ME – PhD Thesis Defence

Influence of surface topography on wear and debris morphology of polymers

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ABSTRACT

The artificial knee and hip joints comprise a polymer-metal tribological system where soft polymers slide against hard metallic surfaces. When a polymer slides on it, the micro hard asperities remove the polymers in the form of debris. Numerous investigations discovered that the shapes and sizes of polymer debris have a major impact on the functionality and life of the artificial knee and hip joints.

The counter surface topography is one of the various parameters influencing debris morphology. Hence, researchers created various surface topographies on metallic surfaces and studied their influence on debris morphology. However, debris generation is a complex process. It depends on various interrelated processes such as deformation mechanisms, adhesion, transfer film formation and debris entrapment.

Friction is the source of stress, causing deformation and wear. Friction has two components: the ploughing component and the adhesion component. One or both components participate in the wear and debris generation. The researchers previously found a relationship between surface topography and the two components of friction. However, previous research is lacking or ambiguous in describing how the wear rate and debris morphology are linked with the counter surface topography.

Hence, this thesis tries to correlate surface topography and wear and debris morphology. The two friction components are used to explain the obtained correlation. The explanation may contribute to understanding the basic wear and debris generation mechanisms.

For the present study, various kinds of surface topography with varying roughness were created on SS316L steel plates. Wear experiments of various polymers with different physical and mechanical properties were performed against the prepared surface topographies. The wear rate was calculated from the LVDT data. The adhesion and ploughing components of friction were calculated from the friction data of the wear experiments under dry and lubricated conditions. The size and aspect ratio of the generated debris were measured using digital image analysis software. The underlying wear and debris generation mechanisms were analysed by examining the worn pin surface and the sliding tracks using a Scanning Electron Microscope. The major underlying mechanisms were ploughing, adhesion, plastic deformation, debris trapping, and debris rolling.

The experimental results show that the roughness does not affect the wear rate, debris size, or aspect ratio. However, surface topography significantly affects the wear rate, debris size, and debris aspect ratio. The results are explained by analysing the variation of adhesion and ploughing components with the surface topographies. The ploughing component finds to be varied with surface topography. However, the adhesion component finds to remain independent of the kinds of surface topography. The results conclude that the ploughing component of friction primarily dictates the wear rate with a proportional relationship. However, the adhesion component of friction primarily dictates the transfer film formation, debris entrapment and its rolling. This provides a reducing effect on effective wear.

The debris morphology results show that, in the absence of the adhesion, debris size has a proportional relationship with the ploughing component. The size of the debris has an inverse relationship with the ploughing component of friction when adhesion is present. The ploughing and adhesion together generate smaller debris than ploughing alone. The results also conclude that the aspect ratio of debris has a proportional relationship with the ploughing component of friction. However, the adhesion and ploughing together produce debris with a larger aspect ratio than ploughing alone produces.

ABOUT THE SPEAKER

Rajeev Kumar Gupta is a PhD student in the Department of Mechanical Engineering, IISc Bangalore. He is working with Prof. Satish V. Kailas in Surface Interaction and Manufacturing (SIAM) Lab. He has completed his B. Tech. from NIFFT Ranchi in Manufacturing Engineering and M. Tech. from NIT Rourkela in Mechanical Engineering. His research interest is polymer tribology.