Abstract

High contact temperature rise and large temperature gradients can be responsible for large thermo-mechanical stresses, which in turn may cause thermo-cracking and extensive wear of the sliding surfaces. It is therefore not surprising that extensive work, both on the theoretical and experimental aspects of this important field of Tribology, have been carried out over the last few decades and this has contributed significantly to our understanding of flash temperatures at the sliding contacts between surfaces with roughness varying over a wide length scale. Nevertheless there remain some important issues which received very little attention till date. Surface roughness is an important parameter in flash temperature analysis and although some studies have tried to correlate the 2-D roughness parameters to these temperatures experimentally, no work on the influence of 3-D surface parameters has yet been attempted. In the present work a detailed experimental program was taken up precisely to correlate contact temperature rise to the 3-D surface roughness parameters. The results identified a set of parameters, an optimum choice of which may result in significantly low contact temperature rise.

A numerical model using a deterministic approach to evaluate the precise locations, areas of real contacts and 3-D contact pressure distributions between the rough sliding surfaces was developed. The corresponding contact temperature distributions were then obtained using a finite element technique. The results confirmed that the 'hot spots' were located exactly at the areas where the contact pressures were extremely high. The temperature contours at different depths were also plotted and it was observed that the temperatures fell away from the actual contact zone but relatively high temperatures persisted at the 'hot spot' zones much below the contact surface. It was encouraging to find a good correlation between the numerical and experimental results and this validated the numerical technique developed.

In view of the recent emphasis on the development of NEMS, MEMS, magnetic storage devices and other such applications it was felt that there is a need to develop an analytical model for predicting flash temperatures at the sliding contacts with nano-scale roughness. This work was done using both stochastic as well as fractal representation of the surfaces. One of the main conclusions from this analysis was that adhesion influences contact temperature rise significantly. Furthermore, it was observed that with the increase in fractal dimension D the contact temperature initially fell till a value of around 1.5 and then it rose. The contact temperature also fell steadily with Fourier number till a value around 20 and then the temperature reached a steady level with further rise in Fourier number. These results essentially indicate the possibility of maintaining a low contact temperature rise with suitable parametric combinations and this is certainly of practical interest.

Although in a real situation many of the operating parameters can be controlled, including the initial roughness of the rubbing surfaces, the in-situ change of the surface topography during the sliding process cannot be assessed apriori. Clearly, the instantaneous surface roughness dictates the interface temperature to a great extent and a multilayer feedforward artificial neural network was used to predict the instantaneous roughness and the corresponding contact temperature rise. A good performance with the neural model was achieved and the correlation coefficient between the model prediction and experimental values were 0.9762 and 0.9795 for surface roughness and contact temperature respectively.