TRIBOLOGICAL CHARAKTERISTICS OF POLYMER MATERIALS

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Abstract
The paper deals with the tribological properties of selected polymeric materials. It communicates with particular selected polymers and their slip properties. It also describes the Tribolab tribological device and the test methodology. In the end, it evaluates the measured values and possibilities of using selected polymeric materials in practice.

Keywords: Tribology, friction, polymer, measurement, friction coefficient.

1 Introduction

By the term tribology we mean the friction of materials. It can be a dry or wet friction, which depends only on the conditions in which the measurement is taking place, in our case it is a dry friction. Materials were provided by TechPlasty s.r.o Žilina. We used selected materials PA G.6 MoS2, PA 4.6, PTFE carbon, PE1000 and PE2000. TriboLAB - Tribological Equipment from Bruker, located at the Faculty of special technology, is one of the most developed tribological systems ever designed. UMT (Universal Mechanical Tester) has been the world's most universal and widely used triester of tribological properties for various materials. The device is unique by being modular.

Fig. 1 *TriboLAB Tribological Device [16]*

2 Work methodology, materials for research, experiments.

Before the measurement itself, several settings were made on the device itself so that it could be technically correct for the individual measurements. First, the device was set for a specific measurement and a suitable module was prepared. A computer program was written to let the device know what parameters to work with. The individual measurements varied in the load force *Fz*, while the measurement time remained unchanged.

Table 1 *Measurement input parameters*

Measurement	Load [N]	Time [s]
1.	10	21
2.	20	21
3.	30	21

Three measurements were made on each sample with different parameters according to the order. In this way, all 6 test materials were tested. Measurement took place in three steps. The first measurement consisted of a spike of the spike following the sample in the z-axis direction, with a load of 10N and a total measurement time of 21 seconds. The second measurement differed only in a load force that had a value of 20N and the measurement time remained unchanged. The third measurement again differed only with a load of 30N, with the time remaining unchanged. The device collected about 2100 friction coefficients after completing all measurements. In the 21-second measurement range, this means that every one tenth of a second has given us one friction coefficient. From all the data we have created graphs with increasing resistance of the material to the stylus of the device.

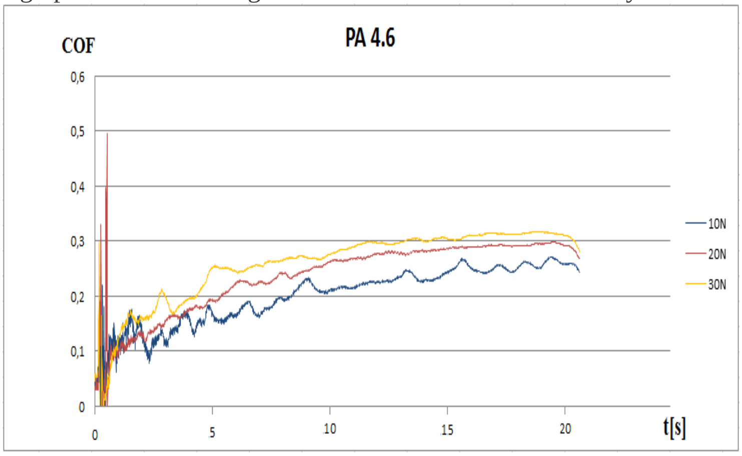

Fig. 2 *Process of measurement PA4.6*

The process of measurement of polyamide PA 4.6 can be seen in graph 4. The graph is seen from the beginning of the jump course, probably due to the extrusion of the material and the loading of the loading force. Significant curves of the curve are due to the fact that when the stylus of the device began to push through the force of Fz, the material was pushed against the stylus and the subsequent release. Approximately ten seconds of measurement at 20N and 30N load forces were smooth. Running at Fn with a force of 10N continually led to jump changes. At the end of the graph, the result is distorted due to the end of the measurement. It comes from a drop in the load. From the data obtained we can conclude that the friction coefficient has increased with increasing load.

