Oscillating Tribological Test Bench for the Testing of Thermoplastic Friction Pairings

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1. Introduction

Friction and wear characteristics are system-dependent. In case of friction pairings with thermoplastics, the system dependence is extremely pronounced.
The reason for this is that the mechanical properties of plastics are strongly temperature-dependent. Friction generates heat in frictional contact. This heat of contact in turn changes the hardness, strength and surface properties of the plastics. The result is a very dynamic friction and wear behavior.
System parameters and components which have an effect on the temperature in the frictional contact thus have a strong influence on the development of friction and wear characteristics.
Parameters such as stress duration, ambient temperature, speed, surface pressure, size of the contact surface, shape of the contact surface, thermal insulation of the frictional contact are decisive in this context.
Thermoplastic components are usually produced by injection molding or mechanical processing. The resultant surface shape and the morphology of the near-edge layer have a very strong effect on wear behavior and friction. The described peculiarities of thermoplastics must be taken into account when selecting the test methodology. In this connection, the test stand presented here is very suitable.

1.1 Tribological Test Bench

The block-on-plate test with oscillating sample movement in many cases fulfills the prerequisites, which allow the results comparability to real assemblies. The prerequisite for the comparability of the results of model tests with the behavior in a real assembly is that the tribological system of the experiment is similar to that of the real application in the parameters described above.

The test bench allows the required realistic test conditions. Because:
-The plate-shaped samples can be produced inexpensively in the same way and with the same surface as the real components.
-The real stress collective can be adjusted (load, speed, stress duration, ambient temperature, etc.)
- Thermal insulation of the samples can be made comparable.
-The sample geometry is variable, which allows tests with the real contact surface size.

The structure and function of our block-on-plate test bench is presented below.

The following figures show the test principle. A block-shaped upper sample (1) is pressed onto the plate-shaped lower sample (2) with a defined normal force and is moved back and forth linearly oscillating. The dynamic friction coefficient and / or the static friction coefficient are recorded over the test duration.

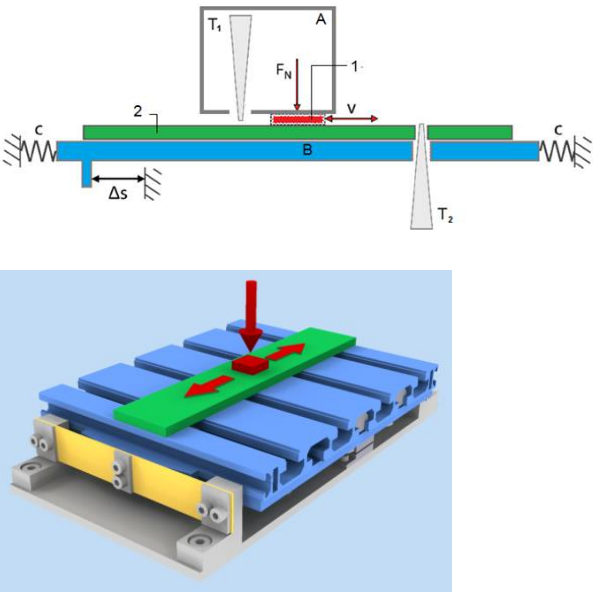

Figure 1: Test principle of block-on-plate with linear oscillating sample movement

In order to achieve accurate measuring results, special measuring tables and a special setup are used for the normal loading of the friction pairings.
The lower sample (2) is fixed on the measuring table. The measuring table itself is suspended at the front and rear by leaf springs(C), respectively. They can be deformed in the direction of movement of the upper sample (1). Depending on the magnitude of the frictional force, the springs are deflected. The deflection is sensitively sensed without contact, multiplied by the spring constant, and as a result the friction force is recorded over time. As there are no friction losses due to additional bearings, the results are exact.
The normal loading of the friction pairing is done by a measuring head (A), at the lower end of which the

upper sample (1) is fixed. It is pressed onto the lower sample (2) by a pretensioned spring. The clamping force (= normal force) is measured and recorded by a force sensor integrated in the head. The ratio “μ = friction force / normal force” results in the determination and ultimately the recording of the coefficient of friction over time. The friction surface temperature is measured over the test period using pyrometers (T1 and T2).
The temperature of the upper sample (1) is detected at the reversal point of the movement through a hole in the lower sample (2).
The result of the test is a diagram with the graph of the friction coefficient and the surface temperature (Figure 2).

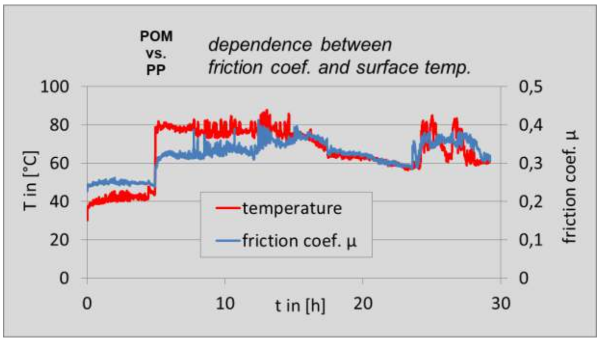

Figure 2: Polyoxymethylen against Polypropylen; dynamic friction coefficient and surface temperature over the test duration

1.2 Determination of wear

The wear characterization is usually carried out based on the material loss.
This works for test samples with small contact surfaces. However, the contact surfaces are large for many real plastic friction pairings. A transfer of the measurement results is then hardly possible. In the test with realistic large-area frictional contacts (>100 mm²), material loss is often minimal and hardly measurable. A further complicating factor is the fact that it often leads to significant deformations, melting of the surface or material transfer.
These forms of wear are not detected by the usual method, but can lead to failure in the case of real components. In order to take account of these forms of wear during evaluation, a method has been developed at the Technical University of Chemnitz, in which wear is assessed not only by the loss of material but by all visible wear marks. [1]
The wear is evaluated on the basis of criteria and the wear is thus quantified. With this method, experiments carried out under the same conditions are practically comparable.

Table 1: Wear rating based on criteria

wear value	**criterion**
0	no visible change against a new surface
0,5	no abrasion particles; only differences of the gloss
1	few abrasive particles; slight run-in traces; friction surface differs significantly from the unstressed surface; scratch
2	many abrasion particles and clearly visible run-in traces such as grooves and furrows over the entire friction surface and / or local clear visible material transfer and / or local melting of the friction surface; but the original friction surface is largely preserved in the profile
3	very strong accumulation of abrasive particles; strong run-in traces; the original friction surface is completely removed and / or large-area material transfers and / or large-area melting of the friction surface, thermal deformations of the friction surface (scales, waves, etc.)
4	wear-induced aborting of the test before the planned end

2. Conclusion

In summary, the test principle and the test stand offer the following advantages:
stroke adjustable from 2 mm to 600 mm; speed and surface pressure adjustable; simple sample production and preparation; also test of real components possible; simple detection of the friction surface temperature; recording of sliding and static friction values over the test period.
The method makes it possible to test the friction and wear behavior under realistic conditions. Therefore the comparability of the test results with the real application is possible. The proposed method for wear determination is very practicable for comparing results, if they are investigated under the same test conditions.

3. References

[1] J. Sumpf, A. Schumann, S. Weise, K. Nendel, S. Eichhorn: Neues Prüfverfahren zur Reibungs- und Verschleißbewertung von Kunststoff-Gleitpaarungen, Tribologie und Schmierungstechnik, 58. Jahrgang, Heft 4, Juli/August 2011