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Research Paper

FRICTION, METALLIC TRANSFER AND WEAR DEBRIS OF SLIDING SURFACE

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In this work the variation in coefficient of friction with sliding distance is presented. It includes different sliding arrangements for both similar and dissimilar metals using pin on disk experiment. When similar metals slide on each other there is a significant change in friction, due to which ploughing occurs. In case of dissimilar metals, coefficient of metals is determined primarily by the way metal transfer occurs between sliding surface.

Keywords: Coefficient of frction, Metallic transfer, Wear debris

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INTRODUCTION

The coefficient of friction (μ) is time dependent in case of two dry metallic surface sliding against each other. This statement holds true experimentally in case of similar and dissimilar sliding metal surfaces. The classical theory of adhesion has failed to explain the dependence of coefficient of friction (μ) on time as the shearing of welded junctions is dependent on the true area of contact which is a function of normal and tangential loads. Hence for a given set of conditions we assume that μ is constant. However the metal transfer and formation of debris in sliding process affects the frictional behavior of sliding metals. Antler (1962) have recently presented a new theory to explain the time dependence of μ according to which there are three frictioncomponents, i.e., surface adhesion, deformation of asperities and ploughingby wear debris or hard asperities, which contribute to μ. Because of thechanging contribution of these three components μ varies accordingly withsliding distance. They have also attempted to generalize the friction behaviors for both similar and dissimilar metals sliding against one another. Mahdavian *et al.* (1982) and Bowden and Tabor (2001) carried out their friction tests on a wide range of free-machining metalsincluding steel, aluminium and brass. The metal transfer and back transfer play a significant role in determining the fiction of sliding metals. Mahdavian *et al.* (1982) are able to show that metallic transfer due to

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adhesion at the early stage ofsliding controls the coefficient of friction. In case of soft metal sliding on a hard metal the coefficient of friction is dominated by adhesion. The wear debris generated in the process is formed from the softer metal. The other case includes dual transfer of metals in which the wear debris generated is of both the metals. The coefficient of friction is greatly influenced by the action of hard asperities that are embedded in the soft metals. Here we intend to study the variation of coefficient of friction with sliding distance.

EXPERIMENTAL PROCEDURE

All friction tests were being conducted on pin-on-disk machine. Four pins were secured to an upper metal disk with equal angles between them on the periphery of a circle with radius of 35 mm. The pins were loaded by a dead weight of 35 N per pin against the rotating disk. The pins and rotating disk are maintained in a continuous contact throughout the wear process. The rotation of the upper disks holding the pin was constrained by a spring attached to the frame. The deflection of the spring could be measured continuously. Through this process coefficient of friction was evaluated as a function of sliding distance. The rotating disk was coupled through reduction gears to a d.c. motor fitted with a variable-speed controller. The angular speed is maintained at 2.5 rad/s.

Machining metals consists of grade mild steel (85 HRB), Aluminum alloy (62 HRB) and brass alloy (75 HRB) were used in a friction experiments. The pins of diameter 7 mm and length 12 mm were used in the friction tests. All the surfaces of pin and disks were polished by using different polish papers. An extreme care was taken so that there is a continuous contact between pin and the disks.

The geometric arrangements of similar and dissimilar metals were tested. The variation of friction with sliding distance was recorded and the wear debris was collected at the completion of test for microstructural analysis with the help of Scanning Electron Microscope (SEM).Similar observations were also conducted on the wear trackof the disk and the worn surface of the pin.

RESULTS AND DISCUSSION

Transfer of metal between two dissimilar metals was studied by using Scanning Electron Microscope (SEM) operating in the scattered electron emission mode. Dual metallic transfer takes place when the aluminium pin slides on the steel disk. This was evident from the fact that steel debris was embedded in the aluminum pin surface and the aluminum which was transferred to the steel disk appeared as dark patches on the Scanning electron microscope. The debrisproduced from sliding the aluminium pin on the steel disk was mainly aluminium with a small amount of steel which was in turn confirmed by the scanning electron analysis of debris. It also gave additional evidence that wear had been occurring in the steel disk and the wear debris was in turn transferred to the softer metal. On the other hand, when the aluminum disk was slid against a steel pin, metal transfer takes place from the softer metal to the harder pin. However the transfer of steel to the aluminum disk was insignificant and could only be detected by using electron microscopy. Microstructural analysis confirmed that particles were largely aluminum with a very small amount of steel.

