Tribological Characteristics of Aluminium Metal Matrix with nano BN Powder Metallurgy Composite.

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Abstract. The tribological characteristics of Aluminium metal matrix with different nano BN powder compositions were investigated using pin on disc tribometer. The pure aluminium, Al +1 wt% BN, Al + 3wt% BN, and Al + 5wt% BN compositions are prepared as 36 specimens using Powder metallurgy technique. In each composition 9 specimens undergone testing with three different load conditions and three different sliding velocities applied at constant sliding distance of 1000m. The result shows that when there is increasing the weight percentage of BN nano particles in aluminium metal matrix there is reduction of coefficient of friction by increasing the load and sliding velocities. Similarly the specific wear rate also gets reduced by increasing the load and sliding velocity.

1. Introduction

The most widely used metal in Metal matrix composites is Aluminium due its wide applications in the industries [1, 2]. There is a good improvement in the tribological properties of aluminium metal matrix reinforced by different nano materials [3-7]. The specific wear rate of Aluminium alloy composites decreases with increase in volume fraction and size of reinforcement. Load and sliding distance show a positive influence on wear implying increase of wear with increase of either load or sliding distance or both. [8]. The sliding speed variations will also causes changes in the wear behavior of aluminium metal matrix composites [9]. Boron Nitride is the solid lubricant material with low density and high thermal conductivity and high electrical resistivity. It also possesses the better wettability and also suggested BN might be an optimum reinforcement for an Al matrix composite [9-16]. Adel Mahmood Hassan et al. have reported decrease in hardness with increase in % reinforcement of Gr due to increased porosity [22].The coefficient of friction is decreased with increasing wt.% of MoS_2 and increasing the due to load. At a higher load and sliding speed the tribolayer that is formed increases, due to squeezing out of solid lubricant from the hybrid composites [23].

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2. Materials

The materials used in present work are 98% pure Aluminium and 99.8% pure Boron nitride nano powder. Boron Nitride Nano particles size limited to 70-80 nm with hexagonal crystal structure. Its density is 2.29 g /cm^3. Aluminium Powder with size limited to 130 – 180 micrometer, density 2.70 g /cm^3 and bears a melting point of 660.32°C.The Aluminium fine powder purchased from LOBA CHEMIE PVT.LTD., MUMBAI, INDIA. The Boron Nitride nano powder purchased from US Research Nanomaterials, Inc, Houston, USA.

3. Experimental Procedure

3.1. Fabrication of specimens

The Blending process is done by planetary ball milling machine using Al powder with 1 wt%, 3 wt%, 5 wt% of BN nano powder. The Blended powder is compacted in a Compacting machine to attain 30mm height. The compacted specimens are sintered using Sintering machine for 2hrs at 600°C.

3.2. Wear testing experimentation.

Each specimen prepared as per ASTM G99 standards and undergone wears testing using Pin on Disc tribometer. There are 3 different load conditions such as 5N, 7N, 10N were applied for testing. There are 3 different sliding velocities conditions such as 1.5m/s, 2 m/s, 2.5m/s were also applied for testing. Table.1 and Table.2 represented below shows the testing results obtained. The wear rates, frictional force, coefficient of friction are calculated for each specimen using Pin on Disc tribometer.

4. Results and Discussions

4.1. Wear testing results.

Table 1 represents the Specific wear rate of all the specimens, hence wear volume per unit distance can be calculated. The formula for Specific wear rate is given below in Equation (1).

Specific wear rate = [illegible] m^3/Nm - Equation (1)

Table 1. Specific Wear Rate calculation for all specimens.

Sl. No	Sliding Distance (m)	Sliding Velocities (m/s)	Load (N)	Specific Wear Rate (SWR) In terms of E^{-9} mm^3/Nm			
				100% Pure Al	99 wt%Al + 1wt%BN	97 wt% Al + 3wt%BN	95 wt% Al + 5wt%BN
1	1000	1.5	5	1.0322	0.9084	8.4592	11.1094
2	1000	1.5	7	9.8238	8.4363	10.5602	17.0982
3	1000	1.5	10	10.0963	9.9551	10.7387	19.1312
4	1000	2	5	7.4948	4.3245	9.3451	19.1756
5	1000	2	7	7.5354	3.9867	11.6831	20.9876
6	1000	2	10	10.0758	8.5645	14.3412	24.1023
7	1000	2.5	5	10.2008	8.5213	11.5106	18.3417
8	1000	2.5	7	10.395	8.7623	14.1214	22.5106
9	1000	2.5	10	10.5537	9.1234	15.0987	24.3234

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Coefficient of Friction $= \frac{(\quad)}{\text{tional force} (\ )(\ )}$ - Equation (2)

Table 2. Co-Efficient of friction calculation for all specimens.

