INVESTIGATION OF TRIBOLOGICAL PROPERTIES OF ENGINEERING PLASTICS WITH SMALL SCALE SPECIMENS

L. ZSIDAI, G. KALÁCSKA
SZIE University of Gödöllő, Department of Mechanical Engineering Technology, H-2103 Gödöllő, Páter K. u. 1.
HUNGARY

P. DE BAETS, F. V. PARYS
University of Gent, B-9000 Gent, Sint-Pietersnieuwstraat 41, BELGIUM

M. KOZMA
Technical University Budapest, H-1111 Budapest Műegyetem rkp. 1-3. HUNGARY

K. VERCAMMEN
Vito, Flemish Institute for Technological Research, Boeretang 2000, B-2400 Mol, BELGIUM;
e-mail: karen.vercammen@vito.be

SUMMARY
The engineering applications of plastics are strongly connected to the different tribological systems, where the machine parts are subjected to friction and wear processes. The design for lifetime of metals in tribological systems has not solved yet, even less known for engineering plastics. The test evaluation and concluding process are rather difficult taking the specific behaviour and features of the polymers into consideration. Due to this point we have been carrying out a wide-ranged tribo-testing with large-scale and small-scale plastic specimens. Based on the obtained results seeking the correlation between the two main systems we try to conclude more general principles. This paper gives a short view about the small-scale experiments. We have done measurements with plastics like POM-H; PETP/PTFE; POLYAMIDES. This was a linear friction-sliding measurement of cylindrical specimens against a metal plate. Measurement was made at 100 N and 200 N load and in two surfaces categories.

Keywords: plastic, sliding friction, counterformal contact, wear

1 INTRODUCTION
This presentation is based on a part of an international tribology research program seeking the correlation between large-scale and small-scale tribo-testing of engineering plastics.

The frictional and wear processes are the basic cause of the failure of machines. A solution can be the use of self lubricating plastics. One-one test is not enough for determining the tribological behaviour in a certain system. Taking the specific features of plastics into account, we can observe perfectly the tribological behaviour of plastics with small-scale and large-scale testing. We have done measurements with plastics like POM-H; PETP/PTFE; POLYAMIDES types [2], [5].

The method for testing is a linear sliding friction measurement without lubricants. The sliding friction is created by a polymer cylinder, which is moved against a steel plate in a counterformal contact. The polymer cylinder is fixed to the moving fixture, and it cannot turn away during the test. Measurements are made at 2 hours / 100 N load (category I.) and 1 hour / 200 N load (category II.) and in two surfaces categories. (Fig. 1)

Aims: To determine the optimal operational conditions, to define the basic failure process of engineering plastics during sliding frictional conditions, taking the severe requirements into account related to the safety against overload, too.

![Cylinder on Plate](image-url)
2 THE TEST MATERIALS, PROPERTIES

The standpoint of choosing materials depended on the bearing manufacturers, the demand of users and wide range of applications. Among the selected materials two are filled composites having different features in sliding and wear properties [3],[6].

2.1 POLYAMIDES PA 6 G (reference); PA 6 G+oil; PA 6 G / Mg(catalyzed)

The cast polyamides are used for tests among the wide ranged polyamide types. The main properties of cast polyamide: high strength, stiffness, thermo- and wear resistance, excellent creep resistance, hardness, good machine-ability, water absorption

2.2 POLYOXYMETHYLENE HOMO-POLYMER POM-H

The properties related to PA 6 G: higher crystallisation ability than copolymer, high strength, stiffness, hardness, excellent creep resistance, good sliding properties and wear resistance, very good dimension stability

2.3 POLYETHYLENE TEREPTHALATE PETP+PTFE(composite)

Properties of PETP+PTFE: solid lubricant spreading homogenously (PTFE composite), improved wear resistance, lower friction coefficient comparing to pure PETP; POM-H and PA, higher load concerning contact pressure and velocity.

