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FRICTION AND WEAR STUDIES ON SPRAY FORMED CERAMIC-CERAMIC COMPOSITES

Traditionally ceramics / tough ceramics find applications as monolithic parts/sprayed coatings. Producing such parts by powder metallurgy route calls for furnaces, presses and hipping facilities. Whereas producing such ceramic bodies by sprayforming technique has the advantage of both rapid solidification and near net shape forming. In the present study the friction and wear characteristics of such sprayformed ceramic composites have been studied and the influence of heat treatment on the tribology of such spray formed specimens have also been studied.

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1. **INTRODUCTION**

Materials and Material Processing is of major industrial and technological concern. Plasma aided manufacturing is a new concept emerging at a very rapid pace, and is likely that many more manufacturing operations in the 21 st century will utilise some form of plasma energy.
Ceramic composites are materials that are being developed for many engineering applications, for their excellent strength, high temperature resistance and wear resistance properties. The fabrication of engineering components made of ceramics poses a lot of problems because of inherent brittleness of the ceramics. The P/M route partially solves this problem for relatively smaller parts with simple geometries1. The problem is still unsolved for larger thin walled parts where plasma spray forming technique provides an alternative solution. In the present study free standing shapes of alumina-titania (Alumina 60 wt% and Titania 40 wt%) composition have been fabricated by plasma spraying, to a thickness of 1 mm. Titania Reinforcement in Alumina will enhance the toughness of the system2. Some of these samoles have been heat treated at

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1200°C for 2hr. Tribological studies have been carried out on these plasma formed/heat treated ceramics.

2. **EXPERIt\,IENTAL**

The specimens were in the form of small squares of cross- section 7 mm x 7 mm and varying thicknesses and these specimens were stuck to aluminium stubs of 10 mm dia and 30 mm length using araldite. These pins were then loaded in the regular test rig and the sliding wear test conducted using a standard pin-on-disc machine {Ducom -TR. 20E shown in Fig. 1). The sliding speed was 2 mlsec and the normal force was 10 N. This range is significant for applications such as seals, pump shafts, and valve seats. The disc mdterial used was EN 31 steel, hardened to 55 HRC and ground to an Ra value of 0.45 ~m.
To study the wear behaviour of the specimens, the weight loss was measured with an electronic: balance {Sartorius) with an accuracy of 0.1 mg, at the end of each test. The frictional force F was measured with a load cell, contacting the cantilever arm, in the machine, from which the coefficient of friction was calculated using the equation F==~N. The parameters recorded were frictional force, weight loss and the surface roughness of the pin. For each specimen anew track was used. Each experiment was preceded by running in the pin for 5 min under dry conditions against fresh 600

grit emery paper fixed to a rotating polishing machine.

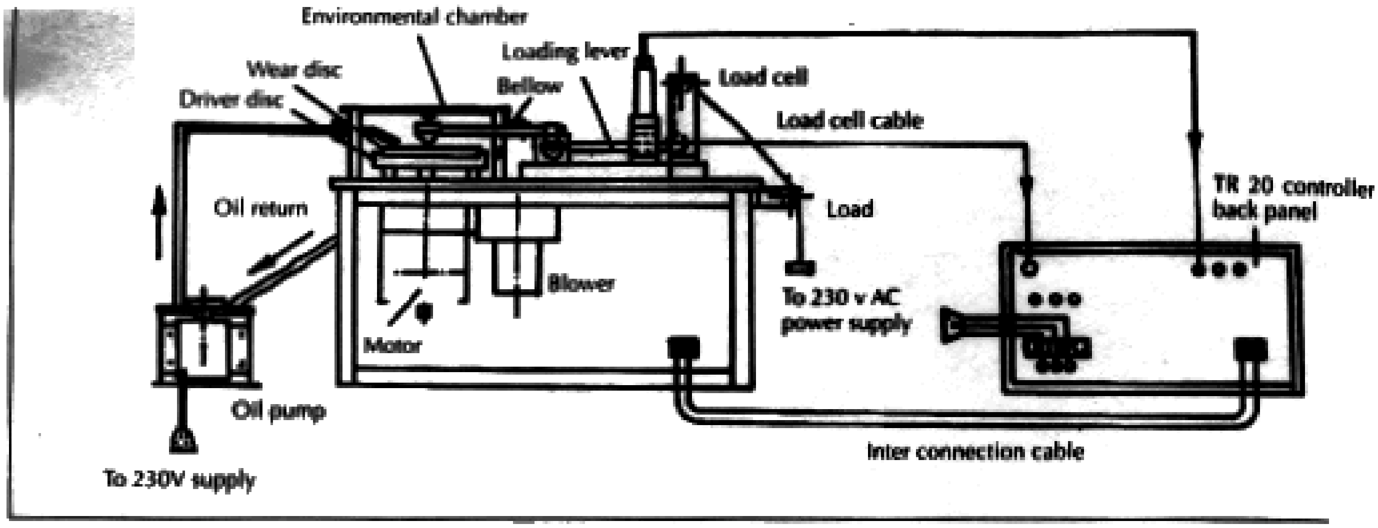

FIGURE 1

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FIGURE 2 **-Effect of sliding distance on wear (1 mm thickness}.**

This procedure ensured uniformly good contact between the pin and disc. The weight loss, and surface roughness of the pin were measured after every 5 km up to 20 km of distance and then for every 10 km, till the end of the experiment (50 km) every time measurement was taken after cleaning the pin in acetone and drying. The experiments were repeated three times for each condition.