S.No	Sliding Distance (m)	Sliding Velocities (m/s)	Load (N)	Co-efficient of friction			
				100% Pure Al	99 wt%Al + 1wt%BN	97 wt% Al + 3wt%BN	95 wt% Al + 5wt%BN
1	1000	1.5	5	0.71	0.46	0.18	0.1
2	1000	1.5	7	0.71	0.51	0.08	0.03
3	1000	1.5	10	0.72	0.54	0.03	0.01
4	1000	2	5	0.76	0.69	0.14	0.08
5	1000	2	7	0.56	0.53	0.05	0.02
6	1000	2	10	0.54	0.51	0.01	0.01
7	1000	2.5	5	0.6	0.43	0.09	0.04
8	1000	2.5	7	0.47	0.34	0.02	0.01
9	1000	2.5	10	0.57	0.29	0.01	0.01

4.2 Specific wear rate versus load:

The test results shows that when 1.5m/s, 2m/s, 2.5m/s sliding velocities were applied, the specific wear rate of Al + 1wt% BN is decreasing when compared with other compositions. When there is increase in Normal load also causes increase in specific wear rate. When there is increase in BN nano particles composition the specific wear rate also gets increased. The Figures 1 (a)-(c) represents the specific wear rate versus normal load at different sliding velocity conditions.

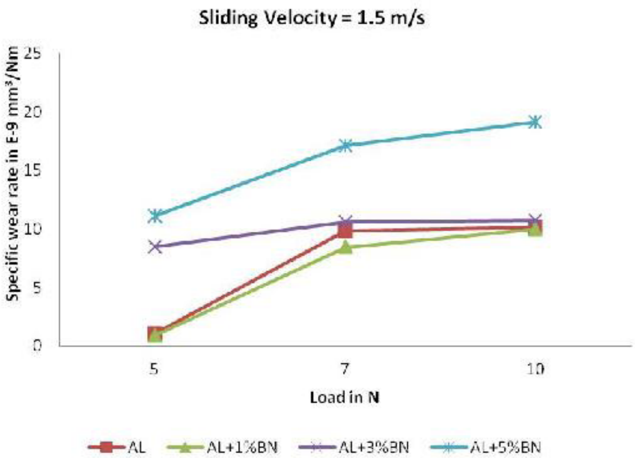

Figure 1 (a) Specific wear rate versus Load at 1.5 m/s Sliding velocity condition,

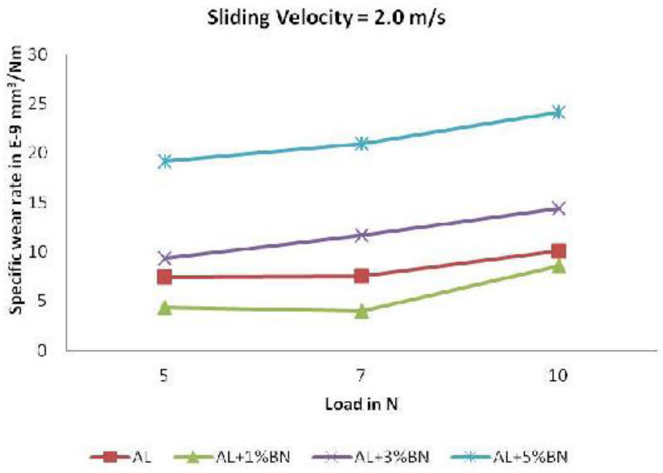

Figure 1 (b) Specific wear rate versus Load at 2 m /s Sliding velocity conditions,

