International Journal of Engineering and Technical Research (IJETR)
ISSN: 2321-0869 (O) 2454-4698 (P), Volume 10 Issue 9, September-2020

Wear behavior of Silicon Aluminium Alloy Based Metal Matrix Composite with TiB_2

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Abstract:- In ceramic metal matrix, the alloy of Al and Si composite base material is used as Si. The structural behavior of Silicon is the pattern of Diamond like and it gives sufficient strength and it is widely used in automotive and aerospace structural application due to improved strength to weight ratio and low density. When Silicon is increased there is an improvement in mechanical property of wear resistance. Here the composite material using in the form of powder metallurgy and mixing of both Silicon and Aluminium their molten form. Better performance of Al and Si in to the presence of K_2TiF_6 and KBF_4 salts. For better binding of $Al-Si$ composite reinforced of 5%TiB_2. The inspection of ceramic metal matrix using Optical Microscope to determine the phase of Aluminium and Silicon. To analyze various condition of Wear rate, Wear resistance and Specific, Wear rate of Aluminium and Silicon.

I. Introduction

The fastest growing field of composites is in the form of aluminum composites due to their superior physical, chemical and mechanical properties. Al-Si alloys are widely used as engineering materials among different aluminum alloys as a mixed phase because of their light weight, good castability, high specific strength, enhanced resistance, and reasonable cost. Addition of ceramic particles such as TiB_2, SiC or Al_2O_3 to the aluminum-based composite phase does not significantly increase the density, but ensures a significant increase in specific strength, modulus, and wear resistance. Synthesizing ceramic particles within molten aluminum alloys is called the in-situ method of preparing Aluminium matrix Composite. The exothermic reaction between potassium hexafluorotitrate (K_2TiF_6) and potassium tetrafluoroborate (KBF4) yields the particles within the mixed salts combined phase in the In-situ synthesis of the salt – metal reaction.

II. Experiment Detail

The overall experimental process can be divided into two phases. In the first stage, $Al-xSi$ alloy (x=7, 11, 12.6) and $Al-xSi-5TiB_2$ composite samples are synthesized and poured. In the second stage, the samples were characterized for their microstructure, and wear behaviour.

2.1Synthesis of In-Situ Al-Axis alloy and $Al-xSi-5TiB_2$ Composite:-Initially, in a non-ferrous furnace the aluminium is melt in a graphite crucible at 720C. The composite was synthesized by the Flux Assisted Synthesis (FAS) technique which involves the addition of halide salts, and, melting the $Al–Si$ alloy at 800 ° C, and a reaction time of one hour. Exothermic reaction with in the melt results in the formation of titaniumdiboride (TiB_2) particles. For homogeneous distribution of molten aluminum and particles melt was stirred every 10 minutes to ensure complete reaction of salts.

After completion of the reaction, the lighter gross was removed. The molten composite was then poured into a preheated (450 ° C) cast iron mould for the preparation of individual samples.

2.2. Characterization

2.2.1 Optical Microscopy:- Microstructures of composite samples were viewed under a computerized optical microscope. The samples were polished using polished paper, followed by disk polishing and etching with Keller's reagent (1% HF, 1.5% HCl, 2.5% HNO_3, 95% H_2O). Micrographs of the samples were obtained.

2.2.2 Hardness:-The hardness test of the micro wicker was performed to measure the stiffness of the AMC in-situ composite with varying amounts of Si in the matrix. The specimens to be tested were prepared to require dimensioning and both of their horizontal faces were polished and made parallel.

The square-based diamond pyramid was used as an indenter and a 1 kg weight was applied for 15 seconds. Hardness values were measured in three locations above the specimen and the average length of diagonals of indentation was calculated. The Vickers Hardness Number (VHN) of the specimens was then obtained.

2.2.3 Wear Testing:- Wear tests were performed on a pin-on-disc wear test machine. Cylindrical pins (10 mm diameter and 30 mm height) of the mixed specimen were cut, machined, and polished onto the metal by a specimen cutter. The wear is tested by varying loads from 10 to 30N, and sliding speeds 1.36, 1.82, 2.27 for 300 seconds and 600 seconds at room temperature without any lubricant. During the test, the pin is pressed onto a steel disc with a normal load applied. With the help of microprocessor controlled wear testing machine in which where height loss and friction force were monitored simultaneously. After the test is complete the sample is removed, cleaned through acetone, dried and weighed to reduce weight due to wear.

