2nd VegOil

Demonstration of 2nd Generation Vegetable Oil Fuels in Advanced Engines

Workpackage WP4

Engine Oil Development

Deliverable N° 4.10a:

Sensor provision

Version: 2

Hazelwood, 20th August 2009

prepared by:

Simon Peal, Dr. Craig Jones

Lubrizol Limited, The Knowle, Hazelwood
Tel.: +44 1332 842211
Fax.: +44 1773 551911
Email: craig.jones@lubrizol.com
Partner website : www.lubrizol.com
Project website : www.2ndVegOil.eu

This publication has been produced with financial support of the European Commission in the frame of the FP7 Seventh Framework Programme under the grant agreement N° TREN/FP7EN/219004/"2ndVegOil".

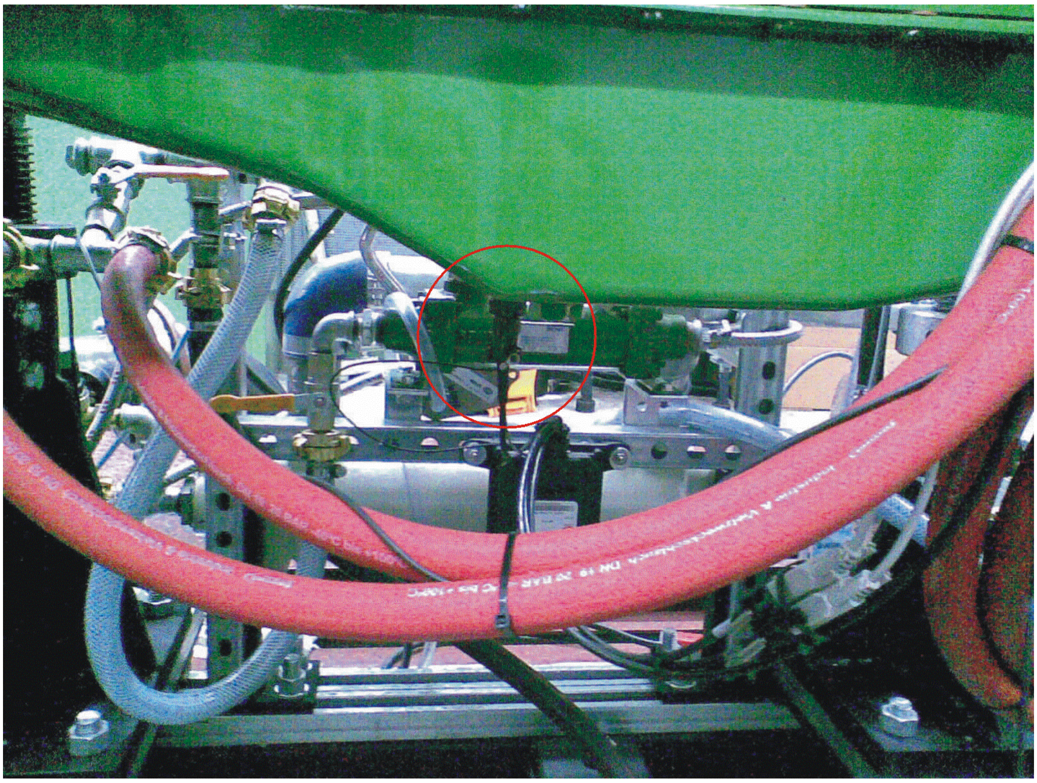
TABLE OF CONTENTS

1 Summary

One lubricant condition monitoring sensor each have been sent to LVK – TU-Munich and to John Deere Mannheim respectively. The sensors are now installed on John Deere test engines and are logging data on lubricant condition. Below is a photograph of the sensor installed at LVK – TU-Munich.

Lubricant Sensor on Test Stand 2/3

TECHNISCHE UNIVERSITÄT MÜNCHEN



2 Description of Sensor Operation

The Quality Diagnostic System (QDiS™) sensor supplied for the 2nd VegOil project determines lubricant condition, that is, the lubricant's ability to provide the desired engine life and fuel economy, in real-time by trending lubricant electrical properties as a function of engine use. Specifically, the sensor sequentially applies voltages to the lubricant at three frequencies, defined as high, medium and low frequency, and measures the electrical response to each applied signal. The measured responses are a function of both the lubricant condition and the lubricant temperature; hence, in addition to measuring responses to the applied signals, the sensor measures the lubricant temperature with each response and compensates the responses to a fixed "normalized" temperature. The compensated responses are then trended as a function of engine operating time from fresh-lubricant fill until lubricant drain (a drain interval) to diagnoses the following lubricant functionalities.

