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Surface Roughness Pairs in a Sliding Contact

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Surface roughness has a major effect on contact conditions, and it is widely recognised that increased roughness leads to higher contact stresses and reduced real area of contact. From contact mechanics analysis, it is common to consider a composite roughness of the two bodies. However, the interaction of topographic features in a sliding contact can be overlooked with this simplification. The sliding contact between surfaces of different roughness necessitates a consideration of the *dual* roughness system rather than the simpler representation as an average or composite roughness. Effects may be apparent for tribofilm formation, adhesion and wear.

Keywords: surface roughness, contact mechanics

1. Introduction

Surface roughness has a major effect on the behaviour of a contact and is a key contributor to tribological performance. The consequences of varying surface roughness are well-understood, even if the complexities of random surface roughness make it difficult to fully describe the impact in a generic, quantitative manner.

In contact mechanics, whether Hertz or discrete boundary element analyses, the representation of the contacting bodies as elastic half-spaces makes it possible to consider the roughness of both surfaces as a *composite* roughness that amalgamates the features of both surfaces. Thus, contact is equivalent to contact between a smooth surface and a suitably rougher surface. Nevertheless, differences between equivalent roughness pairs (i.e. surfaces with equal *composite* roughness) emerge when considering sliding/transient criteria. Moreover, interactions of dual rough surfaces may lead to outcomes more complex than anticipated from a naïve perspective.

2. Methods

Sliding contact was modelled between pairs of rough surfaces having different combinations of roughness. This specifically included pairs having equivalent composite roughness but with different roughness partitions between the sliding and static surface. The surfaces were randomly generated (both Gaussian and non-Gaussian height distributions) and the analysis used a common elastic half-space, discretised contact model, with the surface sliding represented by multiple analyses with one surface moved with respect to the other.

Different assessments of the contact transient behaviour were obtained from the simulation results, including the total area that experiences contact, the variation in surface separation, and the resolved lateral contact projected area (via "ploughing" depth). For example, these may show an influence on adhesive friction component, surface tribofilm formation, and the abrasive component of friction/wear, respectively.

3. Results and Discussion

Whilst an increase in composite surface roughness will almost universally result in a decrease in instantaneous real area of contact, this does not necessarily equate to a reduction in *contacting* surface. Figure 1 shows the total area of a sample rough surface that makes contact during a sliding contact traversal against 3 counterfaces of different roughness. Higher roughness results in *more* contact area, in contrast to the instantaneous state.

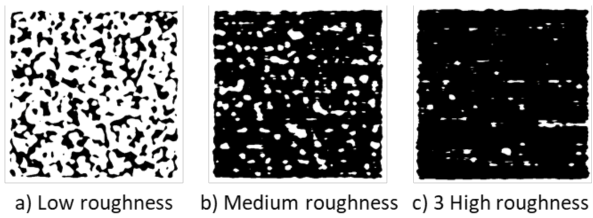

Figure 1: Contacting area (in black) of a rough surface sliding against different surfaces. Counterface roughness is a multiple of a) 0.3, b) 1 and c) 3 of sample roughness.

In Figure 2, we compare a) the plough depth and b) the range of interface gap of three different contact surface pairs, each pair having the same composite roughness, but different ratios of surface roughnesses. The differences may influence friction, wear and adhesion for otherwise comparable contacts.

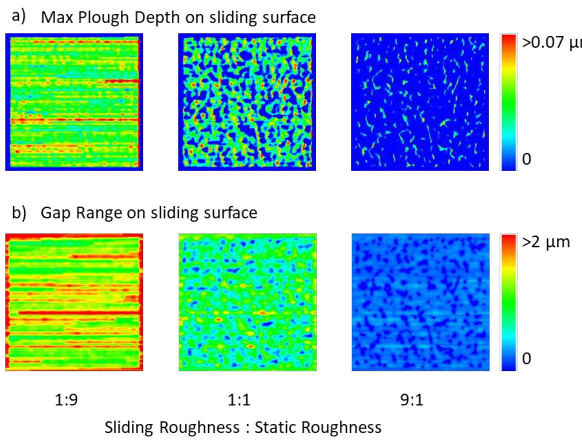

Figure 2: Contact evaluation for pairs with same composite roughness but different roughness ratios.

Beyond these simple comparisons, the effect of considering different height distributions (non-Gaussian) and different elastic properties between the two surfaces will be presented. The effects of all such parameters may refocus attention to more precise consideration of surface roughness *pairs* rather than roughness of a single surface.