EFFECTS OF FRETTING WEAR ON THE EVOLUTION OF HYSTERESIS LOOPS AND CONTACT INTERFACES

A. Fantetti [a*], C. Schwingshackl [a], D. Nowell [a]
*a.fantetti@imperial.ac.uk
[a] Imperial College London,
South Kensington Campus, London SW7 2AZ, UK

KEYWORDS

Friction; Wear; Experiments in Tribology; Contact Stiffness

ABSTRACT

Frictional contacts are a major source of uncertainty for the correct prediction of the dynamic response of jointed structures. This is due to the poor understanding of the underlying physics of friction. This work experimentally investigates the effects of fretting wear on frictional contacts to eventually provide more reliable dynamic friction interface models. The high frequency friction rig [1] built in the Dynamics Group of Imperial College London is used to measure the evolution of friction coefficient and tangential contact stiffness over time. The friction rig measures friction hysteresis loops by generating a flat-on-flat sliding contact between pairs of specimens with a nominal area of contact of 1mm^2. A series of five fretting tests was conducted using different specimen pairs at room temperature and run over different time spans. The excitation frequency was 100 Hz and the normal load was maintained constant at 60N for all tests, which resulted in a nominal pressure of 60MPa. Specimens were all made of stainless steel and the contact interface was flat with a roughness value of about 0.1µm. The sliding amplitude was set to 20µm, which ensured hysteresis loops in full sliding regime. After every test, specimens were cleaned in an ultrasonic bath and, after cleaning, images of the worn interfaces were captured using an optical interferometer.

Values of friction coefficient and contact stiffness were extracted from the measured hysteresis loops. Fig. 1 shows the evolution of friction coefficient, μ, and tangential contact stiffness, k_t, with wear for tests conducted over different time spans. Results are plotted versus the cumulative energy dissipated, which was obtained by summing the area inside the hysteresis loops recorded over the whole experiment. Fig. 1a shows that the friction coefficient initially increases rapidly from a very low value of 0.1 to a value of 1.1 and it reaches steady state after several thousand cycles. The tangential contact stiffness in Fig. 1b nearly doubles from an initial value of 20N/µm to a steady state of about 40N/µm. The friction coefficient reaches the steady state by dissipating 50J, at least 20 times less compared to the tangential contact stiffness. This suggests that in the case of the friction coefficient the running-in may be driven by the rapid removal of initial surface layers of the material, as already pointed out in past studies [2-3]. This removal leads to a metal-to-metal and/or metal-to-wear particles contact that increase the adhesive and ploughing components of the friction coefficient. In the case of the tangential contact stiffness, results show that the steady state is probably attained when a steady contact conformity is reached due to a full interaction between the contacting interfaces. This hypothesis is supported by the evolution of the contact areas in Fig. 1b where the worn area of contact increases for longer test runs. This in turn is assumed to lead to more asperities and/or wear scars in contact, resulting in a higher number of elastic deformations and hence a higher tangential contact stiffness.

These results provide useful information to obtain more reliable contact models to be used in dynamic simulations.

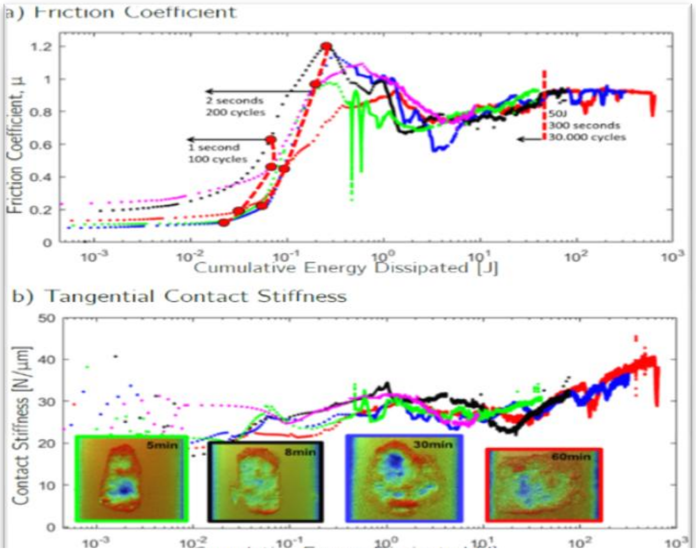

Fig.1 Evolution of contact parameters with wear

REFERENCES

[1] C. W. Schwingshackl, Topics in Modal Analysis I, 5, 2012, 167-177.
[2] W. D. Milestone, J. T. Janeczko, Wear, 18, 1971, 29-40.
[3] P. I. Hurricks, Wear, 15, 1970, 389-409.