High precision Ball Cratering Wear Test

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In the quality management of wear protection coatings the testing of coating adhesion and wear resistance is of central importance. In industrial practice this is done e. g. by drilling a certain number of holes with a coated drill. In the last years the model wear test of ball cratering has found great interest, as it is a cheap and quick test. It can give information about wear resistance, coating adhesion and of course coating thickness.

This talk deals with the development of a high precision ball cratering wear test. The main features are a high sensitivity to coating wear properties and a high reproducibility by means of an optimized wear tester and abrasive slurry. With this testing method wear rates spanning several orders of magnitude can be determined with an accuracy of better than 5% of the individual wear rate.

The wear tester is based on a commercial available ball cratering apparatus (CSEM Calotest®). It was modified with respect to motor control and measuring the number of turns of the ball. An optimized slurry supply gives a reproducible amount of slurry in the contact zone. Together with an abrasive of a defined shape and a slurry of defined viscosity and stability a high reproducibility and sensitivity of the test is achieved.

This talks shows the main characteristics of the tester, describes influences of testing conditions on the results and shows a survey over different coating systems. Determination of wear volume achieved by stylus profilometry and optical microscopy are compared. It was found that there was a certain load and speed of ball rotation for an optimal sensitivity of the system. Different slurries yielded craters which were partly not measurable due to an undefined shape of the crater. With the optimized slurry a well defined shape is achieved. A remarkable influence of humidity is found as the test normally is performed in ambient air. Whether this is due to a change in the viscosity of the slurry or due a change in the wear mechanism is subject of ongoing research.

Wear rates measured on different coating systems ranged from 0.1 – 0.5*10^{-15} $m^3/(m*N)$ for DLC coatings (Ultramicrohardness 25 - 30 GPa) over ~ 3 - 8*10^{-15} $m^3/(m*N)$ for TiN coatings (Ultramicrohardness ~ 20 GPa), 2 – 5*10^{-15} $m^3/(m*N)$ for Me-DLC coatings (Ultramicrohardness 10 - 18 GPa), 10 - 50*10^{-15} $m^3/(m*N)$ for softer, more brittle materials like glass and silicon to over 100*10^{-15} $m^3/(m*N)$ for steels.

Future work includes development of testing parameters for bulk materials, electroplated coatings and lacquers, improvement of slurry stability and reduction of sensitivity to humidity and determination of wear rates by microscopy.

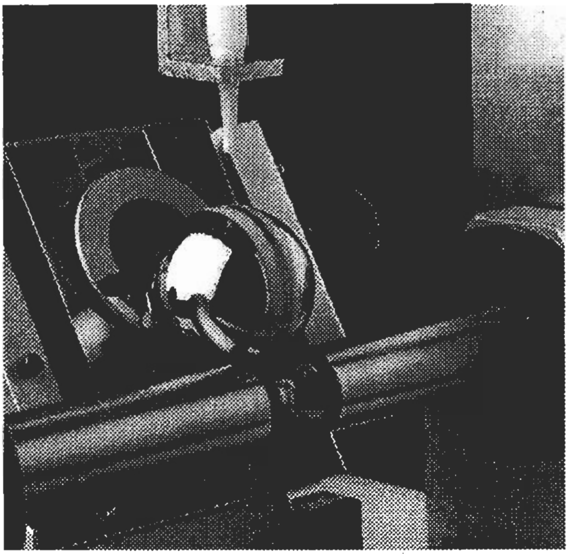

Fig. 1: Detailed view of drive shaft and slurry feed system of modified CSEM Calotest® apparatus

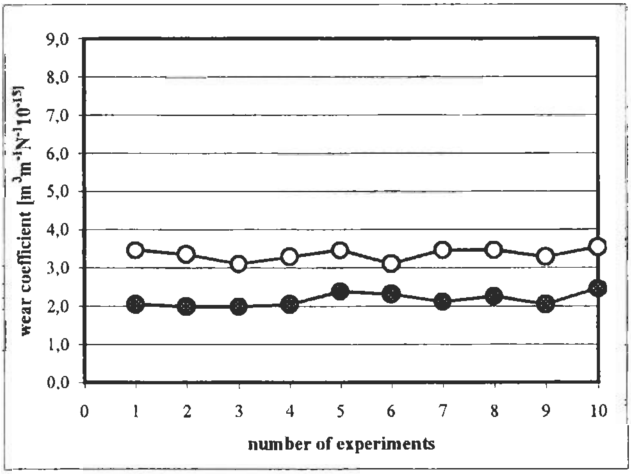

Fig. 2: reproducibility of wear rate of Me-DLC coating. Standard deviation < 5%.
closed circles: rate determination by measurement of crater depth
open circles: rate determination by measurement of diameter