A MICRO-IRRAS STUDY OF LUBRICANT DEGRADATION UNDER THIN FILM CONDITIONS

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ABSTRACT
This paper studies lubricant degradation in a rubbing contact under thin film conditions. Friction tests have been carried out in an MTM test device using a steel ball/steel disc configuration. The tests were run with a small amount of lubricant present. At the end of the test the disc was retained for analysis. Micro-reflection FTIR spectroscopy was used to analyse the lubricant chemistry within and close to the rubbed track. The technique offers a more direct method for studying lubricant degradation products during rubbing. The results are compared to those from more conventional experimental methods.

INTRODUCTION
Many rubbing contacts function with a restricted amount of lubricant present, which can increase the severity of the contact conditions and thus promote lubricant degradation. However, most studies of lubricant degradation and additive layer formation have been with fully flooded systems where there is an excess of lubricant. It can also be difficult to analyse the products of these reactions both on the surface and in the lubricant as they are dispersed in the excess fluid. In the current study oil degradation and additive film formation have been studied under reduced lubrication conditions. Friction tests were run with a ball-on-flat device with a limited amount of lubricant present. This was to promote degradation of the lubricant through the increased availability of oxygen and increased severity of the rubbing interface. At the end of the test a micro-IRRAS (InfraRed Reflection-Absorption Spectroscopy) technique (1)(2) was used to analyse the lubricant condition within and close to the rubbed track. The reduction in the lubricant also ensures that degradation products are concentrated within or close to the track. A micro-IRRAS technique can therefore be used to analyse these products directly from the surface without resorting to solvent washing to remove excess lubricant. Three lubricant systems have been studied: simple base oils (paraffinic and ester), solutions of zinc dialkyldithiophosphate and a friction modifier (copper oleate).

EXPERIMENTAL PROGRAMME
Friction test were carried out in a ball-on-flat device (MTM device PCS Instruments), the test conditions are summarised below in Table 1. At the end of the test the disc was retained for IR analysis. A Perkin Elmer FTIR spectrometer coupled to Multiscope IR microscope was used to take spectra from small areas (100 µm diameter) of the disc surface both in and out of the rubbing track. The disc was not solvent cleaned before analysis.

<table>
<thead>
<tr>
<th>Max contact pressure</th>
<th>1.0 GPa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean speed</td>
<td>100 mm/s</td>
</tr>
<tr>
<td>Slide-roll ratio</td>
<td>50%</td>
</tr>
<tr>
<td>Temperature</td>
<td>100ºC</td>
</tr>
<tr>
<td>Time</td>
<td>4 hours</td>
</tr>
<tr>
<td>Lubricant sample size</td>
<td>0.003g</td>
</tr>
</tbody>
</table>

Table 1 MTM test conditions

RESULTS AND DISCUSSION
IR spectra from a friction test with a poly-α-olefin are shown in Figure 1. IR spectra were taken from the lubricant film within the track and at the edge of the disc. A spectrum from an oil sample thermally aged in a static test is also shown. The track spectrum is heavily degraded and shows evidence of extensive oxidation with new absorbance bands between 1500-1700 cm⁻¹. The oxidation pattern is significantly different to that of the thermally aged sample.
CONCLUSIONS

The paper reports the application of a micro Infrared Reflection spectroscopy technique to the study of lubricant degradation under thin film conditions. Limiting the amount of lubricant available ensures that the test runs under semi-starved or thin film conditions. This increases the severity of the test and availability of oxygen thus promoting degradation of the lubricant. A second advantage is that degradation products are concentrated close to the track and can be analysed without resorting to solvent washing to remove excess lubricant.

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REFERENCES