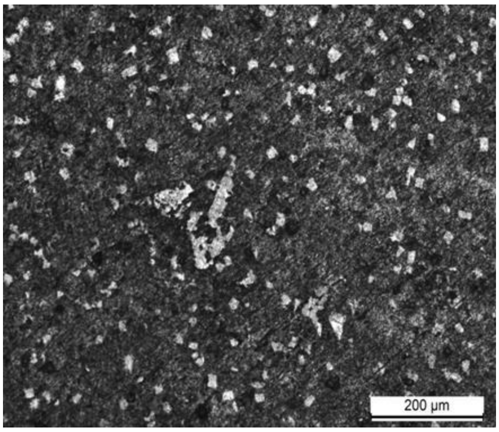
Differences in weight were measured before and after testing to determine weight loss (i.e. wear) in the overall sample. The wear of the composite sample was studied as a function of the weight percentage of the silicon in the alloy matrix, sliding speed, applied load, and sliding distance.

2.2.4 Scanning Electron Microscopy:-

The wound surfaces of the composite were examined with a combined emission electron microscope (FESEM).

III. Results And Discussion:-

3.1 Microstructure:- Optical microstructures of in situ and in situ composites are shown Fig. 1 It is seen from the figure that Si particles are distributed with α-Al. Al-Si is the eutectic structure of the binary alloy, which is the niddle-shaped Si well dispersed in the aluminum matrix but in the formation of particles in the melt, the available space for the growth of Si is reduced. Thus the particles restrict the growth of Si during freezing.



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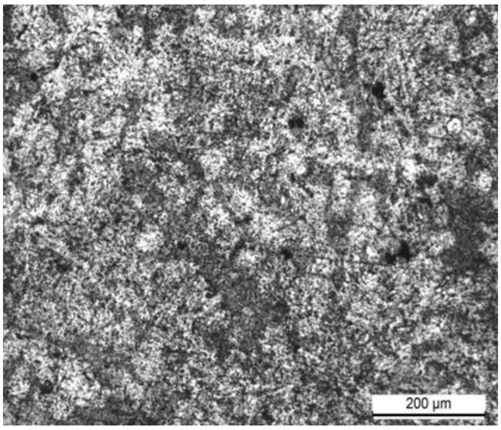

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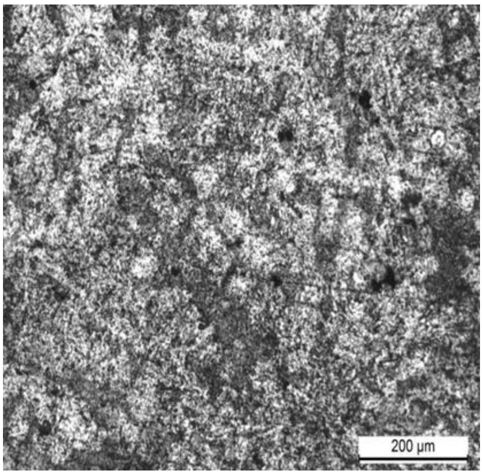


(c)

Fig 1.Optical micro graph at (100X) of (a) $Al-7Si-5TiB_2$ (b) $-11Si-5TiB_2$,(c) $Al-12.6Si-5TiB_2$ in-situ AMC composite (clock-wise)

3.2 Hardness Test Result:-

From the fig. 2 it can be seen that AMC material with 12.6% Si showing maximum hardness and AMC 7% Si showing minimum hardness. Increasing the amount of silicon increases the eutectic Al-Si phase which resists plastic deformation which leads to the stiffness of the composites.