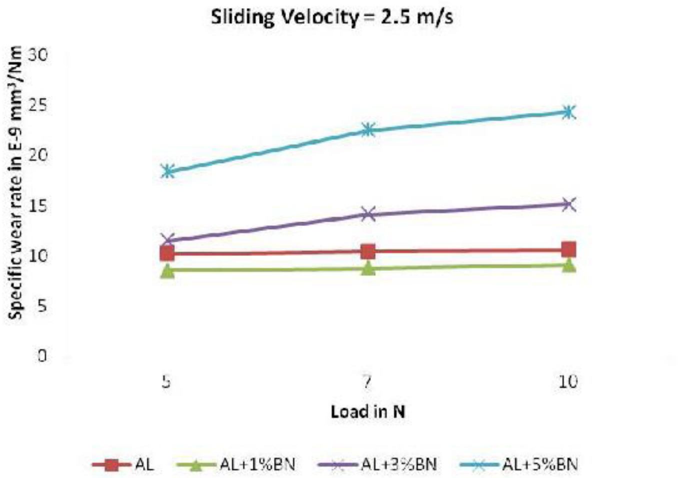

Figure 1 (c) Specific wear rate versus Load at 2.5 m /s Sliding velocity conditions,

4.3 Coefficient of friction versus load:

The test results shows that when 1.5m/s, 2m/s, 2.5m/s sliding velocities were applied, the coefficient of friction is decreasing when BN nano particle compositions are increased with increasing load and sliding velocities.. The Figures 2 (a)-(c) represents the coefficient of friction versus normal load at different sliding velocity conditions.

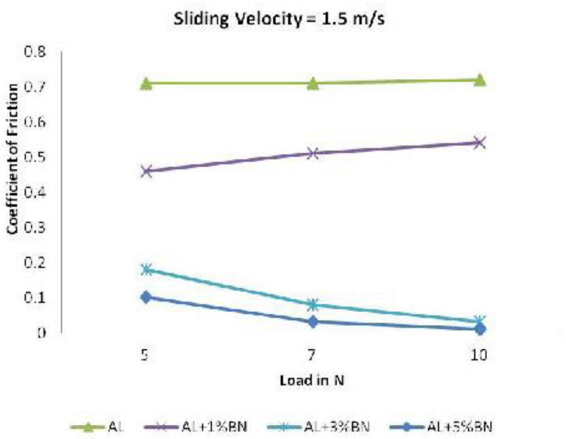

Figure 2 (a) Coefficient of Friction versus Load at 1.5 m /s Sliding velocity conditions,

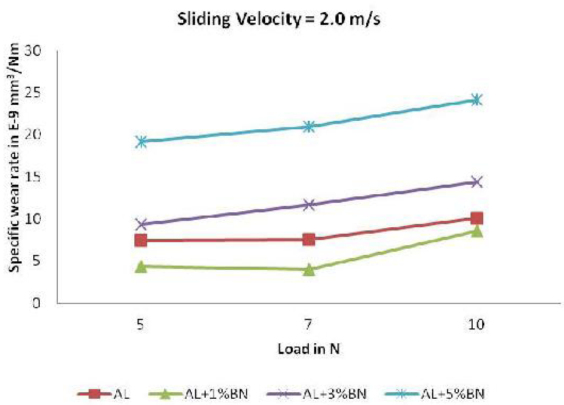

Figure 2 (b) Coefficient of Friction versus Load at 2 m /s Sliding velocity conditions,

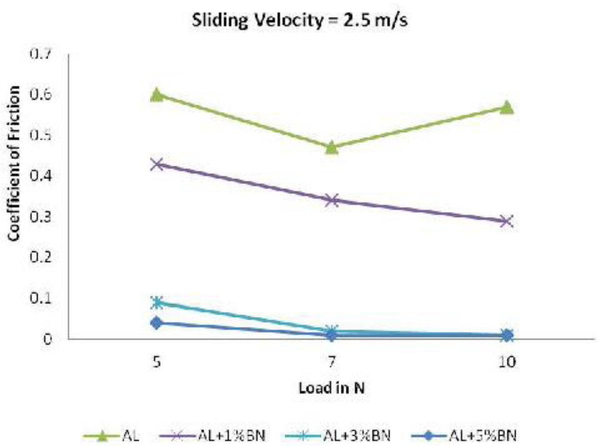

Figure 2 (c) Coefficient of Friction versus Load at 2.5 m /s Sliding velocity conditions,

5. Conclusion

The results showed that Al+1 wt% BN has better wear resistive ability compared with other compositions used in present work. Further reduction of wt % may increase the wear resistive ability and reduction in specific wear rate. The increase in sliding velocity and load causes decrease in coefficient of friction.

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