3D-Local Yield Map of Hard Coating under Sliding Contact

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1. Introduction

In tribological applications, it is quite important to find and control the yielding initiation to prevent the delamination or spalling in the hard coating. Local yield map can be used for users to study and understand the yielding behavior of the hard coating intuitively and efficiently. In this paper, we employed a semi-analytical method (SAM) to analyze the three-dimensional (3D) contact problem in a tribo-system with layered elements, and develop 3D-local yield map of a hard coating under sliding contact, which is more exact and reliable than two-dimensional (2D) local yield map [1].

2. Three-dimensional elastic contact model

Figure 1 shows a model of contact between a rigid ball and a smooth flat with a coating. The coating has a uniform thickness t. Normal load W and tangential forces F_x (μW) are both applied on the rigid ball, where μ is the friction coefficient. The Young's modulus ratio of the coating to the substrate (E_f/E_b) was kept constant at two. In the figure, a denotes the actual radius of the contact zone. The normalized coating thickness (t/a_0) was changed from 0.125 to 4, a_0 is Hertzian contact radius. In this paper, we applied a SAM [2], which is based on conjugate gradient method (CGM) and discrete convolution and fast Fourier transform (DC-FFT) technique, to solve the contact problem in this point contact model and plot 3D-local yield maps.

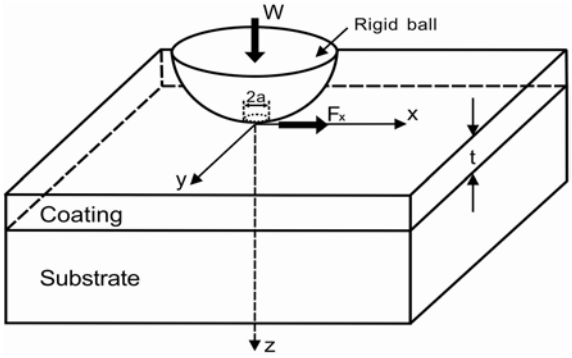

Fig.1 Contact model of ball on layered surface

3. Results and discussion

3D-local yield maps in relation to the yield strength ratio of the coating to the substrate (Y_f/Y_b) and t/a_0 are introduced in Figs.2-3. Full lines are tentatively drawn as boundaries between two different yield position regions and the position of the oval mark in the models of map represents where the yield first occurs. For low friction, as shown in Fig.2, if t/a_0 is smaller than 0.25 and μ is smaller than 0.25, the yield will occur at the surface as we move the value of Y_f/Y_b from 1 to 1.25. And this case will not appear for low friction in 2D-local yield maps. Figure 3 shows that for high friction, local yield at the interface disappears when t/a_0 is greater than about 2.5, which is quite different with those from 2D-local yield maps.

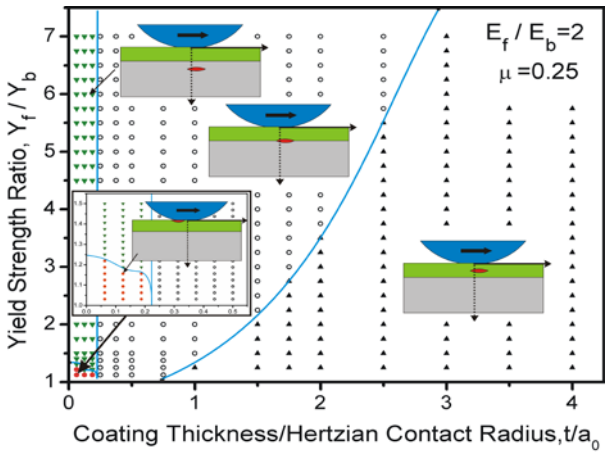

Fig.2 3D-local yield map for low friction

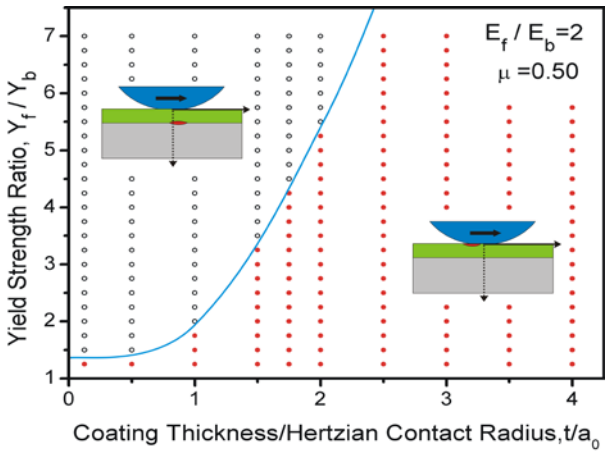

Fig.3 3D-local yield map for high friction

4. Summary

The yield of a three-dimensional substrate with a hard coating under sliding contact was solved. 3D-local yield map for the identification of the yield initiation of hard coating was developed and this map can be used in surface engineering design and tribological applications.

5. References

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6. Acknowledgement

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