International Journal of Mechanical Engineering and Robotics Research

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

Research Paper

ANALYSIS OF RELATION BETWEEN FRICTION AND WEAR

Aadarsh Mishra[1]*

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

To control wear and friction several methods like soft/hard film coating, multi-phase alloying and composite structuring have been developed. We can say that coefficient of friction and wear are not the material properties but they are the responses of tribo-sysytem. They have a relation with each other. Wear is defined as a set of adhesion, transfer, abrasion, fatigue and oxidation. Due to these processes transfer of matter takes place from one state to another. The final transformation in wear is a collection of free debris particles.

Keywords: Wear, Friction, Roughness, Hardness, Ductility, Oxide film, Transfer

INTRODUCTION

Friction and wear can be defined as the responses of a tribo-system.Coefficient of friction and wear define the state of contact of bodies not the material properties of the bodies. Although in some special cases of contact, they can be treated as the material properties of the bodies. Both friction and wear can be treated as two kinds of responses from one tribo-system and are related with each other in each and every state of contact. Now days in addition to traditional method of lubrication methods like soft/hard film coating, multi-phase alloying and composite structuring have been developed to control the friction and wear. To study the tribo-characteristics of materials we should first understand the wear mechanisms in which roughness, hardness, ductility, oxide film, reaction layer and adhesive transfer play a significant role. The purpose of this research paper is to understand the wear mechanisms by studying the characteristics of wear and friction by using different materials.

EXPERIMENTAL STUDIES

Due to partly transferring of the thin soft layer to counter surface by adhesion in tribo-elements, relative displacement takes place at the interface which is between surface of coating and transfer layer. This layer is of smaller shear strength of the softer material than that of the underlying elemental material.

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

Due to this low friction can be obtained and moreover the wear of tribo-system can also be reduced. The examples can include Gold, Silver and lead. If we take any metal on which coating has been done the roughness of substrate has a significant effect on the wear of that particular coating. With increase in the critical number of rolling cycles the friction will also increase. By reducing the surface roughness of substrate, the wear of thin soft coating can be reduced. This can be done by changing the coefficient of friction. The most common example may include lead film on which the analysis was done.

When the coating on the surface of tribo-element is harder than that of the element then there is a reduction in wear of the element till it exists on the surface as the wear in case of harder materials is less than that of the softer materials when the coefficients of friction is same. Delamination of coating takes place when the wear rate of coating is smaller in the steady state because of high hardness. Other reasons may include inappropriate contact pressure and shearstress at the early stage of contact cycles. It can also be introduced by using a critical coating thickness after a certain amount of wear.

For maximum tensile strength at the edge of sliding contact high coefficient of friction has a significant effect. Possibility of crack propagation may increase from the surface defects of coating. Decisive functions for the delamination of coating may include High tensile stress and local yield on thesurface of coating. Hard coating like diamond or DLC against softer material like ceramic during sliding friction tends to be high since asperities on the coating surface work as abrasive. In this case the coefficient of friction may vary from 0.5 to 0.04 which depends on their roughness. To avoid any delamination the surface coating of a material should be minimized.

When a tribomaterial which is made of softer material like plastics is rubbed and is worn then by forming a transfer layer of the soft material on the counter surface of harder material, its wear can be reduced. Wear rate of soft material in sliding against itself is very small in this case.

RESULTS AND DISCUSSION

When a triboelement is made of ductile material like Aluminum, copper, nickel, iron or an alloy with a combination of them then the material in the contact region deforms plastically under the combined stress of compression and shear. Larger wear rate is caused due to large plastic deformation because the wear surface tendsto become rough and protective surface layers are easilydestroyed.The introduction of a harder reinforcing phasein the ductile matrix by a certain volume fraction canreduce ductility of the matrix material in the contact regionwithout having brittleness, and wear of matrix can bereduced.

In case of a triboelement being made of a brittle material the material in the contact region tends to have brittle fracture of microscopic scale underconcentrated large contact pressure at each contact asperity. It also results in large wear rate and rough wear surface. Due to soft reinforcing phase in the brittle matrix a certain volume fraction can give a certain amount of ductility to the brittle matrix material inthe contact region, and wear of matrix can be reduced.

For instance if we take SiC particles on a wear of Ni matrix then it can be classified under a hard reinforcing phase in a ductile matrix. We can say that volume fraction of about 10% of soft phase reduces the matrix wear by more than a half.

Many metallic alloys that have been well used for triboelements. They are alloys based on iron, copper, aluminum, tin, lead or other metals. These types of alloys have more than two phases out of which one is harder and the other can be softer. In case a triboelement is made of one of these alloys and its surface is rubbed in air by other solid surface, the rubbed surface shows the following responsesof multi-phases as the result of repeated stress cycle andfrictional heat cycle:

- Oxide film growth takes place on the surface and fracture.
- Plastic deformation in the surface layer.
- Restructuring of the microstructure.
- Adhesive transfer of materials to the counter surface.
- Retransfer between the two mating surface.
- Generation of wear debris and wear particles.
- Detachment and bending of wear particles.
- Smoothing of wear surface.
- Surface morphology between two mating surfaces after roughening.

These responses may take place at the same time in different phases at the contact interface with different stages. They may depend upon physical and chemical properties of each phase and of each oxide film. Extremehardening in the wear track and the transfer layer can benoticed. It is due to the effect of oxygen that forms oxide films onthe Al-alloys and the steel of counter surface.

Because of hardness and brittleness of ceramics it is recommended that they should be used in the mild wear state to avoid large scale fracture. Humid air or water is active enough to form silicon oxide under rolling contact. Alumina forms aluminum hydroxide by sliding in water. These oxides or hydro oxides in humid air are soluble and the resultant wear surfaces become very smooth and availablefor hydro-dynamic lubrication with air as well as water.

If the wear state is mild and tribo-chemical wear mode is used then the generated chemical products of the wear debris are soft as well as soluble in water. Hence, a reaction layer on a hard ceramic surface works as a verysoft coating and its wear mechanism must be similar tothat of an artificial soft coating.

CONCLUSION

In the near future for the technical development of wear control the characteristics of wear coatings, material composites, metallic alloys and ceramics have been reviewed in relation to their frictional characteristics.the introduced observationson wear and friction of representative materials arewell explained in terms of roughness effect, hardnesseffect, ductility effect, oxide film effect, reaction layereffect and transfer effect. New technologies for bettercontrol of wear will become possible by combining theseeffects better.

ACKNOWLEDGMENT

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

REFERENCES

1. Blau P J (1997), “Four Great Challenges Conforming Our Understanding and Modeling of Sliding Friction”, in D Dowson (Ed.).
2. Kato K (2002), *Wear Mechanisms,* pp. 39-56, New Dir., Tribol.
3. Kim H, Kato K *et al.* (1993), “Lubrication Properties of Tribo-Coating in Ultra High Vacuum”, pp. 405-410.
4. Roberts E W and Price N B (1988), “In Vacuum Tribological Properties of High Rate Sputtered MoS2 Applied to Metal and Ceramic Substrate”, pp. 251-264.
5. Sherbiney W A and Halling J (1977), “Friction and Wear of Ion-Plated Softmetallic Films”, pp. 211-220.
6. Spalvins T (1992), “Lubrication with Sputtered MoS2 Films”, pp. 267-274.
7. Zum Gahr K-H (1987), *Microstructure and Wear of Materials*, pp. 174-176, Elsevier, Tribol.