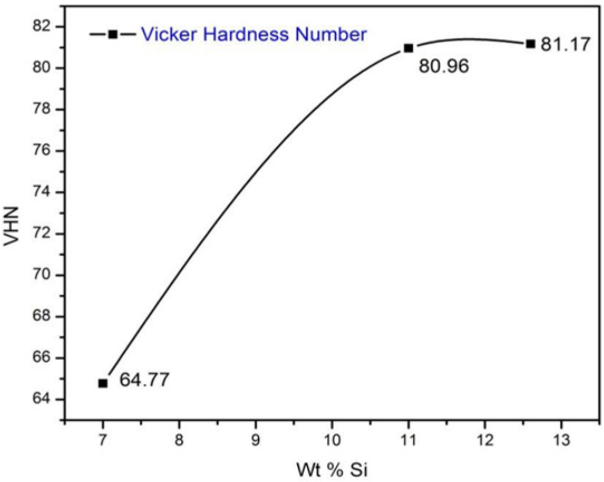


Fig .2 Hardness test results of the prepared in-situ composites

3.3 Analysis of Wear Test Results: -

3.3.1 Wear Rate of The Composite as A Function of Wt% of Si And Load, Speed, Sliding Distance:-

Si and wear rate of finished composite as volume of load, sliding distance, sliding speed. The wear rate of three different WT% of Si of in-situ composites was compared with different control condition. The wear rate was decreased with increasing wt% of s%. Higher wt% is the minimum wear rate in all conditions of use. The wear rate decreases with increase in load. Minimum wear rate achieved for various sliding distances.

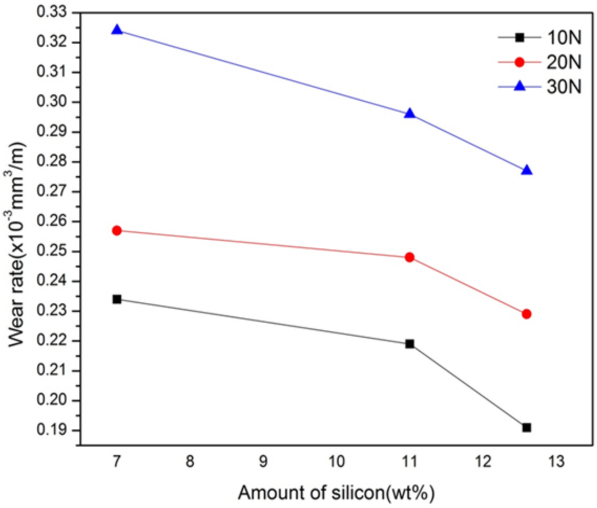


Fig.3 Wear volume of C (wt%) and rate of in-situ compositing of sliding distance

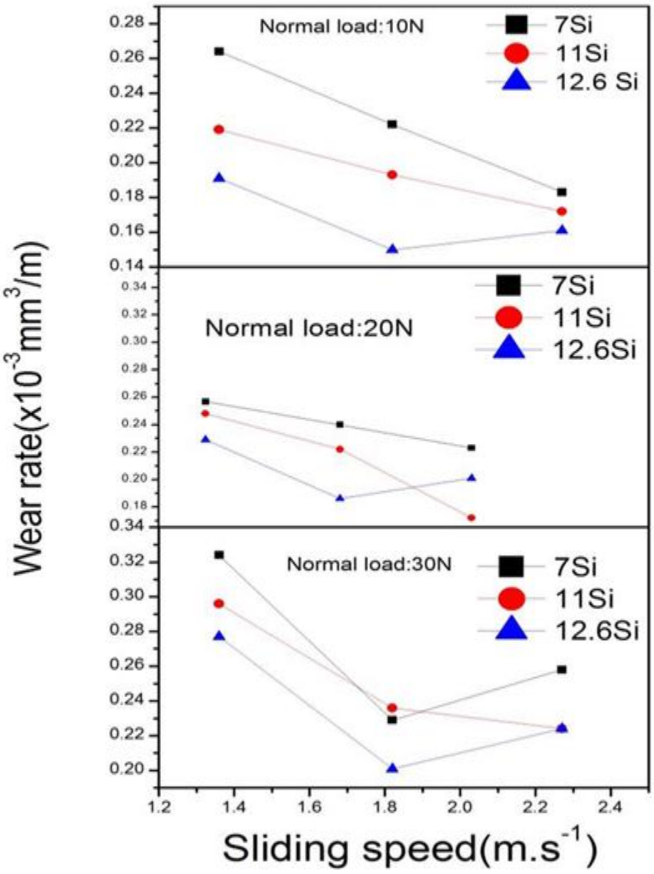


Fig .4 Wear volume of Si (wt%) and in-situ composites of sliding distance

The effect of sliding speed on the wear rate is shown in Fig. 6 for the AMC tested for different loads of 10, 20, 30N, respectively. In all three cases the wear rate was decreased with an increase in sliding speed, initially one of the possible reasons for the low wear rate may be surface oxidation that may increase local stiffness and strength at the interface.

