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International Research Group on Wear of Engineering Materials

BAM VI.2 Tribology and Wear Protection

Tribotesting with small loads and amplitudes – how does it compare to normal conditions?

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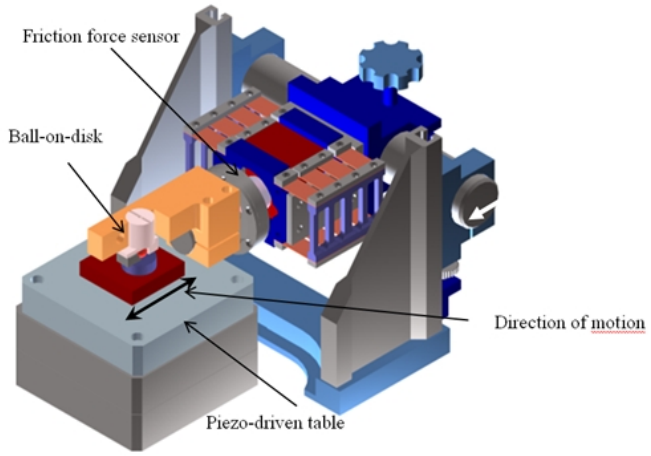
Usually tribological testing is done under two aspects: 1. to evaluate material behaviour under real conditions and 2. to obtain relevant test results in an affordable amount of time. Test parameters for oscillating sliding under these conditions are normally loads in the range from a few Newton up to 100 N (or even higher up to 1 000 N for lubricated systems), amplitudes in the range of 0.1 to 10 mm and frequencies in the range from 1 – 20 Hz. Modern technical trends lead more and more to a miniaturisation of components; consequently, much lower parameter ranges above all lower loads become interesting for tribological testing. On the other end of this chain, nano tribology focuses on problems that are correlated to loads that are even several orders of magnitude smaller – and the gap between these two testing fields is not practically filled yet, leaving a large area of unknown material behaviour. There are several reasons why tribological problems in the “meso” range (below 1 N) are less intensive examined. One of it is obviously the lacking necessary testing equipment, but also because wear determination in this range is rather time consuming. On the other hand, tribological characterisation of material combinations in this range of conditions is important for the handling and safe operation of micro systems.

The aim of this study is to characterise materials with respect to friction and wear behaviour for fretting conditions with small amplitudes (down to 1 µm) and low loads (down to 0.1 N). For this purpose a fretting tribometer was developed (Figure). The results of tests in this range should be compared with results of “classical” gross slip fretting tests that are usually performed with 200 µm stroke, 1 N load at a frequency of 20 Hz. Since the relative humidity of surrounding air can have a fundamental effect on friction and wear even for more or less chemically inert materials like ceramics, the influence of humidity in the ambient air should also be investigated.

The friction and wear behaviour of different ceramic materials was investigated under unlubricated fretting conditions at room temperature. The fretting tribometer works with a piezo driven specimen stage with a ball-on-disk arrangement.

The results of tests with alumina ball against 4 different ceramic materials, all commercially available, were performed with stroke of 10 µm and a load of 1 N. The results are compared with those of tests with oscillating sliding tests with higher stroke (200 µm) and higher loads (10 N). The results show that significant differences in friction coefficients but also in wear coefficients are noticed (Table) with the conclusion that results obtained with parameter sets which differ largely are most probably not comparable. Tribological model investigations in the "Meso parameter field" have therefore to be adapted to the operating conditions of real tribo system of interest. A transfer of results from investigations with standard test conditions to the meso range is not generally possible! A possible reason might be seen in the different overlap conditions which can influence both tribo-chemistry and wear particle generation and transport.



Coeff. of wear		10 µm 50 Hz 2 N	Comparison with „Standard“	*200µm 20 Hz 10 N*
Al_2O_3/ Al_2O_3	dry	*0.08*	*+300 %*	*0.02*
	normal	*0.08*	*+170 %*	*0.03*
Al_2O_3/ SiC	dry	**13.0**	**+ 25 %**	***10.4***
	normal	**1.9**	**-63 %**	***5.2***
Al_2O_3/ Si_3N_4	dry	**2.2**	**-35 %**	***3.4***
	normal	**1.5**	**-81 %**	***7.8***
Al_2O_3/ ZrO_2	dry	**0.30**	**-99 %**	***20.2***
	normal	**0.36**	**-53 %**	***0.77***

Figure: Fretting tribometer
Table: Comparison of wear results; coefficient of wear in 10-6 mm3/Nm.