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Deformation-wear transition map of DLC coating under cyclic impacts

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1. Introduction

The concept of a 'wear map' was first discussed by Tabor, D.[1)], and was inspired by the pioneering work of Frost, H.J.[2)] on 'deformation maps'. The development of deformation-wear transition maps is a useful way to study and predict the transition of deformation to wear of one material impacting against another at different operating parameters. Furthermore, the locations of the transition zones within the operating parameters are important, in order to design engineer less component failures occurring prematurely.

Generally, the construction of transition maps follows two different approaches: empirical and physical modeling. However, only the empirical approach is used in this study. In this century, there is still no development of deformation-wear transition map of the DLC coating under cyclic impact loading. Therefore, the aim of this study is to propose a new deformation-wear transition map of DLC coating based on variations of maximum normal impact loads and impact cycles for future design purposes.

2. Experimental method

In this present study, DLC films were deposited on the tungsten high speed steel (SKH2) substrate using Physical Vapor Deposition (PVD) method. The impact test was performed by using a horizontal impact tester for more than 10^2 impact cycles with a frequency of 10 Hz, and a drop-weight impact tester for low impact cycles. The DLC coated SKH2 disc was repeatedly impacted by a chromium molybdenum steel (SCM420) pin. The 90° inclination of impact tests were performed at room temperature under lubricated conditions. Prior to the impact test, both disc and pin were cleaned using acetone in an ultrasonic bath. The maximum normal impact load was obtained from the graph of normal impact load vs. time, generated by a load cell.

3. Results and discussion

For a given material and fixed variables (pin radius, coating thickness, substrate material, environmental conditions and etc.), the proposed deformation-wear transition map of DLC coating apparently shows that the maximum normal impact load and impact cycles influence this transition, as shown in Figure 1. Three main transition zones have been identified: (i) Plastic deformation of the substrate (ii) Suppression of plastic deformation of the substrate (iii) Wear of DLC coating. By increasing the maximum normal impact load, the suppression of plastic deformation of the substrate taking place, is faster due to the decreasing contact pressure with impact cycles to the yield point. Wear of the DLC coating becomes dominant when the critical limit of maximum normal impact load and impact cycles is exceeded. Some degradation of the DLC coating occurs within the wear zone.

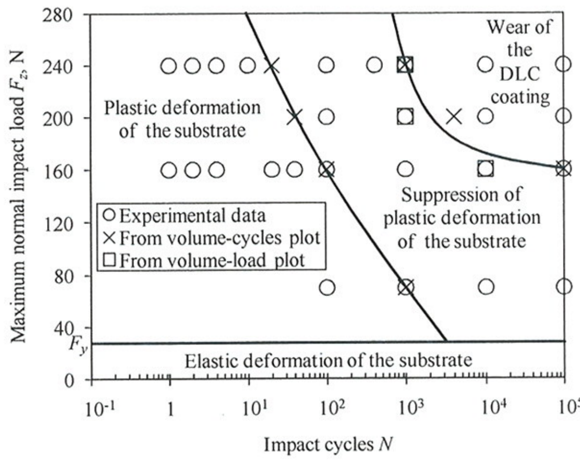

Figure 1 Deformation-wear transition map of DLC coating under cyclic impact loading

4. Conclusion

A new deformation-wear transition map has been proposed using an empirical approach in order to predict the deformation-wear transition of the DLC coating over a range of operating parameters. This transition map reveals the simultaneous dependence on maximum normal impact load and impact cycles. Three main transition zones have been identified. However, an extensive future research is required since this proposed transition map is not in a universal form and only valid for this present work.

5. References

[1] Tabor, D., "Status and Direction of Tribology As a Science in The 80s: Understanding And Prediction," Proc. Int. Conf. Tribol. 80s, 1, 1984, 1-17.

[2] Frost, H.J. and Ashby, M.F., "Deformation Mechanism Maps: The Plasticity and Creep of Metals and Ceramics," first ed., Pergamon Press, Oxford, New York, 1982.