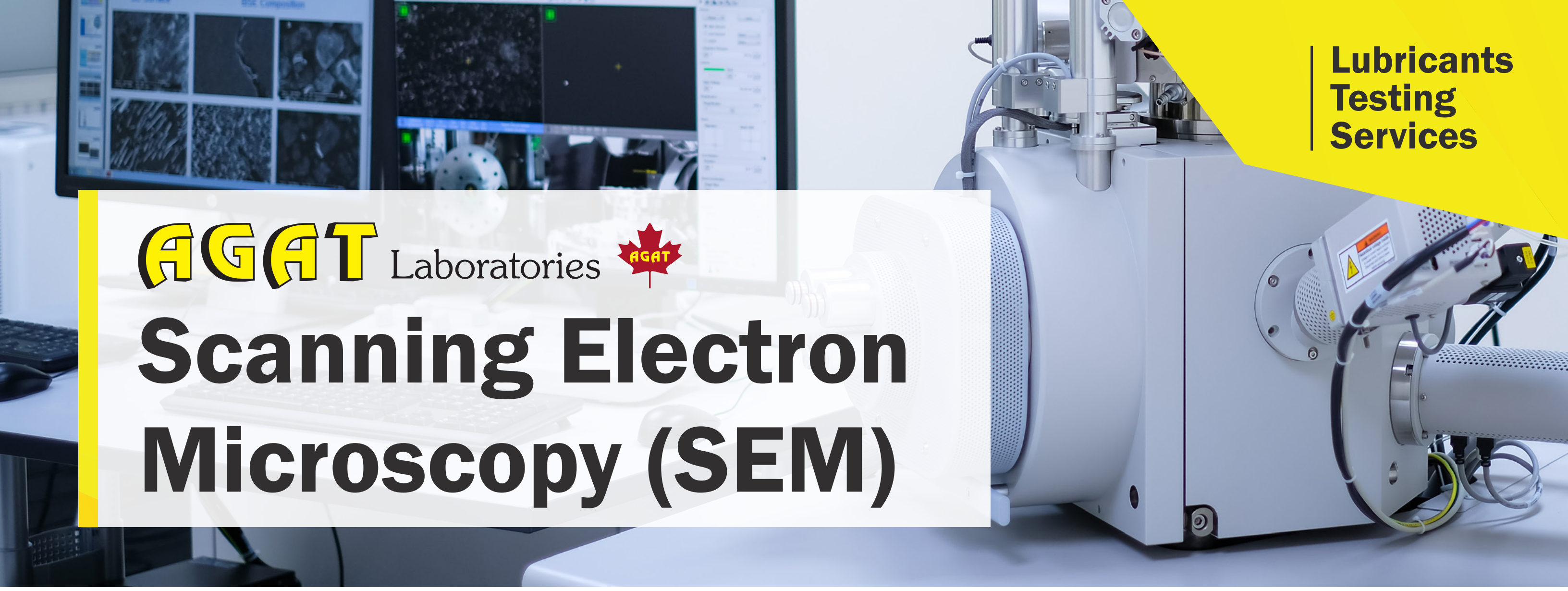

Lubricants Testing Services

AGAT Laboratories

Scanning Electron Microscopy (SEM)

SEM Technology

Scanning Electron Microscopy (SEM) has long been used by geologists in mining, oil and gas production and other industries to evaluate formulations and to determine elemental analyses for the purposes of calculating the viability of various mineral or crude deposits. The use of SEM can assist maintenance and engineering personnel in determining the root cause of failure in both plant and mobile machinery.

Submit a Sample

Diagnosis of machinery failure starts with analyzing a small sample of the metal components to be observed using the SEM. For example, samples may include a piece of a sleeve bearing, a piece of a piston ring, or the component or small surface of a rotating element bearing.

SEM Analysis

SEM is one of the best techniques available to study and document failure patterns and failure analysis. The provided sample is fixed to the equipment and the SEM scans the surface of the sample at high magnification to determine failure types such as abrasion, adhesion, erosion, corrosion and cavitation. Observational information provides evidence as to the probable cause of failure for a given specimen. The Scanning Electron Microscope provides approximately 10,000x's magnification and a greater depth of field than can be experienced by conventional macroscopic analysis. SEM provides a 3D-image of the sample through the use of secondary electrons that are generated by the sample after being bombarded by electrons. Elemental analysis can also be performed using an Energy Dispersive X-Ray (EDX) attachment. EDX is used to identify various precipitates or elements that can form on the specimens. X-ray diffraction can be used to support conclusions such as foreign deposits on pistons, mechanical seals, gears or components to be evaluated for the elements found within.

Caterpillar Engine Cam Shaft Sleeve Bearing Failure

Initial Investigation

The camshaft sleeve bearings were found to be severely pitted. Large particles broke away and a costly failure occurred.

Possible Cause

Cavitation erosion caused by the formation of oil vapour bubbles in low pressure areas and the collapse of those bubbles in higher pressure areas.

SEM Findings

Confirmed that as the initial pitting and material removal continued due to cavitation erosion, larger scale pits/pores developed. This caused a deeper penetration of the vapour bubbles, which resulted in further fracture creation and propagation as well as the large scale removal of bearing material.

Conclusion

This type of failure can occur on diesel engine cam shaft sleeve bearings under high speed and/or high load conditions.

Caterpillar Diesel Engine Bearing Failure

Initial Investigation

The crankshaft bearings were found to be in various states of abrasion.

Possible Cause

Deep scoring and discoloration suggested that high levels of dirt had either severely scratched or become embedded into the soft overlay of the bearings.

SEM Findings

Confirmed deep scoring on the bearing surface combined with foreign material embedded in the bearing surface at random locations. These foreign materials are irregular in shape and showed different colour variations in response to electron bombardment.

Conclusion

These colour variations indicated foreign material of different composition and type.

Tapered Roller Bearing Failure, Final Drive Application

Initial Investigation

Discoloration and severe spalling of the bearing.

Possible Cause

The condition suggested fatigue spalling with possible rust development. However, the oil analyzed for water content and results were negative.

SEM Findings

Confirmed that the severe spalling of the bearing was not due to fatigue. This was evident by the rather smooth surfaces of the damaged areas. Normally, fatigue spalling causes sharp and/or jagged edges to the spalls.

Conclusion

The more smooth spalls that developed indicate the occurrence of strong acids which resulted from excessive water in the oil that had evaporated during a period of hot shutdown just prior to equipment storage. The bearing cones showed similar spalling conditions, though only on the inner race surfaces that were above the surface of the oil.

Caterpillar Diesel Engine Piston, Ring and Liner Failure

Initial Investigation

The Piston failure resulted in a scored cylinder liner and ring sticking condition.

Possible Cause

The owner had been using an after-market oil conditioner to reduce friction and the engine manufacturer refused warranty on that basis.

SEM Findings

Confirmed large deposits of carbon and soot material. Further analysis of these carbon/soot deposits using X-ray Energy Spectroscopy showed the elements; iron, sodium, magnesium, phosphorus, sulphur, calcium and zinc. The high level of sulphur indicated unburned fuel and this supported an initial suspicion that a fuel leak had occurred, washing past the piston ring area. This condition accounted for the ring sticking and eventual piston failure.

Conclusion

Since the remaining elements are indicative of the normal additives found in diesel engine oils, there was no evidence that any foreign or incompatible after-market additives had been the cause of failure.

For more information please contact
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