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Abstract

Gas Sensors: A Non-Contact and Non-Invasive Solution for Checking the Hydraulic Fluid Degradation †

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Abstract: Chemiresistive gas sensors based on metal oxide (MOX) semiconductors are attractive devices used to detect gaseous compounds in many applications. In fluid power systems, they could be exploited to monitor the odor changes of the hydraulic fluid that occur with aging. In this work, an extensive investigation has been performed for many kinds of hydraulic fluids aged in different conditions with the aim to develop a portable device to be installed in every system for performing predictive maintenance increasing system efficiency, reliability, and sustainability.

Keywords: TiO_2 gas sensors; thick film gas sensors; hydraulic fluid degradation; fluids and eco-fluids; predictive maintenance; component efficiency

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1. Introduction

The main reason for the failure of fluid power systems is the unavoidable degradation of the hydraulic fluid (HF) caused by high temperature, friction, contaminations by particles, and water. The failure entails a drop in machine reliability, a leakage of pollutant materials, and an expensive, not planned machine stop. Thus, the continuous monitoring of HF is essential. However, the fluid, generally constituted by a base (mineral, synthetic, or biological) and many additives, is a system characterized by a large number of chemical-physical properties (viscosity, density, oxidation level, etc.) that change with oil aging [1]. For this reason, the monitoring of the fluid degradation is a challenging task that also takes into account the lifetime of the device due to the contact with the fluid.

In this work, an extensive investigation has been performed considering many kinds of hydraulic fluids aged in different conditions to validate the previously proposed methodology [2] tested for a mineral standard oil. The methodology aimed to study the correlation between the fluid aging and the responses of MOX gas sensors toward the analytes' concentrations fluid headspaces. The final goal is to realize a new low-cost, small-size, easy-to-use device based on MOX sensors [3] for the monitoring of hydraulic fluid aging directly on the machines, guarantying a non-contact and non-invasive solution, particularly suitable for the fluid power environment.

2. Materials and Methods

By exploiting the realized instrumentations and the results reported in Ref. [3], for this work, other sensors based on tailored materials were realized, starting from the chemical synthesis of nano-oxides. The thick film technology was used to prepare the MOX sensors, ensuring low cost, small size, easy use, and versatility of the final sensor device.

Different kinds of hydraulic fluids (mineral, synthetic, and biological) have been taken into account and artificially aged in different conditions (by using a specific hydraulic test bench [3], the method and instrument described in ASTM D 2272-14a, etc.). The fluids samples were characterized through chemical-physical analysis, such as the measurements of viscosity and total acid number (T.A.N.), as well as the recording of FT-IR spectra, to check the state of the fluids before studying the profile of volatile organic compounds (VOCs) present in their headspaces by applying gas chromatography-mass spectrometry (GC-MS) and the dedicated semi-automatic laboratory MOX sensor system. Finally, preliminary tests using a disc-on-disc tribometer and different HF were performed in an online experimental setup.

3. Results

The main result was that the methodology was suitable for each kind of tested fluid that was aged in different conditions. Some tested sensors offered good responses toward the fluid headspace analytes of all tested fluids, suggesting the possibility of using the same sensor device for the monitoring of different fluids simply by calibrating the sensor. In addition, for the same fluid, different sensor responses were observed for different aging conditions, thus confirming the possibility of distinguishing the samples as well as their aging process.

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