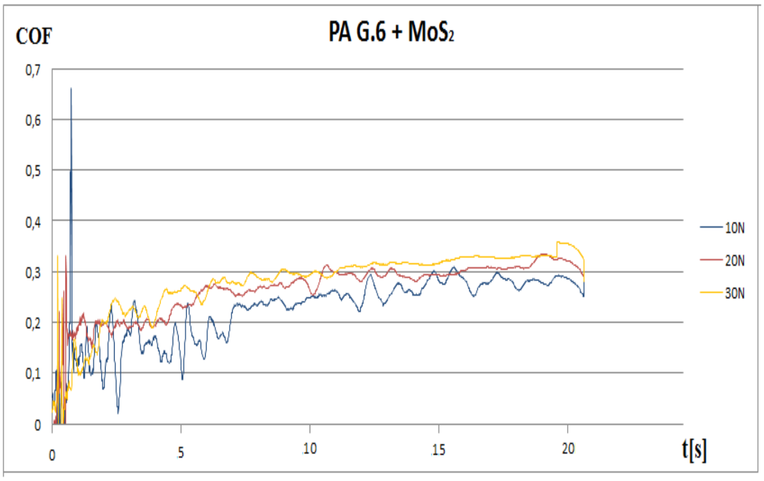

Fig. 3 *Process of measurement PAG.6+MoS_2*

Similarly to PA 4.6, the polyamide PA G.6 MoS_2 cast iron was also used for step changes in all three measurements. This leads to extrusion and compression of the material in front of the stylus, resulting in measurement deviations. From the chart below, we can see that the friction coefficient increases with increasing load. The highest amplitude is achieved by PA G.6 MoS_2 at the lowest load. At the end of the curves, we can monitor the drop due to ending the measurement and reducing the load.

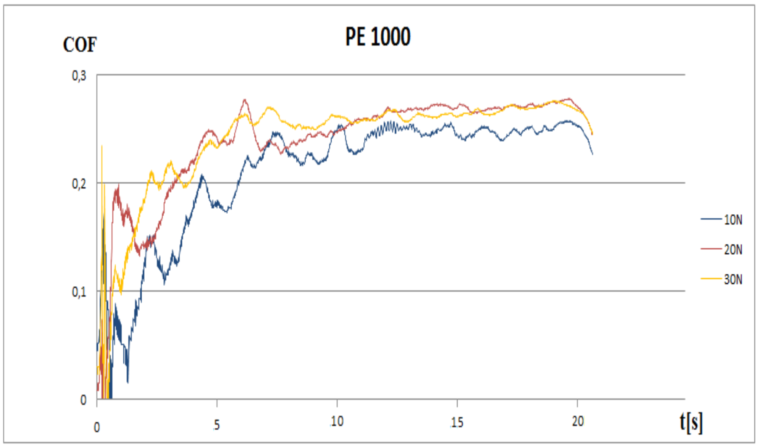

Fig. 4 *Process of measurement PE 1000*

The measured PE1000 polyethylene values for all three loads had a totally similar pattern. Within 20N, there was only a slight variation in the friction factor. This material thus acts as a good wear-resistant even at various load forces. At the end of the curves, we can monitor the drop due to ending the measurement and reducing the load. Approximately from 15 seconds of measurement, the curves are virtually undeformed, so we could assume that longer measurement would be unnecessary. From the measured results we can assume that the material will have good sliding properties.

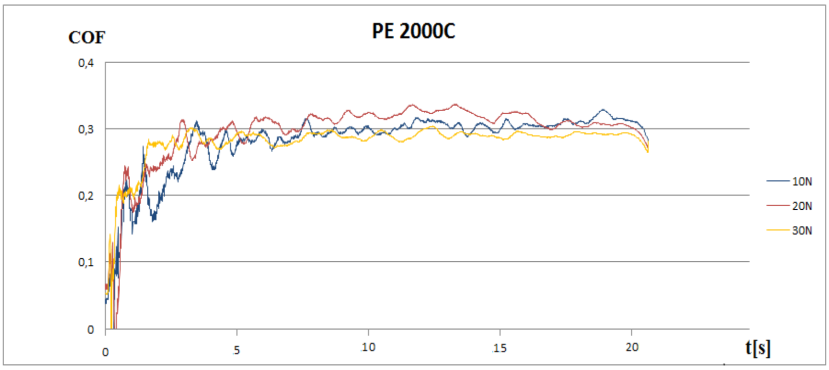

Fig. 5*Process of measurement PE 2000C*

From the following graph we can read that the measured values of polyethylene PE 2000C have somewhat higher values than PE 1000. In previous materials, the curves were compared, but there are still deviations in the PE 2000C. The cause may be the unevenness of the material structure or the direction of monomer assembly.