3. RESULTS AND DISCUSSIONS

Any design of a tribological system which inhibits fracture, must lead to improved wear behaviour[3]. The friction and wear characteristics of ceramics are anisotropic unlike in the case of metals. In general the lowest coefficient of friction is observed when sliding on the preferred slip plane in the preferred slip direction on that plane. Adhesive wear depends on the orientation of the slip plane to the direction of sliding. When ceramics are in contact with metals surface chemistry is extremely

important in determining friction and wear behaviour. For oxide ceramics the free energy of oxide formation for the lowest metal oxide is directly correlated with metal shear properties which relates to friction.

3.1. Cumulative wear

Wear rate was less in the case of higher thickness specimens because of their high* rigidity compared to thinner specimens. Negative wear is observed in the case of a sprayed and samples with 1200°C post heat treatment as in Fig. 2. This could be because of the retransfer of the transferred ceramic from steel and the material transfer from steel to ceramic. This happened more in the case of higher thickness specimens.

3.2. Surface finish (Ra)

There is general improvement in surface finish with sliding wear as shown in Fig. 3. Up to around 20 km of sliding

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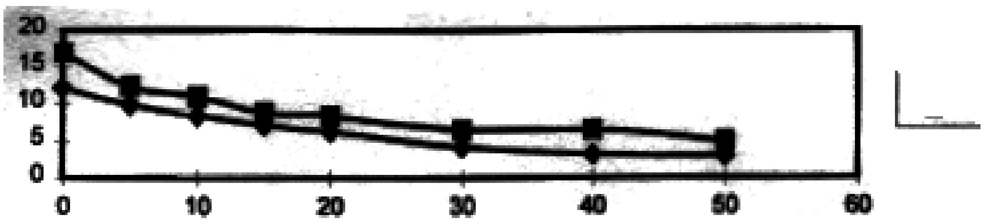

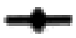

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FIGURE 3- **Effect of sliding distance on surface roughness Ra (1 mm thickness}.**

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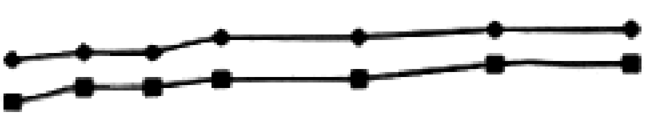

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FIGURE 4 - Effects of sliding distance on coefficient of friction (1 mm thickness)

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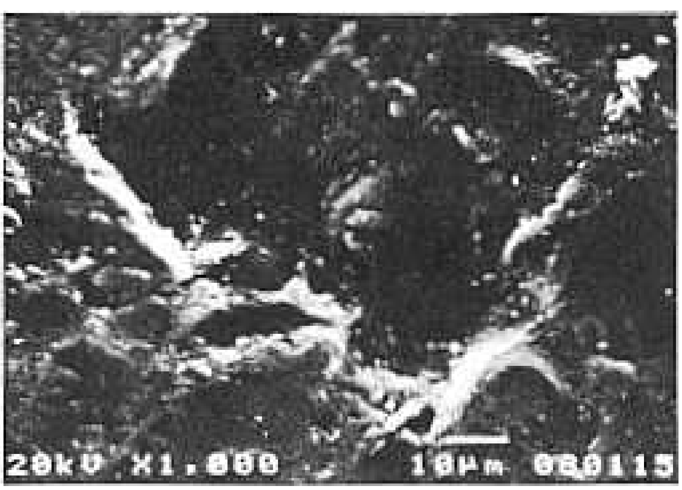

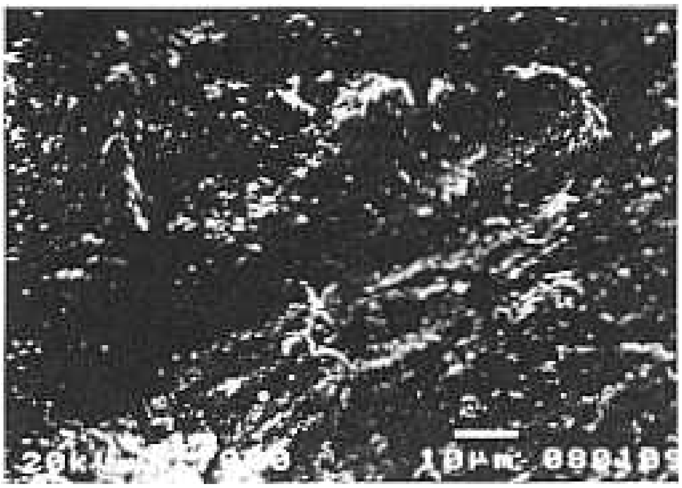

FIGURE 5/6. SEM morphology ofwear tested samples (5); as sprayed (6) 1200°C.

distance there is a continuous improvement in the surface finish, this may be possibly due to levelling of all active peaks/asperities. After the surface area im-provement there is not much improvement in surface finish.

3.3. **Coefficient of friction**

Generally both as sprayed and the post heat treated samples shown negative wear in the initial stage of sliding. This is felt more in the case of specimens heat

treated to 1200°C. A lower coefficient of friction implies a lower shear stress on the sliding surface which will produce less fracture4. This may be attributed to the improved density and hardness of the samples during heat treatment process showed in Fig. 4.

3.4. **SEM morphology** of the **tested samples**

SEM morphology of the wear tested samples are shown in Figs. 5 and 6. The SEM morphology of the

wear tested samples of the as sprayed condition shows localized pullout of the material due to cumulative stressing resulting in spalling with post heat treated sample (1200°C) relatively smoother worn out texture was observed with a few localized spall regions.

4. **CONCLUSION**

Thicker specimens show lesser wear rate, because of higher rigidity and hardness. Specimen post heat

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treated to 1200°C shows the least wear rate.

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