International Journal of Mechanical Engineering and Robotics Research

ISSN 2278 – 0149 www.ijmerr.com
Vol. 3, No. 3, July 2014

Research Paper

EFFECT OF HARDNESS ON SLIDING BEHAVIOR OF MATERIALS

Aadarsh Mishra[1]*

*Corresponding Author: Aadarsh Mishra, ✉ aadarshm9@gmail.com

Hardness is one of the key factors which influence the sliding behavior of materials. In the tribological pairs, the softer hardness among two materials is considered. Effects of hardness are much more complex in tribological condition. Hardness varies with position and time. It also depends on sliding speed, temperature and chemical environment and has a significant effect on sliding behavior. Mechanical mixing strongly influence the local hardness. Hardness can also effect transition phases in friction and wear and can help us to understand the geometric effects when the materials are interchanged in the tribological system.

Keywords: Hardness, Wear, Abrasion, Sliding, Mechanical mixing, Variable and local hardness

INTRODUCTION

The wear volume can be calculated by using the equation:

$$V = kSL/H$$

where V is the wear volume; L is the normal load; S is the sliding distance; H is the hardness of one of the interacting materials and k is the wear coefficient.

Wear coefficient can be defined as:

- Probability that an asperity contact generates a wear particle.
- Ratio of the volume worn to the volume deformed.
- Factor reflecting the inefficiencies associated with the process generating wear particles.

The Linear wear equation can be used to calculate wear volume.The coefficient k is assumed to be constant but can change by orders of magnitude. Hardness is the property that appears explicitly in the linear wear equation. Other materials properties are also included in the coefficient k.The main focus of this paper is the role of hardness in tribological systems.

EXPERIMENTAL STUDIES

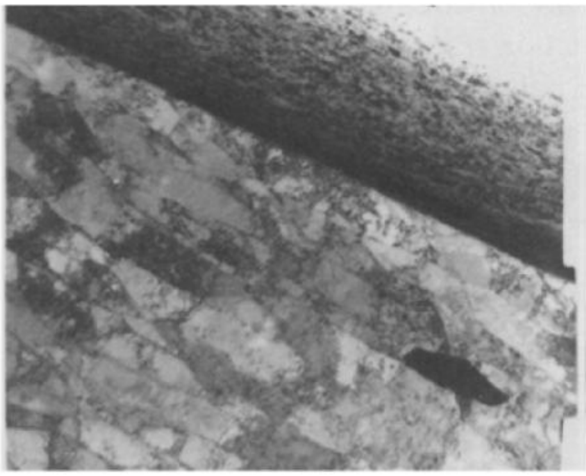
There are various forms of abrasive and sliding wear. These are both part of a continuous

[1] Department of Mechanical Engineering, Manipal Institute of Technology, Manipal University, Manipal, Karnataka 576104, India.

spectrum ranging from microcutting to smooth sliding. When the wear coefficient is large, abrasive wear is a relatively efficient way to remove the materials while sliding wear is a less efficient way of removing materials when the wear coefficient is smaller. Generally abrasion ranges between these two extremities. Microcutting occurs when hardness differences aresufficient and when local rake angles are appropriate. It can be recognized by the debris particles generated. Cutting involves penetration of the workpiece, and this depends on the hardness. The hardness in turndepends on composition and microstructure. The role of hardness in sliding situations are not very clear. Fixed abrasives become less effective in removing materialas the sharp points fracture, wear and becomecoated. A transition occurs from one side of spectrum to the other. In certain materials the transition is in a reverse order.Most common example is 304 stainless steel.

It is commonly observed that transfer of material from one surface to its counterface occurs during sliding in which the process of Adhesion is involved. When there is appreciable transfer, as in many tribo-systemsinvolving metals, it is common to call the wear processadhesive wear. Local contacts createlarge plastic strains and associated changes in the near surface microstructure. The resulting heterogeneities make the material susceptible to localized shear. The transfer can be in either direction, but it is generally larger for the material with smaller cohesive strength transferring to the material with larger cohesive strength. Deformation, adhesion and fracture accomplish mechanical mixing.

Figure 1: TEM Image of Longitudinal Section of a Worn Copper Block After Sliding



The mechanically mixed material on the sliding surface and the resulting weardebris normally have the same microstructure and hardness. Sliding wear debris are not generated directly from the base material.

In case of stainless steel, the mechanically mixed material is very hard. The corresponding material having very fine grain size is effectively softer than the adjacent work-hardened base material. The Mechanically Mixed Layer (MML) can vary considerably from one system to another. It may consist of two or

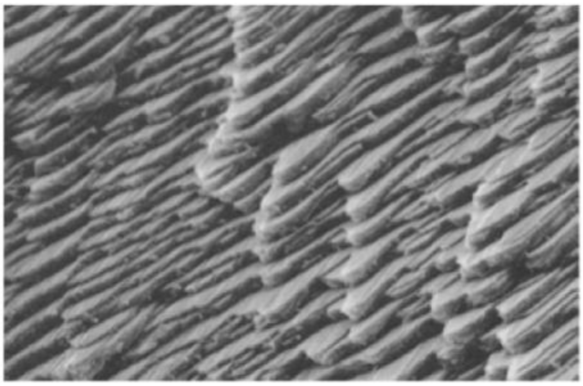
Figure 2: SEM Image of Debris Particles

more than two phases. These phases may consist of wearing materials, from coatings or from components of lubricants present.

