

DEVELOPMENT OF A TRIBOLOGICAL TESTING METHODOLOGY FOR DETERMINING FRICTION AND WEAR RELATED PROPERTIES OF TPU SEALING MATERIALS

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1. Introduction

Mechanical seal performance critically depends on the tribological performance of the sealing material [1]. Former research work clearly indicates that the in service behaviour of TPU seals is associated with the sliding velocity (v) and the contact pressure (p) [2], hence a compelling testing process to determine and compare the friction and wear related properties based on pv -variations is of outermost importance. This paper chronicles an implementation approach for the development of a testing methodology capable to declare the pv -dependency on the tribological performance.

2. Experimental - Methodology

One filled (Shore A/D=95/48) and one unfilled (Shore A/D=95/47) TPU-material representing general sealing materials are investigated. A testing process is set-up demonstrating the influence of variations in pv -parameters on the materials tribological behaviour. Therefore two methods are developed, a load step test at constant speed and a speed step test at constant loads. The validity of the test results are approved by analyzing the coefficient of friction (COF) and the correlating frictional heat build up which respond significantly to the pv -steps. Based on those results, the step tests are performed by progressive stages. After every load/speed step the tribological behaviour of the specimen is evaluated and the formation and evolution of the contact surfaces are analyzed via micrographs (light microscopy, SEM). The measured data is compared to the worn surface micrographs to assess the pv -dependency in more detail. Further thermomechanical analysis of the materials is performed to approve the supposed pv -rating.

3. Experimental Setup and Performance

The tribological tests are performed at the precise rotary tribometer TE 93 (Phoenix Tribology Ltd., UK). The RoD (Ring on Disc, Fig. 1) testing device, based on ASTM D3702 [3] for metallic materials, has been adapted to polymeric materials during our former research [2, 4]. A load cell measures the torque and two thermoelements measure the near surface temperatures due to frictional phenomena at two positions in the counterpart. The loss of mass of the polymer is consulted to analyze the wear. Conclusively, the setting parameters (normal load, speed) are held constant or varied in steps during the tests, while friction and wear related parameters (temperatures, frictional torque) are measured.

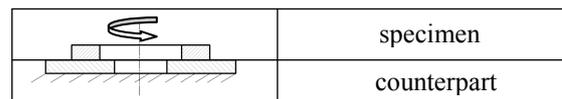


Fig. 1: RoD-Testing (schematically)

4. Experimental Results

The tested materials differ significantly in their tribological behaviour. The unfilled material shows high wear and failure occurs at low pv -levels (Fig.3). The filled material is more immune to tribological load which results in low wear. The load/speed step tests show a strong dependency of the frictional parameters on pv -variations. Figure 2 demonstrates the COF and the near surface temperature for selected pv -levels for the filled and unfilled TPU material.

The COF decreases both with increasing load and speed due to friction heat accumulation and changes in the contact geometry.

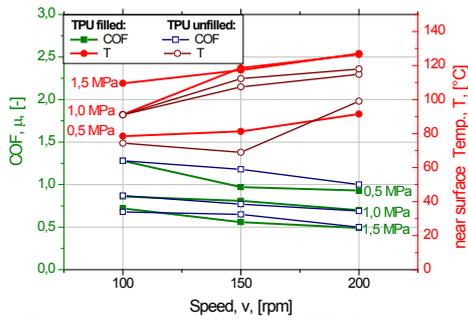


Fig. 2: Frictional behaviour of TPU materials at selected pv -levels

Figure 3 shows an example of the development of the COF and the near surface temperatures dependent on the testing speed for both materials at a constant load of 1 MPa.

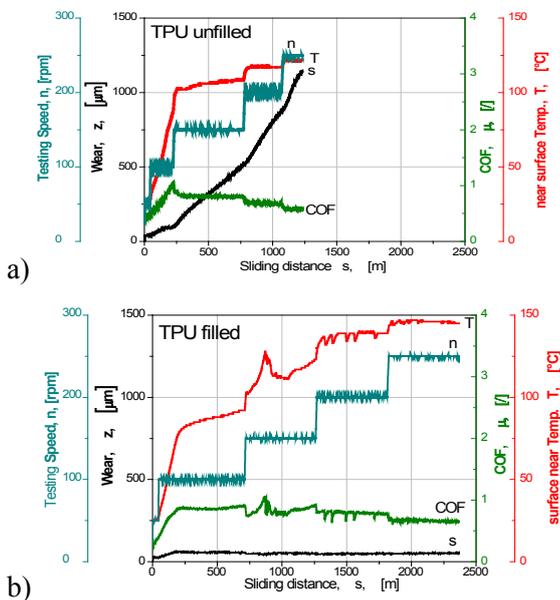


Fig. 3: Speed step test at 1 MPa, a) TPU filled, b) TPU unfilled

The temperature erratically increases with the speed steps. The friction force decreases on account of the development of tribologically more stable surface contact conditions and thermomechanical effects like bulk softening. Dynamical mechanical analysis of the tested materials show bulk softening (loss in modulus) at elevated temperatures of 150°C [5]. Due to the measured temperatures, the same level is assumed for the real contact temperature (Fig. 3). Optical micrographs (Fig. 4) approve the altering contact conditions for the speed steps. Wear particles and a rather coarse surface structure indicate higher wear (Fig. 4b) and failure mechanisms for the unfilled material. In comparison, a lubricating or bearing structure signifying stable conditions and lower wear (Fig. 4a) of filler particles is structured for the filled material.

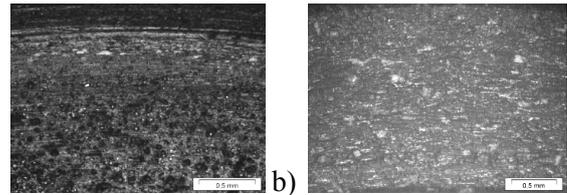


Fig. 4: Worn surface after speed step test, a) TPU filled, b) TPU unfilled

5. Conclusion

The step tests are proved of value as appropriate methodology to rate the pv -dependency of tribological parameters of TPU. It is an approach to formulate a pv -application limit for sealing materials. Additionally, wear mechanisms can be investigated via precise analysis of the surface characteristics.

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