Sliding-friction reduction   Lubricants provide a hydrodynamic film that separate engine components as they move relative to each other. Viscosity is the typical property used to determine if a lubricant's hydrodynamic film is "thick" enough to adequately protect engine components from wear but not so thick that fuel economy is lost due to excessive energy needed to shear the film. There currently are no proven on-board, real-time viscometers that are accurate and cost effective. Hence, instead of measuring viscosity, the QDiS™ sensor's high-frequency-response cost-effectively monitors contaminants that directly affect the lubricant's ability to form an appropriate hydrodynamic film. High-frequency response trend varies as a function of the amount and type of contaminants. In general, the major contaminant in a diesel engine lubricant is soot; however, there can also be fuel contamination (also known as fuel dilution) caused by poor combustion of the fuel in the engine's cylinders, water due to condensation in humid environments or water/coolant due to a coolant leak, and by-products that occur as the lubricant oxidizes with age and temperature. The QDiS™ sensor uses high-frequency relative magnitude and change-rate condemnation thresholds to determine when a lubricant needs replacement due to contaminants and to provide warnings if an abnormal event occurs such as a coolant leak.

Contaminant control   Since contaminant build-up during use is inevitable during engine use, the lubricant must minimize the effect of those contaminants on engine performance and life. A lubricant's contaminant control functionality determines how well the contaminants are dispersed and suspended to minimize their effect on the lubricant's hydrodynamic film, how well contaminants are cleaned from engine components, and how well acids from combustion blow-by and lubricant degradation are neutralized. In general, contaminant control is a function of detergent and dispersant additives in the lubricant formulation. The QDiS™ sensor's medium frequency response is associated with the interactions that provide the contaminant control functionality. Trending the response allows diagnosis of the remaining contaminant control effectiveness. If a lubricant loses contaminant control functionality before the contaminants reach the high-frequency condemnation thresholds described above, then engine damage can occur due to increase wear, deposits formation or possibly catastrophic failure. The QDiS™ sensor uses medium-frequency relative magnitude and change-rate condemnation thresholds to diagnose when a lubricant needs to be replaced due to contaminant control loss and to provide warning if harmful deposits may be forming in the engine.

Surface protection   Not all engine friction is sliding friction. At piston reversals and engine start, there is no hydrodynamic film to protect surfaces. Hence, a major lubricant functionality is to protect surfaces from a wide range of influences that occur in the engine including static friction. All engine lubricants are formulated with surface-active chemical compounds that can include anti-wear agents, corrosion inhibitors, friction modifiers and others. Those additives are consumed with engine use and when depleted component wear rates increase resulting in reduced engine performance and life. The QDiS™ sensor's low frequency response to a signal applied with an offset voltage is associated with the interaction of the additives and the metal surfaces. The QDiS™ sensor uses a relative low-frequency magnitude condemnation threshold to diagnose when a lubricant needs to be replaced due to surface protection.

Hence, the patented QDiS™ sensor trends temperature-compensated responses to three applied electrical signals to diagnose the lubricant's ability to provide the appropriate hydrodynamic film, contaminant control and surface protection for desire engine life and performance. When comparing the QDiS™ results with traditional "off-line" laboratory analyticals of samples removed during a drain interval, the high-frequency trend correlates well with measures of contaminants, soot typically with a diesel engine, and viscosity, the medium-frequency trend typically correlates well with the total-base-number (TBN), and the low frequency trend typically correlates well with antioxidants as measured by RULER® and relative-values of the low-frequency response below the condemnation threshold correlate well with a rate increase of the wear metals, in particular iron wear metal. The medium-frequency trend does not always correlate well with TBN since TBN measures only one aspect, acid neutralization, of the contaminant control functionality of the lubricant. Hence, when the medium-frequency trend and TBN are not fully consistent then analytical measures of all contaminants, for example fuel, are considered in the comparison. The low-frequency trend does not always correlate will with the RULER analyticals since RULER measures antioxidants in the bulk lubricant and there can be significant differences between depletion of bulk additives and surface additives. Hence, comparison of the metal wear rates and low-frequency is better measure of surface protection.

In summary, when the QDiS™ sensor's diagnosis that the lubricant needs to be replaced at the end of its useful life, that is consistent with an objective diagnosis based on all laboratory analyticals. When the QDiS™ sensor diagnosis an abnormal event has or is occurring, for example a coolant leak or possible deposits, that is consistent with the abnormal event being detected in laboratory analyticals.

Appendix A

List of Acronyms

QDiS™ - Quality Diagnostic System