1. Introduction

Engine lubricants are exposed to a wide range of contaminants in their operating environment, and the type and level of these contaminants can cause wear and deterioration of the engine. The lubricants used to lubricate machinery, ships, airplanes, and other equipment with internal combustion or turbine engines play an important role in lubrication, cooling, cleaning, and rust prevention for vehicles, construction machinery, ships, airplanes, and other equipment with internal combustion or turbine engines. As the lubricant degrades due to use and wear, the lubrication performance will decline and the inside of the engine can wear, leading to a decrease in service life and potential engine malfunction. Lubricants deteriorate due to decomposition and chemical reactions, and it is recommended to analyze the lubricant throughout its lifespan to ensure optimal performance.

2. Molecular deterioration analysis

The molecular deterioration of lubricants can be analyzed using infrared spectroscopy. Infrared spectroscopy provides spectral data that reflect the molecular structure of a substance. By the analysis of the spectra, various chemical changes in the lubricant can be detected. The analysis of pure lubricants is straightforward, but the analysis of lubricants in-use can be challenging. The use of FT-IR (Fourier Transform Infrared) spectroscopy is a powerful technique for the analysis of lubricants due to its high sensitivity and specificity.

3. Soot and particulate analysis

Soot and particulates are major components of lubricant deterioration and can be detected using FT-IR spectroscopy. In this study, the soot content of the lubricant was analyzed using a combination system of IRSpirit and Pearl Liquid Analyzer. The results showed that the soot content was lower in the samples analyzed compared to the reference samples.

4. Conclusions

The IRSpirit FT-IR with various accessories stage enable the simple, rapid analysis of lubricating oils to provide timely and accurate information about the condition of the lubricant. With its small form factor, the IRSpirit can easily fit onto the benchtop, without major overhauls to existing setup. The IRSpirit is compliant with industry standard test methods, such as ASTM E2412. With the combination of IRSpirit and QATR-S, quick quantification of soot within the lubricant is enabled. The IRSpirit provides reliable and accurate results, making it a valuable tool for condition monitoring.

Table 1: Example of lubricant analysis accuracy for IRSpirit, QATR-S, and FT-IR.

<table>
<thead>
<tr>
<th>Sample</th>
<th>IRSpirit</th>
<th>QATR-S</th>
<th>FT-IR</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.007</td>
<td>0.008</td>
<td>0.01</td>
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<tr>
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<td>0.008</td>
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</tr>
<tr>
<td>3</td>
<td>0.009</td>
<td>0.01</td>
<td>0.01</td>
</tr>
</tbody>
</table>

Table 2: Spectra of 10 repeated analyses for samples with 0.20 mass % soot (top) and 3.93 mass % soot contents (bottom).

Figure 1: Typical curves of engine oil contamination.

Figure 2: Spectra of 10 repeated analyses for samples with 0.20 mass % soot (top) and 3.93 mass % soot contents (bottom).

Figure 3: Spectra of 10 repeated analyses for samples with 0.20 mass % soot (top) and 3.93 mass % soot contents (bottom).

Figure 4: Spectra of 10 repeated analyses for samples with 0.20 mass % soot (top) and 3.93 mass % soot contents (bottom).

Figure 5: Spectra of 10 repeated analyses for samples with 0.20 mass % soot (top) and 3.93 mass % soot contents (bottom).

Figure 6: Spectra of 10 repeated analyses for samples with 0.20 mass % soot (top) and 3.93 mass % soot contents (bottom).

Figure 7: Spectra of 10 repeated analyses for samples with 0.20 mass % soot (top) and 3.93 mass % soot contents (bottom).