Fretting of DLC coating systems: Analysis of H/E ratio, contact pressure, surface roughness and oil lubrication

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Abstract

Diamond-like Carbon (DLC) coatings are often used for protection against fretting wear due to their low friction and wear properties. DLCs are metastable, allowing them to graphitise under applied load to create a graphitic transfer layer resulting in lowered friction. High residual compressive stresses allow DLC to resist cracking under fretting.
This work analyses the nanomechanics of the coating systems to predict fretting wear performance and further explores the effects of contact pressure, surface roughness and lubricated conditions.

Three DLC coating systems (a-C:H, Si-a-C:H, a-C:H:W top layers) and their uncoated substrates (316L stainless steel and hardened M2 tool steel) were studied. Loads of 20 N and 40 N were applied with ± 50 μm amplitude at a frequency of 5 Hz for 15,000 cycles. 10 mm diameter 52100 steel balls were used as the counterface in a bespoke electrodynamic shaker unit. Gross slip fretting was attained in all tests with a Hertzian contact pressure of 1.1-1.5 GPa. A Group III mineral oil (with and without MoDTC) and fully formulated variant (with and without MoDTC) were utilised for lubricated conditions.

This study shows that for dry conditions, the coating' tribological performance could be ranked by their *H/E* ratios with the a-C:H coating performing consistently well with low friction and low wear. Surface roughness and contact pressure had a significant effect on the running in behaviour. The addition of lubrication reduced the dissipated energy in the contact thereby decreasing wear.
Using a systematic evaluation method as in this study, the design/operating parameters for the coating can be selected for optimal tribological performance of DLC systems.

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