Composition, crystal orientation and microstructure are responsible for local variations in materials. Some of these properties are present in materials even before sliding begins. In sliding tests with aluminum it has been possibleto correlate deformation substructure dimensions withthe thickness of lamellar features.

At higher loads, deformation substructure can develop further below the sliding surface.

Figure 3: SEM Image of a Part of Extruded Material

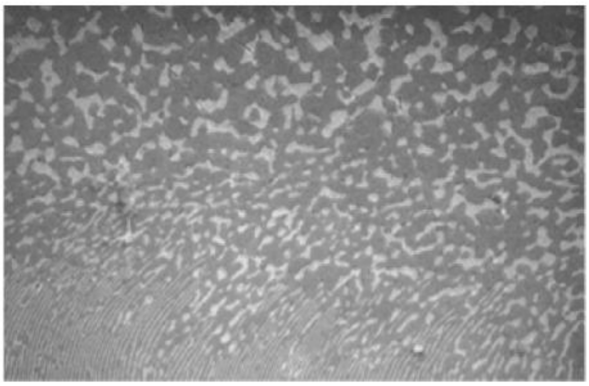


The source of shear instability would then be absent, so transfer of fragments would occur less readily, deformation to a depth of one substructure unit is needed beforesliding wear becomes appreciable.

RESULTS AND DISCUSSION

The sliding behavior may change significantly if the materials in a sliding system are interchanged. This is particularly likely if one component is in steady contact while the other has intermittent contact in pin on disk experiment. The operating mode depends on hardness and geometrical factors, in particular the degree of penetration. The importance of the relative hardnessof the pin and the disk was thus emphasized. The ratio H_d to H_p is used for subsequent sliding tests. When the initial value of H_d/H_p is less then one severe wear occurs and friction is high. On the other hand, when the value of H_d to H_p is greater than one then there are two cases. In one of the case friction is low and sliding is smooth. In the other case transition of materials may occur. Generally if the value of H_d/H_p is less than one rough sliding and severe wear occurs. For many metals and alloys, sliding at or near room temperature produces a hardened surface layer by work hardening and other processes. However, there are other materials, particularly thoseinvolving at least one phase with low melting temperature, in which sliding produces a negative hardnessgradient.

Figure 4: Secondary-Electron Image of Longitudinal Section of Pb Disk After Sliding in Vaccum



Despite the attention already given to the tribological characteristics of steels, there is still much to be learned. Many results show that variations in local hardness values, arising from various sources strongly affecting sliding behaviour.

CONCLUSION

It is well recognized that a basic problem of using solid lubricant films is replenishment. Ideally, the materialitself will continue to supply the appropriateamount of easily sheared material to assure smoothsliding with low friction and wear. The results provide some usefulguidelines for selecting promising compositions and microstructures. The relative hardness or flow strengthof the two phases is crucial. The advancing asperity deforms the matrix phase plastically and this causesthe softer phase to be extruded sufficiently so it canbe spread over the surface by the asperity. If the matrixis too soft, then both phases deform appreciably, and the desired condition of a soft film on a hard base isnot established. If the matrix is too hard, then there is insufficient deformation of the matrix, for a given load and microstructure, to extrude the proper amountof soft phase. Thus, an optimum ratio of hardness orstrength is expected.

ACKNOWLEDGMENT

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

REFERENCES

1. Buckley D H (1971), *Friction, Wear and Lubrication in Vacuum*, NASA Spec. Pub/. 277, Washington DC.
2. Chiou Y C and Kato K (1988), "Japan Sot. Lubr. Eng.", *Int. Edn.*, Vol. 9, pp. 11-16.
3. Khruschov M M and Kragelskii I V (1965), *Friction and Wear*, Translated by L Ronson and J K Lancaster, Butterworths, London.
4. Kuo S M and Rigney D A (1992), *Mater. Sci. Eng. A*, Vol. 157, pp. 131-143.
5. Rigney D A, Chen L H, Naylor M G S and Rosenfield A R (1984), *Wear*, Vol. 100, pp. 195-219.
6. Sliney H E (1992), *Solid Lubricants*, in P J Blau (Ed.), ASM Handbook, Vol. 18, pp. 113-122, ASM Int., Materials Park, OH.
7. Yang Z Y, Naylor M G S and Rigney D A (1985), *Wear*, Vol. 105, pp. 73-86.