Introduction

The benefits with polymer composites are many and the development is progressing steadily. Today there is a large variety in both polymer matrix and fillers, i.e. fibers for strength and PTFE for lubrication. Depending on application a compromise between mechanical strength and thermal properties often need to be considered. In addition, the tribological performance is also an important aspect to take into consideration when choosing polymers for an application.

Materials

<table>
<thead>
<tr>
<th>Polymer matrix</th>
<th>Fillers (wt%)</th>
<th>E-mod. (GPa)</th>
<th>$T_m$ *($^\circ$C)</th>
<th>$T_a$ *($^\circ$C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PPS</td>
<td>40% glass fiber (GF)</td>
<td>15.5</td>
<td>90</td>
<td>280</td>
</tr>
<tr>
<td>PPS</td>
<td>30% glass fiber + PTFE</td>
<td>12.5</td>
<td>90</td>
<td>280</td>
</tr>
<tr>
<td>PPA/PA66</td>
<td>50% glass fiber</td>
<td>18</td>
<td>70</td>
<td>260</td>
</tr>
<tr>
<td>PPA/PA66</td>
<td>50% glass fiber</td>
<td>18</td>
<td>130</td>
<td>325</td>
</tr>
<tr>
<td>PA66</td>
<td>20% PTFE + silicone oil</td>
<td>2.7</td>
<td>65</td>
<td>260</td>
</tr>
<tr>
<td>PEEK</td>
<td>30% carbon fiber (CF) + graphite + PTFE</td>
<td>12.5</td>
<td>143</td>
<td>343</td>
</tr>
</tbody>
</table>

*For the polymer matrix
**High temperature type PPA/PA66.

Experiments

- Reciprocating ball-on-disc setup.
- Ball bearing ball, 100Cr6, ø 10 mm
- Three surface temperatures.
  - Room temperature (RT), $80^\circ$C, $120^\circ$C
  - Contact load, 5 N and 15 N.
  - Number of cycles, 2,000 and 10,000.
- Frequency, 3 Hz.

Main conclusions

- Internal lubrication of the polymers has a very strong effect on friction and wear.
- The glass fiber reinforced PPS causes wear of the steel counter surface.
- Adding PTFE to the material reduces the wear.
- For some materials a test temperature of $80^\circ$C seem to give the best performance.
- In this study, the PA66 material with PTFE and silicone oil shows the best, while the glass fiber reinforced PPS shows the worst friction and wear performances.

Results

- The polymers with only fiber reinforcement and the ones with internal lubrication shows different wear and surface damage behavior.
- With only glass fiber the wear tracks are heavily damaged and rough. Fibers are exposed at the surface in the wear track.
- With internal lubrication the wear tracks are smooth, often smoother than the unworn surfaces. Since there is two other internal lubricants, silicone oil and graphite, it is difficult to separate the specific effect of PTFE on the tribological behavior.
- For all materials, a higher load resulted in wider wear tracks.
- For all the polymers with only fiber reinforcement the fibers were exposed in the wear track.
- The more fibers exposed, the greater possibility to find broken fibers.
- In some tests fibers had come loose from the matrix.
- The wear particles mostly consisted of rolled material for the PPA/PA66 composites.
- At the turning points the worn material were sheared out from within the wear track due to repeated deformation.
- For PPS these sheared pieces of material were present also on the sides of the wear track.
- PTFE is distributed as particles in the matrix.
- In the wear track these appears a bit lower than the matrix. This might indicate that the PTFE is spread over the entire wear track, giving low friction and protecting the matrix from wear.
- For PPS with glass fiber, the wear tracks were rougher with increasing temperature.
- Abrasive wear occurs after 10,000 cycles, for both the polymer and counter surface.
- Iron oxide were present in the wear tracks.

PTFE is spread over the entire wear track, giving low friction and protecting the matrix from wear.