TRIBOLOGICAL BEHAVIOUR OF PTFE + GLASS FIBBER COMPOSITES USED FOR AXIAL BEARINGS, UNDER WATER LUBRICATION

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ABSTRACT

This paper presents experimental results of testing PTFE + glass fibber composites in conditions of sliding and water lubrication in order to establish a hierarchy of tested materials having as criterion the tribological behaviour. For composites with polymer matrix testing under similar conditions to the application ones, is the best way to evaluate tribological behaviour. Mechanical properties could not reflect an actual hierarchy from tribological point of view.

KEYWORDS: PTFE + Glass Fibber Composites, Water Lubrication, Wear

1. INTRODUCTION

Tribological behaviour may be evaluated by several qualitative and quantitative parameters. The authors select friction coefficient and wear as relevant for this study.

Taking into account the disadvantages of PTFE (low mechanical resistance and thermal conductivity, high thermal expansion coefficient), this material has practical applications as matrix or adding material in composites [2, 3, 5, 7, 14].

Recent researches propose using this material as very thin coatings on a more rigid support (steel, bronze) [7, 10] but bonding agents and technologies for PTFE are still expensive.

In many cases, conclusions obtained on theoretical model partially agree with experimental results or only for narrow intervals of commanding parameters. Thus, the friction coefficient obtained on small tribomodels is lower than that resulting for tribomodels with greater dimensions and different shapes. […]

Using water as circulant or lubricant agent involves special materials, with a suitable set of properties: they have to be water-resistant, it is better to manifest good tribological behaviour as water is a poor lubricant and the probability of having total fluid film is very low and an adequate durability and, of course, an acceptable price.

2. MATERIALS AND TESTING MACHINE

Tests were done on four materials and their mechanical properties are given in table 1.

Each test involved a set of three plates (6 x 20 x 30 mm), introduced in a steel support disc (fig. 1). The tribomodel was selected as a result of theoretical studies [1, 6] and experimental reset [4, 5, 9, 14]. The mating disc was made of stainless (40HRC and Rₐ=0.6…0.8μm). Plates were made of PTFE and PTFE composite with different glass fibber concentration (Figure 1).

Testing conditions were: sliding speed v=2.5 m/s, average pressure p=0.22, p=0.77, p=1.46 and p=2.22 MPa, respectively, water temperature being θ = 18±1°C.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>PTFE</th>
<th>PTFE + 15% glass fibber</th>
<th>PTFE + 25% glass fibber</th>
<th>PTFE + 40% glass fibber</th>
</tr>
</thead>
<tbody>
<tr>
<td>Code</td>
<td>F</td>
<td>G</td>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>Relative density</td>
<td>2.15</td>
<td>2.2</td>
<td>2.22</td>
<td>2.23</td>
</tr>
<tr>
<td>Shore hardness</td>
<td>55</td>
<td>59</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td>Traction limit (MPa)</td>
<td>25</td>
<td>20</td>
<td>10</td>
<td>11</td>
</tr>
<tr>
<td>Friction coefficient</td>
<td>0.04…0.63</td>
<td>0.013…0.22</td>
<td>0.012…0.024</td>
<td>0.01…0.035</td>
</tr>
</tbody>
</table>

Table 2 Characteristics of the tested materials
Testing machine has an original design [4] in order to allow a large range for sliding speed and loading (fig. 1).

Friction coefficient was calculated based on the output from the torsion gauge 6, during a sliding distance of 5000m, using the following relationship:

\[ \mu(i) = \frac{2 \cdot M(i)}{d \cdot F(i)} \]

where \( M(i) \) and \( F(i) \) are resistant torque as measured by gauge 6 and the normally applied force, respectively, for time moment \( i \), \( d \) being the steel roller nominal diameter. [...] 

The testing machine allows to keep the sliding speed in a narrow range (±5%) and it has a mechanical loading device (0…10kN±3%).

3. EXPERIMENTAL RESULTS

3.1. Wear evolution

Mass loss \( \Delta m_{total} \) and wear rate \( \Delta m_i \) were determined as following

\[ \Delta m_{total} = m_o - m_{final} \]  \[ g \]

where \( \Delta m_{total} \) is mass loss after 4500m of sliding \( m_o \) is the initial mass of the shoe; \( m_{final} \) is shoe mass after 5000m of sliding in water.

Figure 2 presents the wear evolution for the tested materials, as a function of average pressure. One may notice a wider scattering for the higher pressures for all materials but absolute values of the scattering interval are significant for the polymer.

3.2. Friction coefficient

Sliding regime may be considered EHD as friction coefficient was very low for all tests (\( \mu < 0.08 \)). Theoretical models demonstrated that very thin water film might be obtained on whole or partial contact [11, 14].

At low pressure, the friction coefficient seems to be greater (fig. 3) and this could be explained by the poor lubricant properties of water (very low viscosity, especially), the regime may be considered mixt, with zones of wet, or even direct contact migrating on the whole contact region [7, 11].

For PTFE, the friction coefficient has no significant evolution for the same average pressure, especially at starting, pointed out this
material is recommended when a system starts and stops frequently. This recommendation must also take into account wear parameters. As one may notice from figure 2, wear of PTFE sharply increases after an average pressure of 1.5MPa.

4. CONCLUSIONS

Analysing the mechanical properties given in figure 1, one may notice that traction limit can not characterise the tribological behaviour of these materials. PTFE has the highest value of this parameter but also the poorest tribological behaviour under tested conditions. […]

For composites with polymer matrix testing under similar conditions to the application ones, is the best way to evaluate tribological behaviour. Mechanical properties could not reflect an actual hierarchy from tribological point of view.

REFERENCES