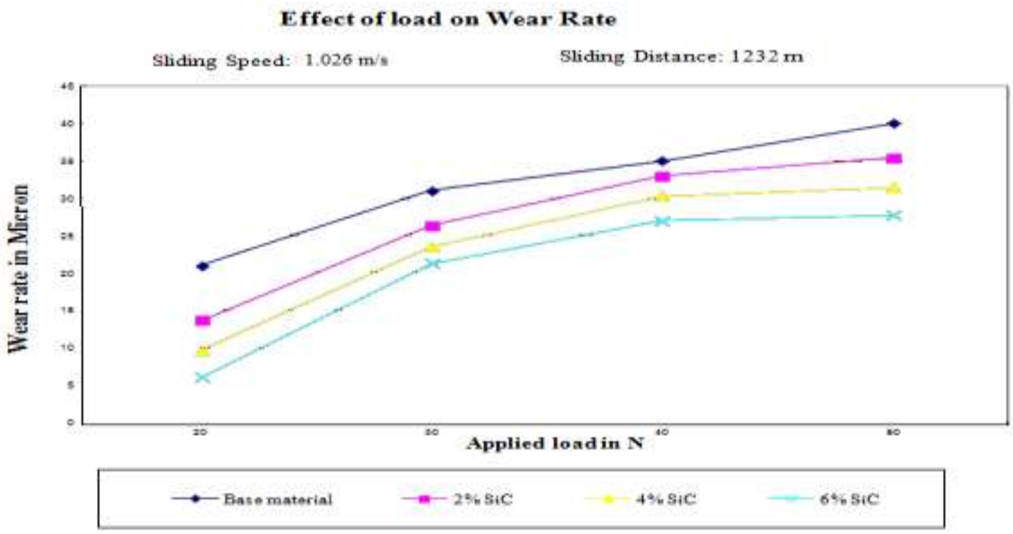

Figure 4.1: Effect of applied load on wear rate of AA-2618 alloy and its composites

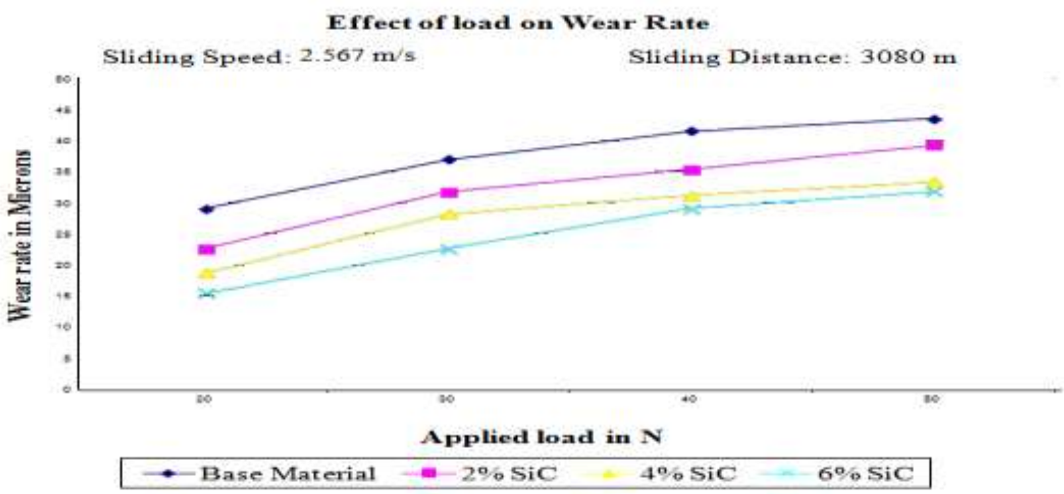

Figure 4.2: Effect of applied load on wear rate of AA-2618 alloy and its composites

Figure 4.2 shows the variation of wear rate of AA-2618 alloy and its composites at a constant sliding distance of 3080 m and a sliding speed of 2.567 m/s. As the applied load is increased from 20N to 50 N, there is a reduction in wear rate for both the base material and the composites. The composite with 6% wt. of SiC shows the minimum wear rate. Thus, the wear resistance of the composite increases with the increase in weight percentage of SiC reinforcement particulates.