Figure 1: SEM Analysis Showing Transfer of Aluminum to the Steel Disk After Sliding

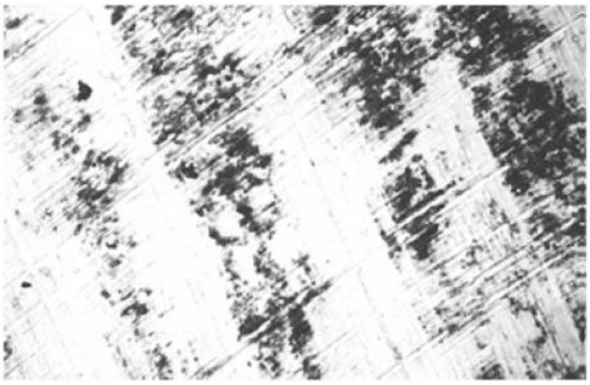
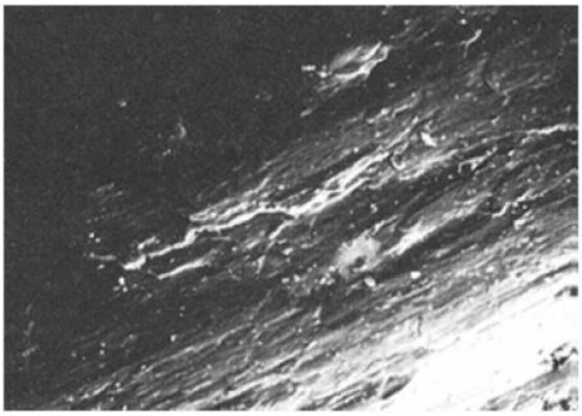


Figure 2: SEM Analysis Showing Transfer of Steel Particles to the Aluminium After Sliding

Figure 3: SEM Analysis of the Wear Debris



From the microstructural analysis we can say the following points:

- There was a transfer of material from the brass to the steel pin. The type of transfer was a dual metallic transfer.
- The debris generated from sliding was mainly brass with some traces of steel.
- On reversing the sliding arrangement transfer takes place from softer to harder metal.

Figure 4: SEM Analysis Showing the Transfer of Brass to the Steel pin

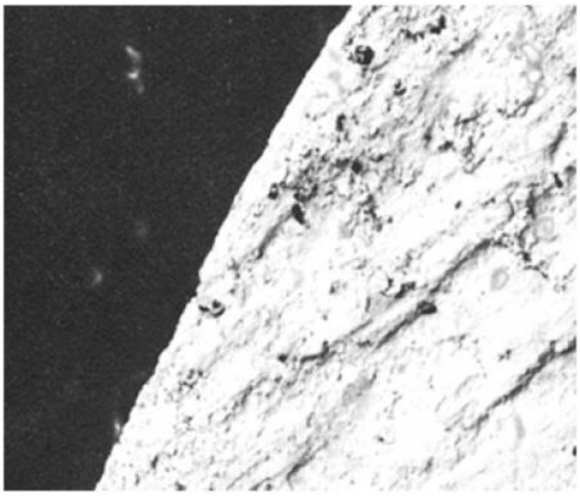
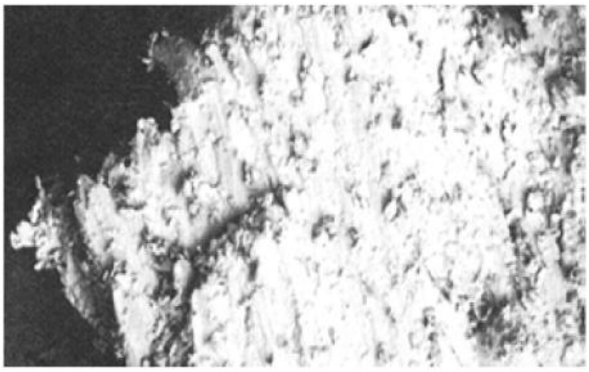


Figure 5: SEM Analysis Showing Transfer of Steel to the Brass Disk

Figure 6: SEM of Collected Debris



- There were no traces of steel on the worn surface of the brass pin and the debris.

CONCLUSION

The pin on disk friction results confirm that the coefficient of friction between sliding metals is dependent on time. One of the important reasons can be severe ploughing action obtained in the pin-on-disk geometry. The mechanism of metal transfer plays a significant role in determining coefficient of friction for similar and dissimilar metals sliding against each other. A detailed research work is needed to investigate the effects of embedding of asperities and wear debris as well as the effect of thickness of metal transfer film on the coefficient of friction.

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I would also like to dedicate this research work to my father late R S Mishra and mother K L Mishra.

REFERENCES

1. Antler M (1962), “Wear, Friction and Electrical Noise Phenomena in Severe Sliding Systems”, *ASLE Trans.*, Vol. 5, pp. 297-302.
2. Bowden F P and Tabor D (2001), “Friction and Lubrication of Solids”, Vols. 1, 2, Clarendon, Oxford.
3. Glardon R and Finnie I (1981), “A Review of the Recent Literature on the Unlubricated Sliding Wear of Dissimilar Metals”, *J. Eng. Mater. Technol.*, Vol. 103, pp. 333-340.
4. Halling J (1961), “A Crossed-Cylinder Wear Machine and its Use in the Study of Severe Wear of Brass on Mild Steel”, *Wear*, Vol. 4, pp. 22-31.
5. Mahdavian S M, Mai Y W and Cottrell B (1982), “Friction, Metallic Transfer and Debris Analysis of Sliding Surfaces”, *Wear*, Vol. 82, pp. 221-232.
6. Rice S L, Wayne S F and Nowotny H (1983), “Specimen Material Removal in Pin-on-Disc Tribotesting”, *Wear*, Vol. 88, pp. 85-92.
7. Suh N P and Sin H-C (1981), “The Genesis of Friction”, *Wear*, Vol. 69, pp. 91-114.