A METHOD FOR PREDICTING THE EVOLUTION OF SURFACE TOPOGRAPHY DURING WEAR

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SUMMARY

Investigators at the University of Central Lancashire are interested in the evolution of the surface topography of metals during adhesive and abrasive wear processes. In the early 1990's, work was undertaken by the group to develop techniques to measure topographic wear volumes (1,2,3). However, recent effort has focused on developing a method to predict changes in the surface topography of components during wear (4,5).

The method is based on the measurement of the 3D topography of unworn components and the evaluation of the corresponding 3D "Bearing Area Curve". This curve is a graph of the area of material, S_{tp}, that would be intersected by a plane positioned at an arbitrary level in the surface topography parallel to its mean plane. The integral of the Bearing Area vs. height curve represents the volume of material contained in asperities above the intersecting plane. i.e., it is a graph of the cumulative volume of material in surface asperities. This property makes the curve a potentially useful tool in the prediction of worn surface topography.

The authors have undertaken a short series of pin on disc wear experiments in which brass pins with shot blasted tips have been worn against ground steel discs in nominally un-lubricated conditions. The surface topography of the tips of the brass pins was recorded before the test and at stages during the test allowing a range of surface parameters to be evaluated at each stage of wear. Additionally, the mass of the material lost from the pins was assessed by accurate weighing at the same stage. (Weight data and a knowledge of the pin density were used to calculate the volume of material lost from the pin as the experiment progressed.)

Areal surface parameters were also evaluated from computer simulated "worn topography". This topography was generated under the assumption that the wear volume measured in the experiment had been removed from the unworn topography of the test pins by pure truncation. The truncation depth, d_t, being established using data extracted from the Bearing Area curve of the unworn topography.

Comparison of surface data generated by experiment and simulation revealed an appreciable level of correlation. This encouraged the authors to believe that a predictive wear model, based on Archard's equation, could be developed and used to describe changes in the surface topography of a component as it is worn in a range of dry and boundary lubricated situations. The method for doing this would briefly be:

1) measure the 3-D topography of the unworn surface,
2) use Archard's wear equation to evaluate the volumetric wear rate,
3) calculate the volume of material lost in sliding a short distance,
4) use the Bearing Area curve evaluated from the unworn topography to evaluate the truncation height, d_t, which corresponds to the wear volume found by 3) above,
5) truncate the unworn topographic data by an amount d_t, to simulate the wear,
6) evaluate the surface parameters required,
7) repeat steps 3 to 6 to simulate wear by truncation to the level required.

The authors believe that, with appropriate development, the method could provide a good first order estimate of the condition of the worn topography of metal components sliding in dry or boundary lubricated conditions where abrasive / adhesive processes predominate. (E.g., to predict the evolution of the topography of cylinder liners near tdc/bdc, or the wear of cams and followers.) However, there are clearly, issues that need to be considered in developing the model. Notably, it has been shown by Hirst and Hollander (6) that the wear rates of metals depend strongly on whether the dominant asperity contact mode is elastic or plastic. Obtaining reliable simulations of topographic wear for a wide range of contact modes will, therefore, depend on incorporating the effect of the predominant contact regime on wear rate. (This could probably be pursued by evaluating the Plasticity Index for the simulated contact and modifying wear coefficients according to its value.) Additionally, where significant plastic deformation arises, changes in topography will not only arise from material removal (wear), they will also result from the plastic deformation of asperities. (See work by Chowdry et al (7) for illustration.) Consequently, some account of this effect also needs to be incorporated in a general model. Finally, if a boundary lubricant is present, it will be necessary to include a factor to account for its lubrication "effectiveness", as this will vary according to the choice of lubricant and the operating conditions, directly influencing the wear rate.

Details of the work outlined above including: some of the experimental and modelling methods used, preliminary results, further work and issues for discussion, will be presented at the meeting.

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