Performance Analysis Of Ceramic Composite For Bearing Application

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Abstract - In the application where wear resistance properties of material are required very good , we are generally used the metal alloys. Metal alloys are can be easily ground forged or machined for various wear resistant parts in the industries that have properties different from ceramics. Compared to ceramics, metal alloys have higher toughness but lower strength, hardness, and wear resistance. Ceramic, on the other hand, has low thermal shock resistance despite its high thermal resistance, high strength, and extremely high wear resistance. Thermal shock is nothing but the function of thermal conductivity and thermal expansion. The phase composition, relative density, and SiC percentage included in the composite all have a significant impact on the strength of Mullite-Sic ceramic. It is observed that the various mechanical properties of ceramic composite can be obtain at different % of weight addition of Sic.

Key words: Metal alloys , Ceramic, Mullite, Thermal Shock, SiC.

I. INTRODUCTION

A bearing is a mechanical component that reduces friction between two moving parts by converting one motion into another. Bearings come in a wide variety of shapes and sizes; the thrust bearing and radial bearing are the most common. Metal alloys are typically utilized in applications requiring wear resistance from the material. Despite the fact that metal alloys outperform ceramics in terms of toughness, strength, hardness, and wear resistance. Ceramics are resistant to high temperatures, high temperatures, and wear, but they are not very resistant to thermal shock. The mullite-Sic ceramic composite strength depends upon the relative density phase composition and the percentage addition of Sic. Ceramic composites can be made with a variety of mechanical properties by adding different amounts of Sic. Compared to monolithic mullite, the strength and toughness of mullite-Sic composites press higher values.

Advanced ceramic materials such as alumina or silicon carbide offer a high potential under such severe loading condition. Ceramic/ceramic or steel/ceramic sliding pairs can achieve greater power transmission under oil lubrication than, for instance, steel/steel sliding pairs. High scuffing resistance of ceramics is beneficial under lubrication with liquids of low viscosity or at mixed and boundary lubrication at more or less fractions of solid/solid contact. Friction and wear are strongly influenced under poor lubrication by topography of the functional surfaces. With decreasing film thickness of the liquid a transition to boundary friction can occur depending on the operating conditions and thus tribochemical reactions may be caused on materials such as Al_2O_3 or SiC or even phase transformations in the surface of partially stabilised zirconium dioxide (ZrO_2) ceramics. Tribochemical films produced at the loaded surface dominate friction and wear characteristic under these conditions

II.LITERATURE REVIEW

S. Taktak And M.S. Baspinar :-The main purpose of this paper is to optimize the Wear and friction behaviour of alumina/mullite composite by sol–gel infiltration technique. Structural ceramics are those ceramic materials that possess sufficient mechanical properties for use as load bearing components. Ceramics based on alumina have been used in commercial applications for many years because of their availability and low cost. In this investigation we studied and explored the influence of mullite phase, speed and load values on friction and wear behaviour of alumina ceramic. Wear tests for alumina and composites contained mullite from 0 to 11 vol% were carried out with a ball-on-disc machine. Tribological tests were under 2.5, 5, 7.5 and 10 N load, at the speeds of 0.15, 0.3 and 0.6 m/s and unlubricated conditions in air. Wear rates were deduced from mass loss. The wear rate for alumina was in order of 6.76 · 105 –1.66 · 104 mm3 /N m, while the wear rate of alumina/mullite composites was in the order of 4.6 · 105 –1.3 · 104 mm3 /N m. The results indicate that wear rates and friction coefficient of alumina/mullite composites are lower than alumina ceramics.

.S. Akpinara, and K. onelc - In this research paper the authors explained the silicon carbide particle reinforced mullite composite foams wear produced by the polymer repli method using alumina and kaol into form in situ mullite matrix.

Ji Hyeon Bak and Dae Hyun :-In this research paper the authors explained the engine Crankshaft bearing materials need improved wear resistance to withstand high speed and heavy loads. Requirement of bearing material, a new material matrix composite was designed. Hear, the hybrid aluminum borate whisker hexagonal boron nitride carbon nanotube CNT/AL-5Sn Alloy. MMCs were fabricated by squeez infiltration and compare MMC with AL-Sn alloy.

