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The Effect of Hardness Ratio on Friction: Role of Surface Texture

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1. Introduction

Surface texture is one of the most important factors that control friction during sliding. Attempts have been made to study the role of surface texture on friction[1, 2]. Efforts have also been made to study the influence of hardness of materials on friction[3]. However, the effect of hardness as a function of surface texture on friction has not been well studied. Thus, in the present investigation, the effect of hardness of soft materials as a function of surface texture of hard material on friction during sliding is ascertained.

2. Experimental

In the present investigation, various kinds of textures (*undirectional*, *8-ground*, and r*andom)* were attained on a set of steel plate surfaces. The roughness of the textures was varied using different grits of emery papers or polishing powders. The surface textures of steel plates were characterized in terms of roughness parameters using an optical profilometer. Soft pins made of various materials (Al, Mg, Pb, Cu, Sn, Zn, Al-4Mg alloy, Al-8Mg alloy, Mg-8Al alloy) were then slid against hard steel plates of various surface textures and roughness using a pin-on-plate sliding apparatus. Tests were conducted under both dry and lubricated conditions at a velocity of 2 mm/s in ambient environment. The pins were slid both in perpendicular and parallel direction to the unidirectional grinding marks on the plate. Thus, four sets of topographic conditions were used for a given material. Normal loads increased up to 120 N during the test. SEM was used to study the pin damage and morphology of the transfer layer formation on the plates.

3. Results

It was observed that the coefficient of friction did not vary significantly as a function of normal load up to 120 N during the test. Figure 1 shows the variation of average coefficient of friction with hardness ratio for various surface textures under lubricated conditions. In the figure, UPD and UPL respectively represent sliding direction perpendicular and parallel to the unidirectional grinding marks. Each symbol on Fig. 1 refers to the average coefficient of friction of five roughness of the same texture. It was observed that the range of surface roughness, R_a, varied between 0.02 and 0.8 μm for different textured surfaces. For a given texture, the average coefficient of friction did not substantially vary over this range of roughness. Under both dry and lubricated conditions, the friction was highest for the UPD case, followed by the 8-ground, UPL case, and was the least for the randomly polished surfaces. It was seen that the coefficient of friction values are much higher under dry conditions when compared to the lubricated conditions. For a given material pair, it was observed that the transfer layer formation on the steel plate depends on coefficient of friction. It was also found that among the surface roughness parameters, the mean slope of the profile, Δ_a, correlated best with the friction. It was noticed under both dry and lubricated conditions that the variation of coefficient of friction with hardness ratio depends on surface texture. Under lubricated condition as shown in Fig. 1, the coefficient of friction decreases with increasing hardness ratio for the UPD surfaces. The correlation between friction and hardness ratio is found to be less for 8-ground and UPL surfaces. However, the coefficient of friction does not vary with hardness ratio for the random surfaces. These variations could be attributed to the extent of plane strain conditions taking place at the asperity level during sliding. Thus, it can be deduced that the coefficient of friction is not necessarily lower for harder materials and hardness alone cannot be used as a criterion for predicting coefficient of friction.

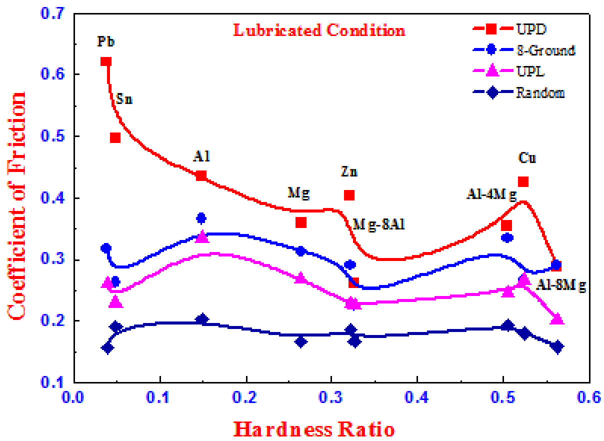

Fig. 1: Variation of friction with hardness ratio for different textured surfaces.

4. Conclusions

It was observed that the variation of friction as a function of hardness ratio depends on surface texture of the harder mating surface.

5. References

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