Calculation of wear in ball-on-flat tests

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Abstract

Tribo tests with a ball-on-flat configuration are world-wide in use for the determination of friction and wear behaviour of materials. Different on-line and off-line wear quantities are discussed with respect to their content of information and suitability to describe the wear behaviour of tribo couples. A guide for interpreting of on-line measurements is derived for continuous and reciprocating motion.

In a ball-on-disk test a wear scar is produced at both bodies; different wear quantities can be derived from the dimensions of the wear scars after the test ("***off-line***"). The most meaningful wear quantity is the volumetric wear, since other quantities as wear scar diameter, planimetric wear and linear wear are ***not*** related linearly to of the amount of material that is removed in a test.

Furthermore, the size of the wear scar and the linear wear in continuous sliding tests are significantly different for cases, where the wear occurs mainly at the ball and where the wear occurs mainly at the disk.

The ***on-line*** measurement of the linear wear allows the calculation of volumetric wear in cases where the mechanisms of wear do not change during the test. The planimetric wear of the disk (determined off-line after the test) is a necessary input quantity for this calculation.

Model calculation of different wear quantities reveal the following tendencies:

- The size of the wear scar increases for increasing wear (constant volumetric wear rate) according to a power law with the exponent **1/4** for a wearing ball against a not wearing disk and with the exponent **1/3** for a not wearing ball against a wearing disk.
- The linear wear increases for increasing wear according to a power law with exponent **1/2** for wearing ball against not wearing disk and with the exponent **2/3** for a not wearing ball against a wearing disk.
- Linear wear rates, based on wear scar dimensions or linear wear decrease with increasing wear.
- The linear wear is significantly higher for wear at the ball than for wear at the disk.

Experimental investigations with steel/alumina and alumina /steel in air of different humidity show a pronounced increase of wear for reduced humidity and a retardation of wear in moist air. Tests that do not run long enough will provide values that ***do not describe the long term behaviour.*** Test duration has to be selected long enough to obtain stable conditions, this can be checked only by on-line measurement of linear wear.

Recommendations

The consequence of this result is:

- Wear scar dimensions, linear wear and planimetric wear in ball-on-flat tests increase with increasing removal of material with decreasing slope. These quantities are therefore ***not*** recommended for the definition of "wear rates"
- The volumetric wear of a system often increases linearly with test duration or sliding distance and ***is therefore recommended*** as a base for the determination of wear rates.
- The volumetric wear in ball-on-flat tests can be calculated separately for both bodies from the wear scar dimensions and the planimetric wear (profile of the scar on the disk).
- The total volumetric wear of a system can be calculated from the slope of the linear wear W_l, which can be measured easily "on-line".
- Relative humidity can affect wear rates significantly in unlubricated tests at room temperature and can also affect the running in behaviour and has therefore always to be controlled.