K.-h. Zum gahr :-In this paper author conclude that, ceramic materials can offer a substantially greater resistance to sliding wear than steels, particularly in lubricated contact. Under severe loading the low thermal conductivity of ZrO, may be a disadvantage compared with Al,Os, but it can be compensated by using a steel counterbody. A1203 showed the lowest wear of the self-mated ceramics tested in air, water and oil. Al,Os sliding against steels resulted in greater wear loss than in the selfmated A1203 pairs. Increasing brittleness of ceramics increased wear intensities under the severe test conditions used. ZrO, and SiSiC mated to steel may offer greater wear resistance under oil lubrication than that of selfmated Al,O, or Al,O,-steel couples. A relatively high wear resistance with oil lubrication was also measured on 20, containing 10% open porosity in sliding contact with hardened steel .The investigated ceramic and metallic materials are listed in Table 1. With the exception of SiSiC, all ceramics were oxides based on Al,O, (A90, A99), Al,O, and ZrO, (ZA50), Mg-PSZ (Z96V10, Z96V20, Z95P) and A12Ti0, (AT(p)). The Z96VlO ceramic was produced by using a synthetic and the Z96V20 by using a natural powder. SiSiC was a reaction-sintered, free-silicon-containing silicon carbide.

Gaurav Mittal :- In this research paper the authors explained the bearing materials need improve wear resistance to withstand high speed and heavy loads. The powder metallurgy technique has been used to try to improve the properties of mullite and sic ceramic matrix composite material, which can be used to make sleeve bearings. Addition of SiC weight percentage in aluminum based composite material increases the micro-hardness and compressive strength.

From the study of above literature the main problem with metal sleeve bearing is the metal alloys are generally used in applications where wear resistance properties of materials are required because they can be easily machined, ground or forged for various wear resistant parts that have properties different than the ceramics . Although, metals have high toughness but have low strength, low hardness and low wear resistance properties compare to ceramics.

Because they can be easily machined, ground, or forged into a variety of wear resistant parts with characteristics distinct from those of ceramics, metal alloys are typically utilized in applications requiring wear resistance properties from materials. However, metals outperform ceramics in terms of toughness, strength, hardness, and wear resistance. Ceramics are resistant to high temperatures, high temperatures, and wear, but they are not very resistant to thermal shock. The thermal conductivity and expansion of the material are largely responsible for thermal shock. Over the past ten years, a lot of work has been done or has been reported on to prevent thermal shock. One of the solutions is found in composite materials. As an example aluminum oxide nano-fiber can improve the ductility of ceramic metal composites.

For making power transmitting elements which are under continuous loading conditions Al-SiC metal-matrix composite can be used which possesses high strength, high stiffness, thermal stability at elevated temperatures, high corrosion and wear resistance and more fatigue life . The micro-hardness and compressive strength of aluminum-based composite materials are enhanced by including a weight percentage of SiC. The phase composition, relative density, and percentage of SiC added to the mullite-SiC ceramic composite all have an impact on its strength.

III. PROBLEM STATEMENT

The Most of the metal matrix sleeve bearing in turbine of locomotive train having a problem of corrosion, brinelling as well as it provides high coefficient of friction. As Compare to metal sleeve bearing ceramic composite bearing have high load carrying capacity and low coefficient of friction. So that the use of ceramic composite is increasing continuously.

Fig 1- Failure Occurs in Sleeve bearing

IV. OBJECTIVE

The main objective is to be developed a new ceramic composite for the application of sleeve bearing. To decrease the problem arises from the existing material that is metal matrix.

The objectives sssssare as follows,

i) To determine the coefficient of friction.

ii) To determine the wear rate

V. PROPOSED METHODOLOGY

1 Method used for manufacturing

Fig 2– Ball Mill

Both the powdered form of the ceramic matrix material mullite (3Al2O32SiO2) and the powdered form of the SiC were obtained from the market. In a laboratory ball mill, the powders were combined with the binder polyvinyl alcohol (PVA) to create the ceramic matrix composite. Initially mullite powder 90% (by weight), SiC 10% (by weight) was mixed with PVA binder in ball mill for 8 h for making homogeneous mixture.

In order to produce green compact, the resulting homogeneous mixture was compacted using a hydraulic press. In order to produce green compact samples, the mixture was pressed in a die using a hydraulic press at a load of 220 MPa. For microwave sintering, the green compact ceramic composites underwent additional processing. Using a microwave sintering furnace that operates at 2.45 Hz, three samples were sintered in a variety of conditions to meet the requirements. Based upon different input conditions set as per , Fig. shows finally procured sintered samples.

