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Influence of macrodeformation of PE-UHMW and PTFE on the friction force in rolling-sliding contacts

Piotr Kowalewski[1)*]

[1)] Department of Fundamentals of Machine Design and Mechatronic Systems,
Wroclaw University of Science and Technology, Poland.
*Corresponding author: piotr.kowalewski@pwr.edu.pl

The results of the experiment stated that the deformation of polymeric material resulting from displacement of the contact point in rolling-sliding contact affects the value of the friction force. The experiment allowed the macrodeformation (F_{md}) and mechanical-adhesive (F_{m-a}) components of the total friction force to be separated. The analyses determined correlations between the values of the mechanical parameters of thermoplastic polymers and the values of the macrodeformation component of friction force F_{md}. For the tested polymers (PE-UHMW, PTFE), the average macrodeformation force was directly proportional to the value of the retardation time.

Keywords: rolling-sliding contact, viscoelasticity, macrodeformation, PE-UHMW, PTFE

1. Introduction

The design of modern bearing and sealing systems is becoming increasingly complex due to the fact that their sliding elements are operating under complex kinematics conditions. In many cases, the polymeric material is subject to significant deformation during operation and, what is more, the deformation is dynamic [2]. Whenever the contact area moves in relation to the polymer element, dynamic deformation takes place [1]. If the element on which another part is slipping exhibits plastic or viscoelastic properties, a significant portion of the energy used to deform the material is dissipated [4]. The viscoelastic properties of polymers make the deformation of the polymer dependent not only on the load, but also on the duration and speed of the load [3]. The main goal of the experiment was to prove that the deformation of viscoelastic materials during rolling-sliding contact has a decisive influence on the tribological phenomena and friction force.

2. Methods

Realization of the set of research objectives required tribological and mechanical (strength) tests. The tribological tests included measurements of the friction force in different values of: v_p - displacement velocity of polymer (slip), and ω - angular velocity (roll). The total value of the slip velocity s at the contact point is dependent on the angular velocity of the cylinder ω and the linear velocity of the plate v_p:

$$s = \omega \cdot r - v_p \qquad (1)$$

The used test stand allows independent setting of v_p and ω. The experimental plan, in which six constant values of total slip s (0÷50 mm/s) were applied at eleven different polymer deformation rates v_p (-50÷50 mm/s), takes 60 different motion cases, which were then analyzed.

Tribological investigations were carried out for two polymer plates (ultra-high molecular weight polyethylene - PE-UHMW, polytetrafluoroethylene-PTFE) against a steel roller (1.0503) in 3 different temperatures: 5, 20 and 40˚C.

3. Results

For the same value of total slip s, the total friction force F_T depends on the polymer deformation speed - v_p (Fig. 1).

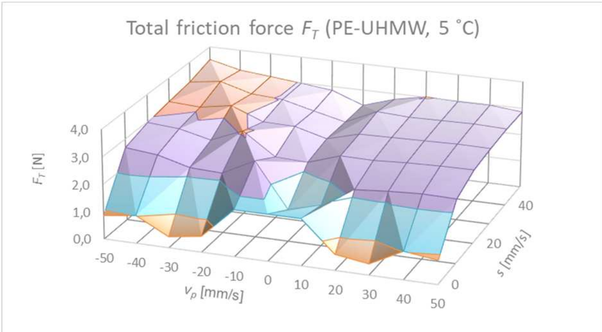

Figure 1: Total fiction force F_T with regards to the kinematic conditions (s, v_p) for PE-UHMW in 5˚C.

4. Discussion

A comparison of the results of the tribological and mechanical tests shows correlations between the value of friction force and the viscoelastic parameters of the tested polymers (viscosity – η, and shear modulus – G). The average macrodeformation compound of the friction force was directly proportional to the value of the retardation time of the deformations (η/G). It was also proved that the macrodeformation resistance constitutes a significant part of the total friction force.

5. References

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