The Influence of Deformation under Tension on Wear and Selected Properties of PTFE

Maciej Kujawa[1)*]

[1)] Faculty of Mechanical Engineering, Wroclaw University of Science and Technology, Wroclaw, Poland
*Corresponding author: maciej.kujawa@pwr.edu.pl

PTFE lip seals are widely used and well described in the literature, however, when analysing this material researchers do not take into account that deformation may affect its tribological properties. The tests showed that after deformation by tension ε = 50% the wear was 63% higher than for the undeformed sample. The difference was already visible at ε = 5% (wear increased by 22%). Moreover, a correlation between the microhardness, SFE and the wear coefficient was observed. The change in tribological properties with deformation ought to be taken into account when designing PTFE lip seals.

Keywords: friction, wear, hardness, stress, strain

1. Introduction

Polytetrafluoroethylene (PTFE) lip seals are used when there is a need for chemical and thermal resistance that exceeds the capabilities of classic seals made of elastomers. PTFE seals are used, for instance, as shaft seals in car engines. This kind of seals have been studied in detail for a long time [1], however, researchers do not take into account that deformation of the material may affect its tribological properties. The author of the current study has already demonstrated the influence of deformation on the tribological properties of PE-HD [2], and now presents research proving such an effect for PTFE.

2. Methods

The works carried out included tests of wear, surface free energy and microhardness. The research concerning surface free energy and microhardness was conducted in order to gain information to explain why deformation affects wear. Strained polymer sample left freely at room temperature changes its deformation. It is crucial to take into consideration that PTFE seals remain deformed after assembly. To recreate such situation, the polymer samples should remain in a deformed state during the test, therefore, they had to be held in grips to prevent them from returning to their original shape (Figure 1).

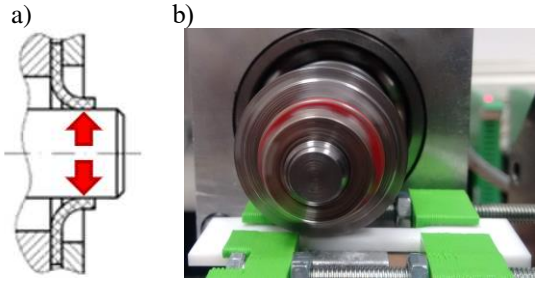

Figure 1: a) Deformed shaft lip seal; b) Sample held in grip during the wear test

2.1. Results

The obtained data proved that the wear of PTFE considerably increases after the polymer material is deformed by tension. When analysing the values of wear coefficient, a correlation between SFE, the microhardness and the wear coefficient can be observed (Table 1). It can be stated that when microhardness decreases and SFE increases the wear coefficient is increasing.

Table 1: Test results of wear (K_w), surface free energy (*SFE),* and microhardness (*HK 0.01*) for tensile deformed PTFE.

ε	0%	2%	5%	20%	50%
K_w $(\frac{10^{-5}\ mm^3}{N\ m})$	56,9 ±2,5	59,2 ±4,1	69,5 ±3,6	81,7 ±5,3	93,0 ±5,8
ΔK_w	**-**	**+4%**	**+22%**	**+44%**	**+63%**
HK 0.01	3,14 ±0,20	2,80 ±0,08	2,7 ±0,12	2,28 ±0,08	2,04 ±0,14
ΔHK 0.01	**-**	**-11%**	**-21%**	**-27%**	**-35%**
SFE (mJ/m2)	34,0 ±1,1	X	X	43,4 ±0,5	39,1 ±0,4
ΔSFE	**-**	X	X	**+28%**	**+15%**

3. Discussion

Even a small deformation (ε = 5%) increases wear, thus this effect ought to be taken into account when designing PTFE lip seals. Probably the reduction of microhardness should be associated with the reduction of the material cohesion forces. Therefore, material fragments can be torn out easier during cooperation. Increased SFE caused the higher adhesion between the polymer and the metal. As a result the PTFE fragments stick to the metal more easily and are taken out from the material.

4. References

[1] Choi H. J. et al., "Analysis on the mechanical characteristics of PTFE oil seal for the rear part in the automotive engine", International Journal of Precision Engineering and Manufacturing, 12, 3, 2011, 485–490.

[2] Kujawa, M. et al., "The Influence of Deformation under Tension on Some Mechanical and Tribological Properties of High-Density Polyethylene", Polymers, 11, 9, 2019, 1429 - 1446.