VI. EXPERIMENTAL SETUP

Fig.3- Photograph of experimental set up (Tribometer TR-20LE)

Working Procedure-

1. Connect the power input cable to 230 V, 50 Hz, and 15 Amps supply. Switch ON controller. Allow 5 minutes for normalizing all electrical items.
2. Using dial indicator, clamp disc within 10 µm run out.
3. Thoroughly clean specimens, remove burs from the circumference using a 2000 grit fine silicon carbide abrasive paper. Clean the wear disc thoroughly with the petrol.
4. Insert specimen pin inside the hardened jaws and clamp to specimen holder. Set the height of specimen pin above the wear disc using height adjustment block, ensuring the loading arm always horizontal. Tighten clamping screws on jaws to clamp specimen pin firmly. Swivel off the height adjustment block away from loading arm.

5. Set the required wear track diameter (18 mm to 32 mm) according to sliding speed by moving the sliding plate over graduated scale on base plate. Tighten both the clamping screws to ensure assembly is clamped firmly.
6. Wear display: Loosen LVDT lock screw; rotate thumbscrew to bring LVDT plunger visually to mid position, the wear reading display on controller should be as near to zero. Initialize wear display to _0' by pressing _ZERO' push button on controller.
7. Frictional force display: Move loading arm away from frictional force load cell and set frictional force display _0' by pressing relative _ZERO' button on controller.
8. Place required weights on loading pan to apply normal load.
9. Setting the disc speed: Set 15 minute time on controller, press test, start push button and rotate. Set by rotating rpm knob on controller till required test speed is displayed. Continuaslly run for the remaining time to observe any fluctuation. Press the STOP button.
10. Setting the test duration on controller: Test duration is set either in time mode (set in hr, min, sec) or counter mode (set in no. of cycles, max. is 100000 cycles). Mode selection is by the toggle switch below timer display, the switch position indicates selection as either time or counter. Test duration of 90 minutes is selected.
11. Setting of computer for testing and data acquisition:

i. Connect the data acquisition cable from controller to PC.
ii. Open the software Winducom 2008 on PC.
iii. Click on mode run continuously icon on software screen to the activate screen.
iv. Click on ACQUIRE tool bar at screen top to open acquiring screen.
v. Enter the name on file name window.
vi. In the cell for Sample ID, enter the material of the specimen and its dimensions.
vii. Fill the remaining empty cells for speed, load, wear track and data sampling rate.
viii. In the Remark cell, enter dry test, duration of test, speed etc.
ix. Click START button in PC window.
x. Press START push button on the controller front panel to commence the test and send data to PC.
xi. Set the required rpm by rotating slowly the rpm knob in clockwise direction.
xii. Measured rpm is displayed on the SPEED window of the controller front panel. .
xiii. Click zero button on PC screen and initialize all sensor values to zero.
xiv. Click SAVE button on PC screen to save data.
xv. On controller the acquired test parameters like wear, frictional force, speed and temperature are displayed, the same values are displayed on PC screen with graph.

VII. EXPERIMENTAL RESULTS AND PERFORMANCE EVALUATION

Observation Table:

In this experimentation used L8 Mixed orthogonal array for the design of experiment.

Table No.1 - L8 Mixed array

1	1	1
1	2	2
2	1	1
2	2	2

3	1	2
3	2	1
4	1	2
4	2	1

After incorporating the actual parameters for the design the orthogonal array is given below,

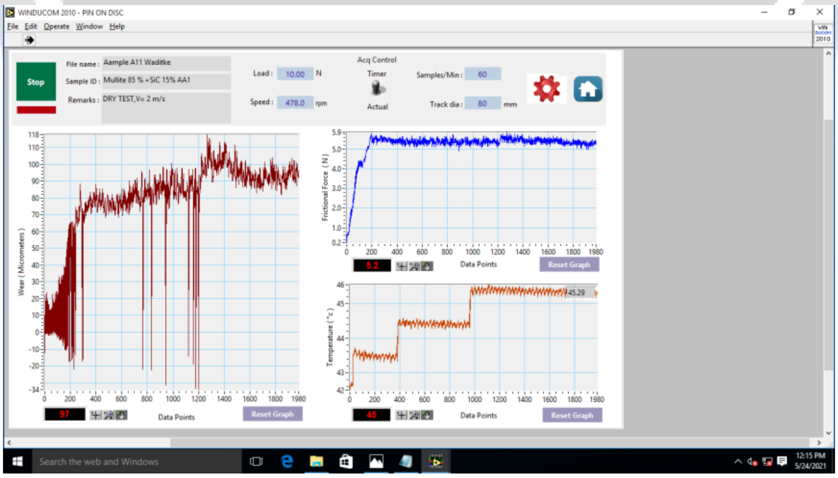
Table No. 2 - Number of Experiments.