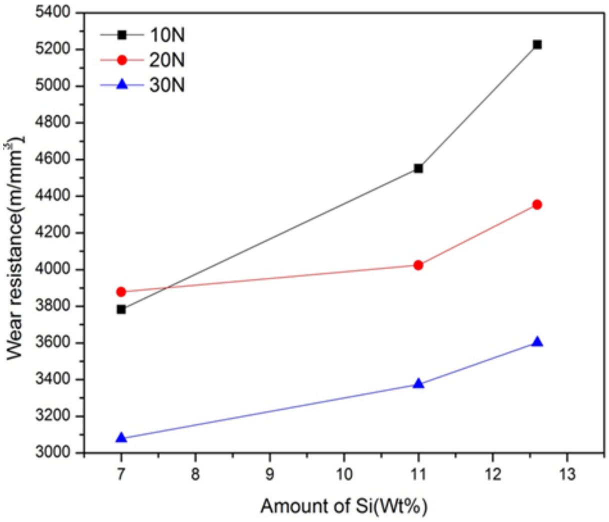


Fig .5 Wear rate of in-situ composites as a function of sliding speed and volume of Si (wt%) at different loads

3.3.2 Wear Resistance Of The Composite As A Function Of Wt% Of Si And Load, Sliding Distance: -

Composites with high wt% of Si have high resistance to wear resistance of composites prepared with different parameters. Increased sliding distance increases wear resistance.

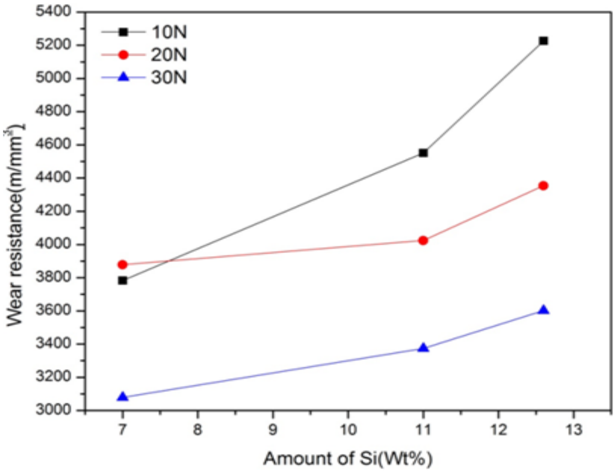


Fig .6 Wear in-situ composites as a function of c (wt%) and volume of load

3.3.3Worn Surface Analysis:-

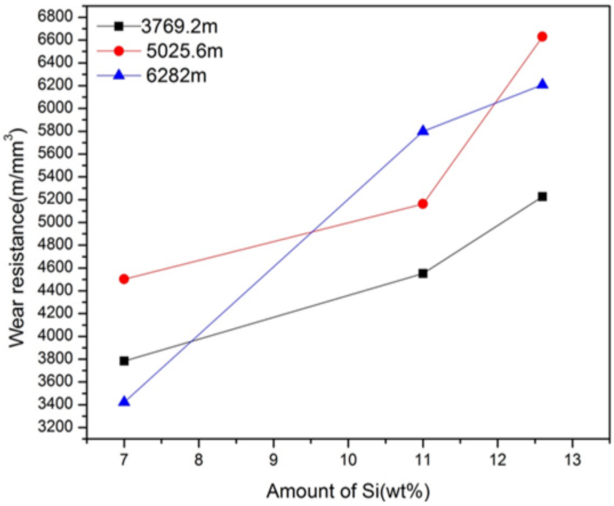


Fig .7 Wear resistance of the in-situ composites as a function of amount of Si (wt%) and sliding distance

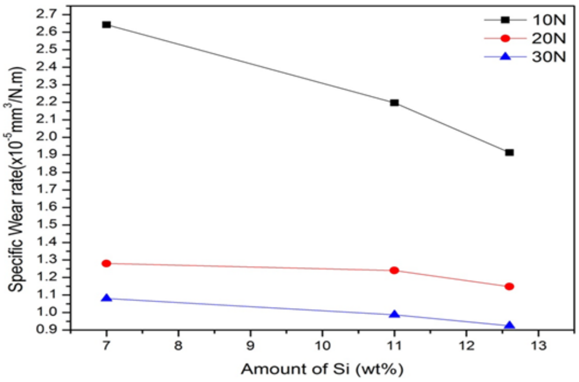


Fig .8 Specific wear rate of the in-situ composites as a function of amount of Si (wt%) and load

