Online monitoring of the oil acidification using a chemical sensor measuring corrosiveness

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Abstract

Chemical corrosiveness sensors based on capacitively coupled electrodes were used to determine the corrosiveness of lubricants. Thereby, a sacrificial layer is immersed into the oil and the material loss due to corrosion is monitored by measuring the capacitive coupling between sacrificial layer and readout electrodes. The online applicability of the chemical sensor was investigated by artificial alteration experiments of selected oils in the laboratory. The usefulness of the sensor concept is illustrated by field trials. The results showed that critical amounts of acidification initiated the accelerated corrosion of the sacrificial layer.

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1. Introduction

Acidification is a crucial parameter for the evaluation of the condition of lubricating oils, for instance in stationary engines driven by gaseous bio fuels. Here, acidification is considered as the main indicator for an oil change. For this reason, the online monitoring of the engine oil’s acidification by means of a chemical corrosiveness sensor is proposed. Previous concepts were based on the measurement of the electrical resistance of a metal film [1-3]. For example, a novel readout method was presented [2] which measures corrosiveness without electrical contact using capacitively coupled planar electrodes. The material loss due to corrosion was continuously monitored by measuring the capacitive coupling between the sacrificial layer and the readout electrodes. In this paper, the fundamental behaviour of the

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The corrosiveness sensor is evaluated in laboratory experiments by integrating the sensor in artificial oil alteration [4]. The usefulness of the proposed sensor concept is also illustrated by results from corrosiveness sensors installed in stationary gas engines. The results of laboratory experiments and field trials are discussed in comparison with conventional oil parameters like acid number.

2. Sensor design

The schematic setup of the chemical sensor for online measurement of oil acidification using capacitively coupled electrodes is shown in Fig 1. The chemical sensor consists of a sacrificial element and the sensor body. The sacrificial element was prepared from a metal film deposited on a ceramic substrate as nonconductive carrier. Lead with a thickness of 600 nm as metal film is applied for these evaluations. After these fabrication processes, the metal film is covered with a protective lacquer to avoid an undesired surface passivation by air during storage (prior use). The sensor body – including the readout electrodes – is connected with the sensor cap for fixing the sacrificial element to the sensor body.

Fig. 1. Schematic setup of the chemical sensor for online monitoring of oil acidification using capacitively coupled electrodes. Sensor is positioned in a beaker filled with lubricant.

3. Results

3.1. Online condition monitoring in laboratory

The online applicability is investigated by integrating the corrosiveness sensor in an artificial oil alteration set-up [4]. Thereby, the oil is stressed under high temperature and blowing of air through the oil (“alteration – air”) to significantly change the oil properties in short time periods. The second method “alteration – biogas” is based on the method “alteration – air” adjusted to simulate the impact of biogas on accelerated oil degradation. Fig. 2 shows the sensor signals during oil alteration. Alteration with air (blue curve, low acidification) as well as alteration with biogas (green curve, higher acidification) give characteristic sensor responses: higher acidification necessitates an earlier oil change which is clearly indicated by the corrosiveness sensor by the earlier observation of significant increase of the sensor signal.
3.2. Field trials

The usefulness of the sensor concept is also illustrated by results from corrosiveness sensors installed in stationary gas engines. Fig. 3 exemplarily shows the trend of the online corrosiveness sensor signal for one engine oil in a gas engine driven with wood gas. It can be seen that the increase of the sensor signal occurs after about 750 h. Complete loss of the sacrificial layer is achieved after about 1300 h offering sufficient time to the engine operator to prepare an oil change.

3.3. Comparison of sensor signals with laboratory analyses

The sensor for online monitoring of the oil acidification shows in laboratory experiments and at field trials a significant increase of the signal after a specific time. Therefore it can be concluded that the sacrificial layer is corroded at a critical amount of acid in the oil. The comparison of the sensor signal with acid number (AN, DIN 51558-1 (1979)) determined in the laboratory from oil samples taken during the experiments is shown in Fig. 4. It can be seen that in all experiments – both artificial oil alteration and
field trial – the critical amount of acid equals AN of about 2 - 2.5 mg KOH/g. Significant onset of corrosion of the sacrificial layer is noticed by a sharp increase of the sensor signal when the degree of oil degradation reached this amount of acid.

Fig. 4. Comparison of signal of corrosiveness sensor with acid number of taken oil sample from the experiments.

4. Summary

The concept of the corrosiveness sensor presented is suitable for the indication of the impact of biofuel quality on the engine oil condition. It is concluded that the corrosiveness sensor is appropriate for online condition monitoring in engines as pre-warning system for an oil change caused by a critical amount of acid content.

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References