NO. OF RUNS	MATERIAL (Mullite-SiC)	LOAD	SLIDING VELOCITY
1	85-15	10	1
2	85-15	20	2
3	80-20	10	1
4	80-20	20	2
5	75-25	10	1
6	75-25	20	2
7	70-30	10	1
8	70-30	20	2

After that eight readings are taken on pin on disc appatatus at various conditions , the graphical results are obtained are as follows, From that the better result are obtained as follows,

Experimental Data of Lubrication-85%Mullite + 15% Silicon Carbide.

Velocity: 1 m/sec, Time -15 min, load-10N, Speed -238 rpm.



For the first composition i.e. specimen of 85% Mullite + 15% Silicon Carbide the reading is taken, the above graph is obtained on pin on disc apparatus, the wear rate increases with time but wear is low , load is taken for the reading is 10 N and sliding velocity 1m/s & speed is taken as 238 rpm, the track diameter is taken as 80mm, the test conducted time is 15 minutes . the mean of coefficient of friction getting from graph for this reading is 0.422 and the wear calculated is 1.272, After certain time pasess the graph of frictional force is constant and wear graph is also steady after few minutes (Sample A1).

After the all testing of eight specimen s following results obtained are as follow,

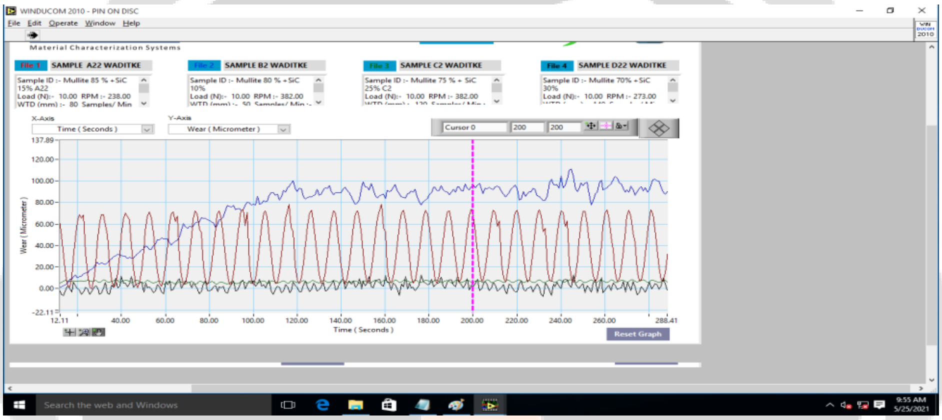
Table No. 3 -Result Table

Material	Load	Sliding Velocity	COF	SNRA1	WEAR (10^{-6})
85-15	10	1	0.422	18.434	1.272
85-15	20	2	0.402	19.210	0.849
80-20	10	1	0.483	19.689	2.543
80-20	20	2	0.446	18.769	2.123
75-25	10	1	0.483	18.434	1.275
75-25	20	2	0.454	19.789	1.275
70-30	10	1	0.474	18.143	1.693
70-30	20	2	0.483	18.346	2.543

VIII. RESULT AND DISCUSSION

Effect on wear-

After experimental work, graphical comparision of the graph of the four sample is shown in following graph,



When the composition 85%Mullite +15% Silicon Carbide is taken the wear rate increases with time but wear is low , load is taken 20 N and sliding velocity 2m/s the 1st optimum value of wear obtained hear. (Sample A1)

When the composition 80%Mullite +20% Silicon Carbide is taken the wear rate increases with time but wear is low, load is taken 10 N and sliding velocity 1m/s the 2nd optimum value of wear obtained hear.(Sample B1).

When the composition 70%Mullite +30% Silicon Carbide is taken the wear rate increases with time but wear is low , load is taken 10 N and sliding velocity 2m/s the 3rd optimum value of wear obtained hear. (Sample D2)

IX. CONCLUSION

From the above result it can be seen that as the wt% of Silicon Carbide in the Mullite increases from 0 wt% to 15 wt%. The wear rate is reduced as well as Coefficient of Friction is also reduced.

The best outcome, which was achieved for the load of 20 N and the sliding velocity of 2 m/s, was The composition of 85 percent Mullite and 15 percent Silicon Carbide has a wear rate of 6 and a COF of 0.402. Hence 15 wt. % Silicon Carbide gives better result as compared to other composite.

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