INFLUENCE OF WATER AND OIL LUBRICATION IN SLIDING CONTACTS WITH DIAMOND-LIKE COATINGS

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The tribological properties of three kinds of diamond-like carbon (DLC) coatings sliding against steel and alumina countersurfaces were investigated in dry, water and oil environments. The investigated coatings were hard amorphous hydrogenetad carbon films (a-C:H) and similar films containing titanium (a-C:H(Ti)) coated on steel by radio frequency assisted plasma deposition, and hydrogen-free carbon films (a-C) coated on steel by vacuum arc deposition. The hydrogen content of the hydrogenated films is about 26 % and that of the hydrogen-free film less than 1 %. A titanium carbide interlayer was used in the hydrogenated films and a titanium interlayer in the hydrogen free films to improve the adhesion to the substrate. The thickness of the DLC coating plus interlayer was 0.5 μm for the a-C coatings and 1μm for the a-C:H coatings.

Tribological model tests were performed with three liquid lubricants using a reciprocating pin-on-disc device at a speed of 4 mm/s and a Hertzian pressure of about 1 GPa both for steel and alumina balls. The liquid lubricants were distilled water, a mineral base oil with no additives (viscosity 7.5 cSt/40°C) and a hydraulic oil containing zinc-based wear prevention additives (viscosity 21.6 cSt/40°C). Component testing was performed in a journal bearing test rig at an intermittent speed of 0...1 m/s with 10.000 starts and stops, a radial load of 4000 N and a total sliding distance of 100 km. In the tests, hardened shaft sleeves without coating, with an a-C:H coating and with an a-C coating were rotating in a journal bearing made of carbon steel, and the above mentioned hydraulic oil was used as lubricant.

In the reciprocating pin-on-disc tests, water lubrication decreased the coefficient of friction with 25...50 %. A wear protecting layer, probably aluminium hydroxide, was formed on the alumina ball when sliding against the a-C, coating and the water-lubrication decreased the wear of the coating. For the a-C:H coating considerable wear occurred and the coating was quickly worn through, while the a-C:H(Ti) coating behaved in a similar way but the Ti made the wear process slower.

coefficient of friction (<0.1) but have a high wear rate (10^{-4} $mm^3/N \cdot m$), which is not acceptable for tribological applications.

CONCLUSIONS

Both as-deposited, fine-grain diamond films and DLC films can be effective wear-resistant, self-lubricating coatings in humid air and in dry nitrogen, but they are not effective in ultrahigh vacuum. For the use of diamond and diamondlike carbon films in ultrahigh vacuum, film modifications (e.g., ion implantation) that provide acceptable levels of friction and wear properties are necessary.

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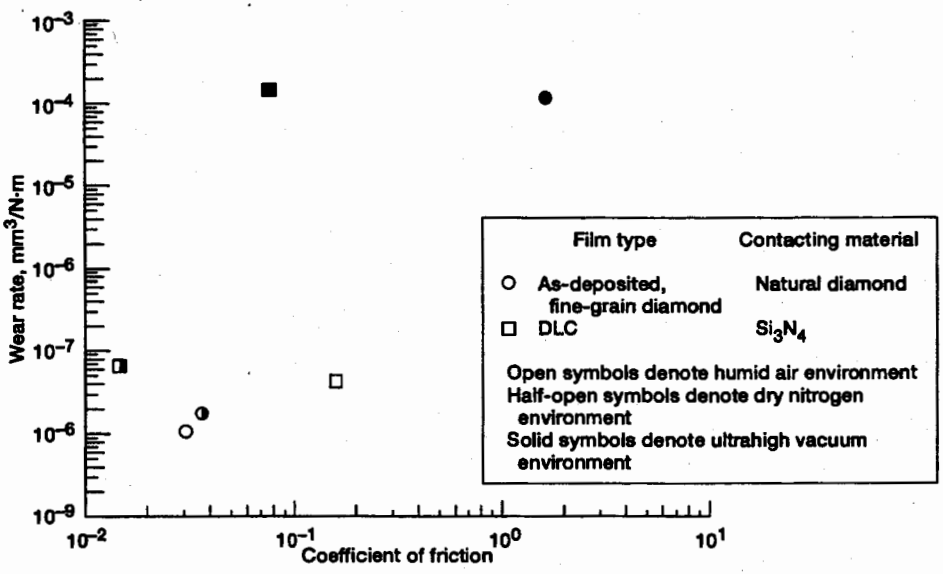

Figure 1.—Coefficient of friction and wear rate for fine-grain diamond films and diamondlike carbon films.