Development of a Micro Sensor for Monitoring Thermal Properties of Oil/Refrigerant Mixtures

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This work reports development of a thin-film micro sensor to measure the thermal properties of lubrication oil/refrigerant mixtures in real time. The intended use of the sensor is real-time monitoring of the oil in the industrial refrigeration system, such as detection of the oil-level and composition in a compressor. The micro sensor, embedded in a lubricated component of a refrigeration system, measures the thermal conductivity and heat capacity of the surrounding fluid simultaneously, which can be correlated with the state of the lubrication oil. The thermal sensor is fabricated using a metallic thin-film heater deposited on a glass substrate using a standard microfabrication technique. The measurement scheme employs an AC thermal-sensing technique based on the 3-omega method. Experimental results show that the sensor is sensitive enough to detect the composition of the oil, i.e., the dissolved refrigerant content in the oil. Notable is that the performance of the sensor is insensitive to the flow conditions, unlike the conventional DC thermal sensors. The sensor therefore is thus capable of measuring the thermal properties even in the presence of a strong turbulence flow, which is believed to be due to the small thermal penetration depth. Consequently, the sensor along with the proposed sensing technique is expected to be used in various potential applications involving thermal property measurement under flow conditions as well as oil monitoring in industrial lubrication systems.