3 PARAMETERS OF TESTS

<table>
<thead>
<tr>
<th>PARAMETERS</th>
<th>CAT. I</th>
<th>CAT. II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency (f) (velocity)</td>
<td>30Hz (0.27m/s)</td>
<td></td>
</tr>
<tr>
<td>Running time (t)</td>
<td>2 hours</td>
<td>1 hour</td>
</tr>
<tr>
<td>Load (L)</td>
<td>100N</td>
<td>200N</td>
</tr>
<tr>
<td>Stroke (s)</td>
<td>4,62mm</td>
<td></td>
</tr>
<tr>
<td>Surface of metal specimen (Ra)</td>
<td>0,02-0,1/0,1-0,2</td>
<td></td>
</tr>
<tr>
<td>Humidity (H)</td>
<td>50%</td>
<td></td>
</tr>
<tr>
<td>Ambient temperature (T)</td>
<td>30°C</td>
<td></td>
</tr>
</tbody>
</table>

MEASURED PARAMETERS

- Static friction coefficient
- Dynamic friction coefficient
- Wear (mm)
- Relative humidity (constant)
- Ambient temperature (constant)
  
(Ra 0.02 - 0.1 is called smooth and Ra 0.15 - 0.3 is called rough surface)

4 COMPARISON OF THE RESULTS

According to the results of our investigations the followings can be established. We can see each type of materials of both investigations on column diagrams in both categories. The values of the friction coefficients are shown in diagrams in order. These values are averaged from more measurements (Fig. 2, Fig. 5).

4.1 Tests carried out 2 hours / 100 N

Figure 2: Comparing the dynamic friction coefficient among different materials, classifying according to surface roughness (Tests carried out 2 hours / 100 N)

4.1.1 POM-H

Favourable, nearly similar frictional results were measured ($\mu_{\text{dyn.mean}} = 0.25 - 0.3$) on both surface roughness. The initial peak was followed by a reduction and stabilization stage in the friction results. If the surface is smoother, the wear is less.

4.1.2 PETP+PTFE

Advantageous effect of the internal lubricant was detected during sliding. Generally small wear ($w = 0,048 \text{ mm}$) was measured varying on the different surfaces. The curve of friction is rather levelled. (Fig. 3)

Figure 3. Friction coefficient and wear of PETP-PTFE; 2 hours; Load 100 N; rough surface
4.1.3 POLYAMIDES

The polyamides have higher friction coefficients than the polymers mentioned above.

- PA 6 G+oil shows better sliding properties than pure PA 6 G and PA 6 G/Mg (lubricant effect).
- PA 6 G/Mg shows about 20 - 25% higher sliding resistance than the natural PA 6 G. Its wear is less than the wear of other polyamides. This can be caused by the altered catalytic process in the production. We can conclude from the wear curve a high surface toughness against wear. (Fig. 4)

4.2 Tests carried out 1 hour / 200 N

4.2.1 POM-H

Lower friction coefficient at rough surface and increasing friction coefficient at smooth surface was found. The wear was almost similar at both surface roughnesses. (Fig. 6)

4.2.2 PETP+PTFE

The internal lubrication showed positive effect on the value of friction coefficient. The wear was small and almost similar at both cases:

\[
\begin{align*}
0.0235 \text{ mm} & \leftrightarrow 0.0241 \text{ mm}
\end{align*}
\]

4.2.3 POLYAMIDES

- In case of PA 6 G+oil the difference between the friction coefficients was lower comparing to the other polyamides. This phenomenon signs the important role of the load and surface deformation of plastics. The internal lubricant could not act as effectively as under lower load (2 hours / 100 N category).
- The load is higher the friction is lower at PA 6 G materials. The difference in friction coefficients depends on the filling materials and production technology.
- The wear rate of PA 6 G on rough surface decreases suddenly after a certain period of time getting a transient point. The same tendency can be seen on the curve of friction coefficient, too. These phenomena are due probably to a polymer transfer process, which was observed on the metal specimen. (Fig. 7)
The friction results are almost similar at PA 6 G/Mg ($\mu_{\text{dyn.mean}} = 0.58 - 0.62$) at both roughness, but the wear is quite different: 0.1961 mm ↔ 0.6324 mm).

POM-H and PETP/PTFE showed nearly the same low friction coefficient, but PETP/PTFE gave a bit better value of friction coefficient. It could be caused by the effect of solid internal lubricant.

POM-H has more favourable friction coefficient than the polyamides have. (In many practical cases the widely used POM-C shows more unfavourable friction than PA 6 G/Mg. It seems there are essential differences between POM-H and POM-C in the friction properties.)

6 ACKNOWLEDGEMENTS

The authors wish to acknowledge the Office OTKA for supporting this work by the research project of OTKA T 032590. This publication and research is supported by the Flaminsh-Hungarian bilateral scientific and technological cooperation (OMFB TéT B-9/98), too.

7 REFERENCES