Influence of lubricant additives and SRR in tribofilm generation

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**Subject:**
The reaction pathways of lubricant additives under various sliding conditions as well as the tribofilm properties and morphology have become an important subjects of research.

- AFM and spacer layer imaging methods combined with the rolling-sliding Mini Traction Machine (MTM) have shown that lubricants containing calcium detergent form tribofilms at 50% Slide-to-Roll Ratio (SRR)\(^a\). Recently, the combination of MTM and Auger Electron Spectroscopy (AES) depth profiles has produced similar results with a formulated oil containing five additives, including a calcium detergent.\(^b\) The authors have also shown that tribofilms can be formed at much lower SRR. These tribofilms increase the friction coefficient compared with the pure base oil value. The rate of friction coefficient increase augments with the SRR.

- The work presented here compares the results of 5h tests performed with base oil (BO) and the formulated lubricant (formulated lubricant, FL) in terms of friction coefficient, topography and chemical composition for various SRR. The influence of SRR and the presence of additives are investigated.

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**Mini Traction Machine**

<table>
<thead>
<tr>
<th>SRR*</th>
<th>&lt;1, 1, 5 and 25%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Speed</td>
<td>100 mm/s;</td>
</tr>
<tr>
<td>Temperature</td>
<td>80°C;</td>
</tr>
<tr>
<td>Max Hertz Pressure</td>
<td>890 MPa;</td>
</tr>
<tr>
<td>Minimum film thickness</td>
<td>11nm</td>
</tr>
<tr>
<td>λ</td>
<td>0.95; 5h</td>
</tr>
</tbody>
</table>

**Ex situ surface analyses**

The same chemical components are detected in the rolling track on:
- Two balls from 2 different tests
- A pair ball and disc from the same test

**AFM** topography

- Roughness inside the wear track = Roughness outside
- Tribofilm (25%, FL)
- Thickness \(\approx 30\) nm

**Conclusion**
The tribofilm:
- is generated only in the rolling track.
- forms even at very low SRR.
- increases friction coefficient but does not modify surface roughness.
- chemical composition is identical on both ball and disc in contact during an MTM test.
- chemical composition is identical at all SRR.

Friction coefficient increases when SRR augments.

Film thickness evaluated by AFM and AES depth profiling are similar. It seems that the film thickness reaches a maximum at 5% SRR.