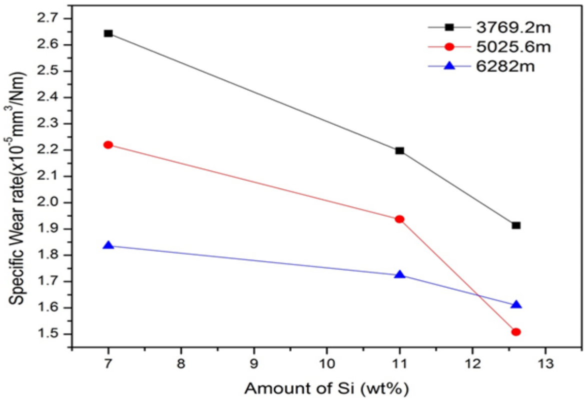
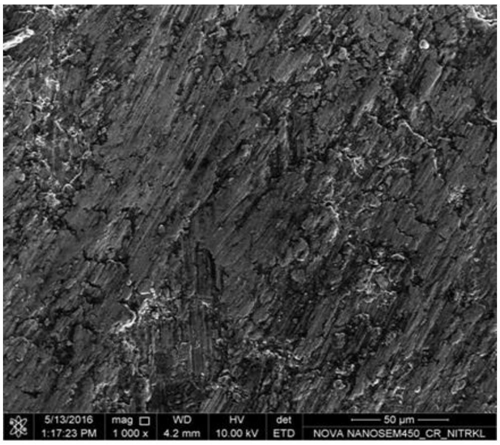


Fig .9 Specific wear rate of the in-situ composites as a function of amount of Si (wt%) and sliding distance



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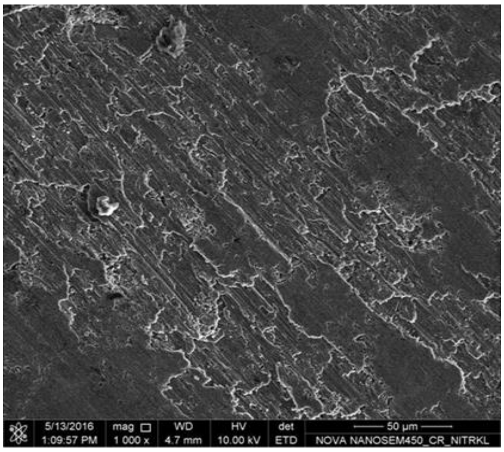

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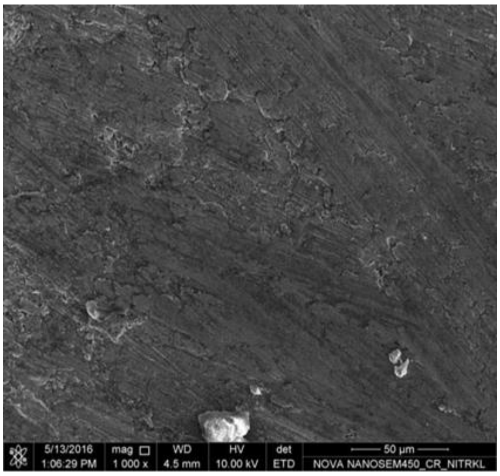

(c)

Fig .10 FESEM micrographs of worn surfaces of $Al-xSi-5TiB_2$ in-situ composite (a) 7 wt% Si (b) 11% Si (c) 12.6% Si

Morphology (wt%) of worn surfaces of Al with varying amounts of silicon. The wear mechanism is characterized by the flow of material in wavy form and deep grooves on the wear surface. However, the material flow was lower in the worn surface SEM images of "12.6%" Si AMC. But large grooves were clearly visible in the "7% Si" Micro-graph. In all three cases the construction of grooves of hard holes of Si.

IV. Conclusions: -

The following findings were obtained from the present investigation:

Future Scope of this composite material in aerospace for dynamic part.

Strength of this composite material good as compares Aluminium

After mixing of silicon it is heat resistant because it's melting temperature is 1414^{0}C.

Al-xSi-5TiB2 in-situ composites were successfully synthesized by melt casting.

The hardness value increases with an increase in the amount of Si (wt%).

The wear rate (mm3 / m) and specific wear rate (mm3 / Nm) decrease at all operating conditions with an increase in wt% Si.

All resistance increases with increase in wt% Si.

Wear mechanism was studied from the SEM micrograph of the in-situ AMC surface.

V. References

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