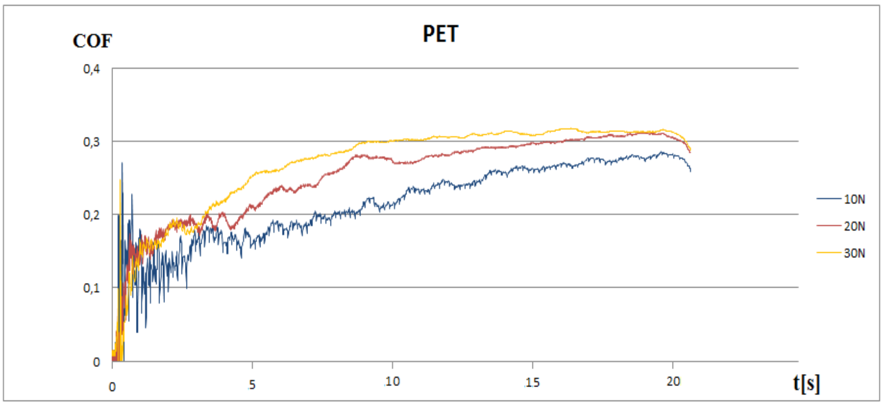

Fig. 6 *Process of measurement PET*

From the graphical representation of the PET polyethylene measurement process we can see that after 5 seconds of measurement, the value of the coefficient is gradually increased up to 20 seconds when the value starts to stabilize at about 0.3 for the 20N and 30N load. For load 10N this value is lower but also stable.

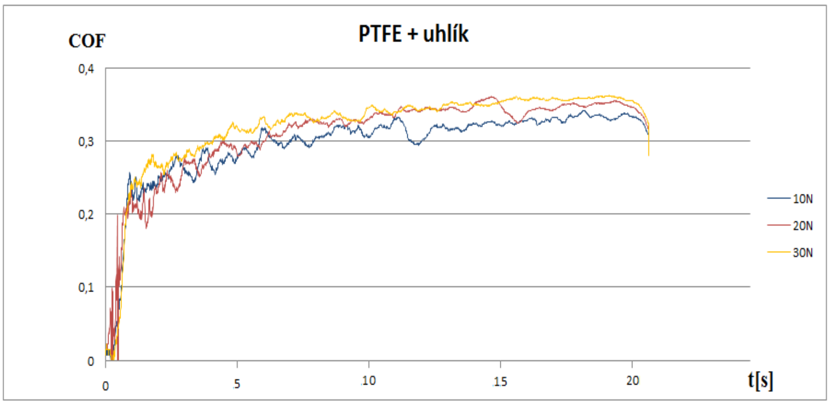

Fig. 7 *Process of measurement PTFE +carbon*

The process of measuring PTFE + carbon can be seen in graph 9. As in the previous cases, we can observe the jump progress at load 10N and 20N. With 30N load, the curve is already milder and more fluid. Resistance of material to the stylus of the device is higher than that of non-carbon polyethylene. At the end of the curves, we can monitor the drop due to ending the measurement and reducing the load.

3 Description of achieved results

From the data obtained, we could conclude that the best values were achieved by PE1000 and PA 4.6. The values of their friction coefficients differ only slightly at increased load. Measurement ranges ranged from the onset of the force to the end almost smooth, up to a few jumping offsets due to the extrusion of the material and subsequent release.

From the available measurements, we can conclude that PE1000 would be the best material for the friction factor. The best material among the polymers tested was PET. The value of its friction coefficient is 0.27 at the highest load. One of its uses could be in the food industry, as PET has good chemical resistance and stability. It is also suitable for the automotive industry to guide the sliding parts of the timing mechanism. It could also be used as machine parts that require high precision and shape stability.

We originally assumed that the results will be the same or at least approximate to the values we obtained from TechPlasty s.r.o. Based on the measured results, we can conclude that our measured values do not match the values from Techplasty s.r.o. The biggest differences were recorded for PTFE carbon and PE 2000C. The smallest differences in values were PET.

4 Conclusion

Keeping pace, increasing requirements and achieving the best results is an integral part of any research and development. The endless upgrading process has also caught the material group of polymers. This group of polymers is one of the most progressive materials in the last period, and tribalism is an integral part of this. Tribology, the science of the process trec, has one of the greatest effects on the final properties of the material. The use of knowledge of tribolology and tribotechnika has a tremendous presence in the process of creating new materialsWe hope that much attention will be paid to this issue in the future as research and development of polymers is on the right track, as evidenced by many progressives, such as the self-repairable polymer or the Buckypaper.

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