FRETting BEHAVIOUR OF PACVD DEPOSITED DLC COATINGS AGAINST DIFFERENT COUNTER BODIES

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ABSTRACT
The aim of this study was the investigation of the fretting wear of industrial and newly developed multi-layered coatings. The tribological behaviour of flat DLC coated specimens was investigated in fretting mode I and fretting mode II against different ball counterbodies namely, corundum, 100Cr6, and DLC coated 100Cr6 using a broad range of strokes, frequencies, and loads. From Fretting I a dependency of the wear behaviour with the type of DLC coating, and an influence of the normal load with the coefficient of friction was observed. Using Fretting mode II, an attempt was made to study the fatigue and toughness properties of the coatings.

INTRODUCTION
The fretting behavior of DLC coatings is a complex process that involves the interaction of various chemical and physical phenomena during a small amplitude-displacement oscillatory motion between two solids in contact. The material response is dependent on the loading conditions (displacement amplitude, normal loads) where cracking is induced by surface fatigue and wear by debris formation. In this study three industrial Bekaert coatings were evaluated with respect to their behavior in fretting mode I and II.

EXPERIMENTAL
The principles and relevant test parameters (stroke, frequency and load) ranges of fretting mode I and II are shown in figure 1. Under fretting mode I a ball counterbody (point contact) is forced onto the flat sample at a normal force applied by means of springs. The counterbody materials used were: corundum, 100Cr6, and DLC coated 100Cr6. The DLC-coated samples are oscillating horizontally with a certain amplitude and frequency. Fretting mode II consists of dynamic loading, also with a ball counterpart, of the coating system. The main properties of the coatings investigated are shown in table 1.

Figure 1: Fretting mode I and fretting mode II

- Normal load: 1 – 20 N
- Frequency 10 Hz
- Distance 100 µm
- Cycles: 50k – 100k
- Ball diameter: 5, 10 mm
- 50 %RH, Temp.: 23°C

- Static load: up to 230 N
- Dynamic load: up to 200N
- Frequency: 50 Hz
- Cycles: up to 30M
- Ball diameter: 10 mm
- 50 %RH, Temp.: 23°C
Table I: Coatings investigated

<table>
<thead>
<tr>
<th>Chemistry</th>
<th>Dylyn®/DLC</th>
<th>Cavidur®-n</th>
<th>Dylyn®-Plus</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>a-C:H:Si:O/</td>
<td>a-C:H:Si:O/</td>
<td>a-C:H:Si:O/</td>
</tr>
<tr>
<td>Hardness (GPa)</td>
<td>23</td>
<td>24</td>
<td>20-23</td>
</tr>
<tr>
<td>Layer thickness (µm)</td>
<td>2-4</td>
<td>2-4</td>
<td>2-4</td>
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<tr>
<td>Sliding ball on disk (dry, 100Cr6 ball)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wear factor (mm³/Nm)</td>
<td>10x10⁻⁸</td>
<td>5x10⁻⁸</td>
<td>5x10⁻⁸</td>
</tr>
<tr>
<td>Coeff. Of Friction</td>
<td>0.05</td>
<td>0.1</td>
<td>0.1</td>
</tr>
</tbody>
</table>

RESULTS

The fretting mode I results showed a different behavior for the corundum ball against the different coatings. Figure 2 displays the wear volume as a function of the dissipated energy. The latter parameter has the advantage that can be used to correlate various tribological, which does not happen with the product of the normal force with the sliding distance from Archard wear rate. It is observed that Dylyn®/DLC and Dylyn®-Plus exhibited a higher wear rate coefficient (µm/J – wear volume/dissipated energy) than the Cavidur®-n coating.

Figure 2: Fretting wear against corundum

The effect dissimilar counterbodies on the wear rate of Dylyn®/DLC coating was investigated. The main observation was the very reduced wear rate of a DLC versus DLC surface in comparison to corundum or steel, as is shown in Figure 3.

Figure 3: Comparison of Dylyn®/DLC against different counterbodies.

Beside the wear rate also the coefficient of friction versus number of cycles was monitored. Here one can notice the influence of the normal load and also the change in function of time (or # of cycles) (see Figure 4 and 5). This might indicate a change of the wear mechanism in function of time and/or load.

Figure 4: Dylyn®/DLC vs Dylyn®/DLC at a normal force of 2N.

Figure 5: Dylyn®/DLC- vs Dylyn®/DLC at a normal force of 5N.

The fretting mode II results at a maximum load of (230 ± 200 N) showed that wear occurred only at the counterbody without any visible damage to the different coatings.

CONCLUSION

Fretting mode I showed different behavior of various coatings and allows to make a distinction between the wear rate of these coatings. Two groups of coatings can be distinguished, however, explanation about these phenomena is lacking and additional characterization of the wear tracks will be carried out.