4.6.2. Effect of sliding speed on wear rate

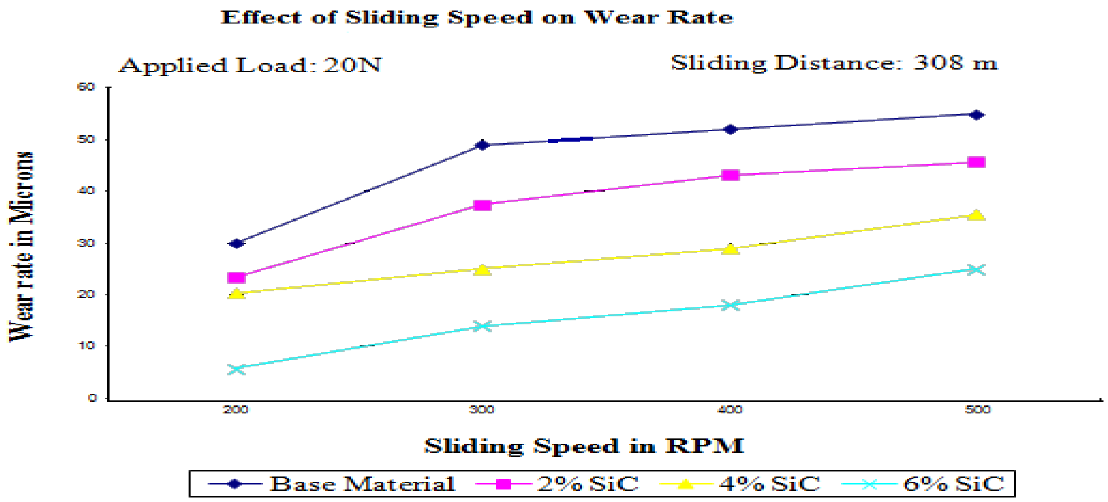

Figure 4.3: Effect of sliding speed on wear rate of AA-2618 alloy and its composites

Figure 4.3 shows the variation of wear rate of AA-2618 alloy and its composites at a constant sliding distance of 308 m and applied load of 20 N. As the sliding speed increases from 1.026 m/s to 2.567 m/s, there is a reduction in wear rate for both the base material and the composites. The composite with 6% wt. of SiC shows the minimum wear rate. This proves that the wear resistance of the composite increases with the increase in weight percentage of SiC reinforcement particulates.

Figure 4.4 shows the variation of wear rate of AA-2618 alloy and its composites at a constant sliding distance of 308 m and applied load of 50 N. As the sliding speed increases from 1.026 m/s to 2.567 m/s, there is a reduction in wear rate for both the base material as well as the composites. The composite with 6 % wt. of SiC shows the minimum wear rate. This also proves that the wear resistance of the composite increases with the increase in weight percentage of SiC reinforcement particulates.

