THERMAL AND FRICTIONAL AGING IN TRIBOLOGY - STATUS ANALYSIS OF ENGINEERING AND HIGH-PERFORMANCE THERMOPLASTICS

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INTRODUCTION

Tribology as a relevant knowledge for many fields of engineering consists in optimization of mechanical properties by reducing friction and wear related energy and material losses. Hence, study the influence of important parameters such as contact temperature, environmental temperature, sliding velocity and load on the wear and friction coefficient is very important. Thermoplastics are especially found in applications of non-conformal tribological contacts such as gears or bearings. Between most frequently used engineering thermoplastics, aliphatic polyketone (APK), polybutylenterephthalat (PBT) and polyoxymethylene (POM) are widely used for tribological applications due to their high abrasion and heat resistance. For comparison reasons, the tribological tests are also performed for polyether ether ketone (PEEK) and polysulfone (PSU).

Numerous studies show that abrasive wear processes in polymers are complex and hardly to generalize. Unal et al. [1, 2] investigated the impact of sliding speed and applied normal pressure on the tribological performance of different polymers including POM and APK at room temperature. They concluded that with increasing the pressure the coefficient of friction decreases linearly, whereas wear rate showed less sensitivity to the applied pressures and sliding speed. Unal et al. [3] has also shown that the wear rate of POM and APK decreases with the increase in sliding distance. However, the influence of the environmental temperature on the tribological performance of these materials is not found in the literature.

The aim of this study is a fundamental and systematic approach of the interaction between microstructure, mechanical, and tribological properties. Studies have shown that polymer wear undergoes two main mechanisms, deformation wear and interfacial wear [4]. Deformation wear involves abrasive and fatigue wear while the interfacial wear involves adhesive or transfer wear. Wear of polymers is influenced by sliding contact conditions, the bulk mechanical properties of the polymer and properties of a third body, which generally appears as transfer film or loose degraded polymer particles [5]. The performance of a tribological system is governed by the interplay of these three groups which is in focus of this study.

EXPERIMENTS / FUNDAMENTAL OF THE PROBLEM / EXAMINATIONS

In this study, the wear deformations on the polymer surface are investigated when a steel ball is loaded against a polymer specimen (ball-and-plate test), a polymer pin is loaded against a steel disk (pin-on-disc test) and when the aforementioned tests are performed at temperatures below and above the glass transition temperature of the polymers. Hence, to determine the wear behavior in a dry sliding environment, tribological tests are performed for two sliding speeds 0.075 m/s and 0.15 m/s, and for two normally applied loads 30 N and 60 N, under two different measurement temperatures 23°C and 80°C. Since the surface roughness has impact on wear rate and friction coefficient [6], the surface roughness is modified to reach a high and a low roughness value.

RESULTS AND DISCUSSION

Figure 1 represents the variation of friction force with time for POM and PEEK, performed on a pin-on-disc apparatus for 6 hours under 0.075 m/s sliding speed and normal load value of 30 N at room temperature. The coefficient of friction can be calculated by dividing the friction force by the normal force. It is evident from this picture that the friction force increases rapidly at the early stages due to the formation of ridges on the surface, and reaches a stable plateau as the test progresses and a layer of wear debris is built on the surface. Besides, based on the measured weight loss of pins after each measurement it is clear that the weight loss of PEEK is about 5 times higher than POM.

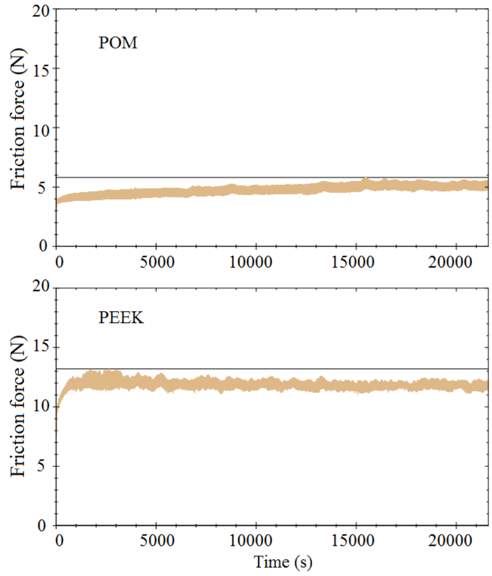

Figure 1: Friction force as function of time resulted from the pin-on-disc test

Figure 2 represents the variation of friction force with time for POM and PEEK performed on a ball-and-plate apparatus for 6 hours under 0.075 m/s sliding speed and normal load value of 30 N at room temperature. Both surfaces were prepared with a defined low roughness value. As it can be seen, the friction force of PEEK is almost two times higher than of POM and increases constantly during the testing time up to a maximal value of about 12 N or a coefficient of friction of 0.4.

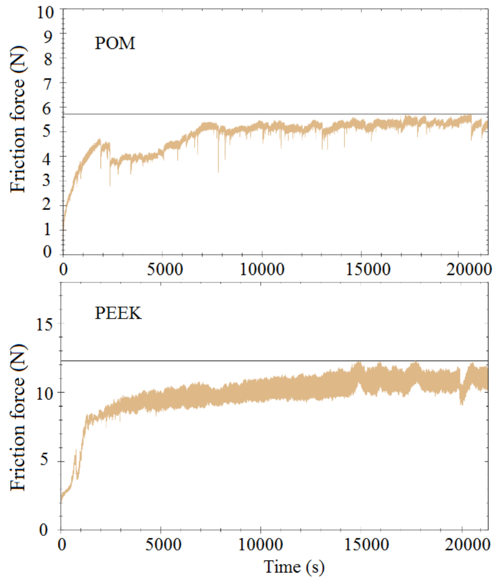

Figure 2: Friction force as function of time resulted from the ball-and-plate test

CONCLUSION

The wear rate and frictional behavior are significantly influenced by the surface roughness and sliding distance. Future experiments will include performance of the tribological measurements at temperatures above the glass transition temperature. Furthermore, measurements with different load conditions will be also carried out.

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