Thermally Induced Wear of Ceramics

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Introduction

Ceramics have a high strength and are chemically stable materials, however they are often not used because extreme wear is feared due to their brittle nature. Therefore a model has been derived, predicting the transition of mild to severe wear due to thermally induced stresses (Metselaar et al. 1999): The temperature rise due to frictional heating in a tribological contact induces thermal stresses in the material. When this stress exceeds a threshold value, fracture will occur. The severity of the contact can be described as:

$$TS = \frac{fWV}{aK_{eff}\Delta T_s}$$

in which ΔT_s is the thermal shock resistance, proportional with $\frac{(1-\nu)K_{Ic}}{E\alpha\sqrt{\pi d}}$ and $K_{eff} = 2.667\left(K_2 + \sqrt{K_1^{\,2} + 0.4Va\rho_1 c_1 K_1}\right)$. Severe wear will occur when TS exceeds a certain threshold value that is to be determined. The validation of this model will be described here, as well as the determination of the threshold value.

Validation

In order to validate this model, wear measurements have been performed on a pin-on-disc tribometer. As disc material a zirconia was used because of its low thermal conductivity, allowing high TS-values at moderate loads and speeds. As pin materials several other ceramics were used, viz. alumina, silicon carbide, silicon nitride and zirconia. For each experiment the TS-value was calculated from the experimental conditions and the resulting coefficient of friction. These TS can be plotted against the resulting specific wear rate (in mm^3/Nm), to obtain the following graph.

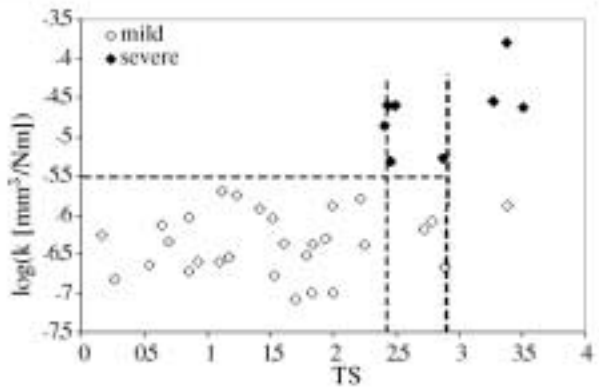

Figure 1: Overview of results of all present experiments.

Conclusion

Simple pin-on-disc experiments using different materials were performed to validate a model describing the onset of severe wear in ceramic tribosystems. From these experiments also a threshold value could be determined.

References

Metselaar, H. S. C., Winnubst, A. J. A. & Schipper, D. J. (1999), 'Thermally induced wear of ceramics', Wear 225–229, 857–861.