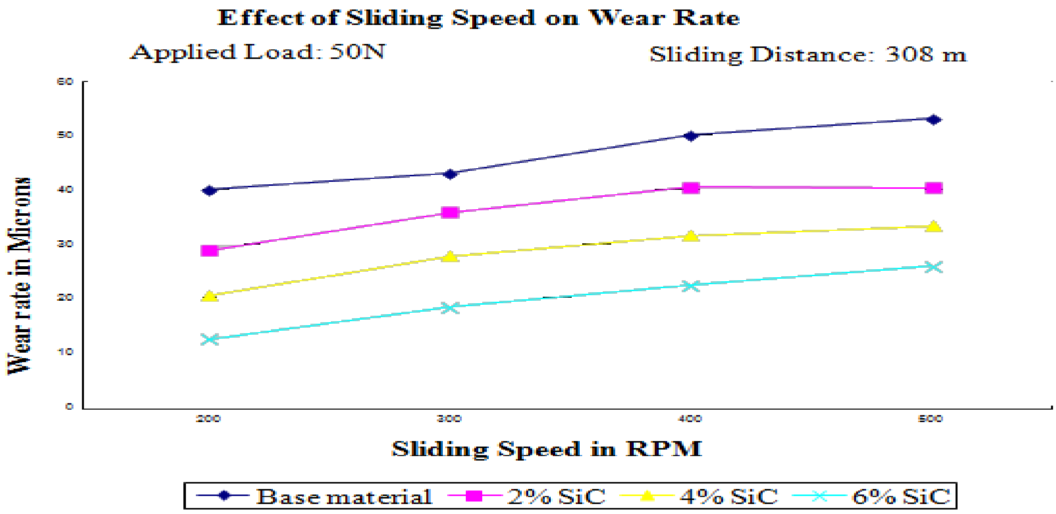

Figure 4.4: Effect of sliding speed on wear rate of AA-2618 alloy and its composites

3.2. Microstructure results

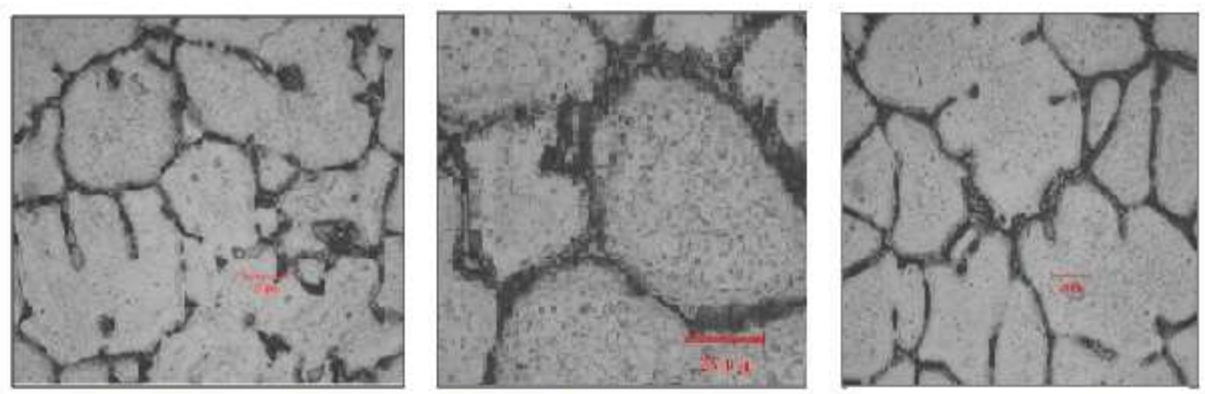

Fig. 4.5 (A): AA-2618 + 2 % SiC Fig. 4.5 (B): AA-2618 + 4 % SiC Fig. 4.5 (C): AA-2618 + 6 % SiC

Figure 4.5: Microstructure of AA-2618/ SiC metal matrix composites

The microstructure of aluminium metal matrix composites with different weight percentages of SiC are shown in Figure 4.5. The equipment which is used to study the microstructure is Nikon Microscope LV150 with Clemex Image Analyzer. It is observed from the microstructure images of the specimens, the microstructure consists of fine precipitates of alloying elements dispersed in the matrix of the aluminium solid solution. As can be observed by the micrographs, the microstructure shows a near uniform distribution of the reinforcement particles with the base alloy.

4. CONCLUSIONS

The following conclusions were drawn from the current research:

- Dry-sliding wear tests were conducted successfully for the composite specimens.
- The tribological properties of the composites exhibit better wear resistance properties showed improved values. The wear resistance improved with the addition of SiC reinforcements to the base alloy.
- The microstructure study realizes fine precipitates of alloying elements dispersed in the matrix of the aluminium solid solution.

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