Detection Technique for small metal contaminants in oil using HTS-SQUID

*Taiki Hino[1], Takahito Omoto[1], Ayumu Kihara[2], Yoshimi Hastukade[1, 2], Masahiko Kawabata[3]

[1]*Graduate School of System Engineering, Kindai University, Higashi-Hiroshima-City, Hiroshima 739-2116,*

[2]*Japan Faculty of Engineering, Kindai University, Higashi-Hiroshima-City, Hiroshima 739-2116, Japan*

[3]*TRIBOTEX Co., Ltd., 45-7 Nagakusa-Machi Yamaguchi, Obu, Aichi 474-0052, Japan*

Abstract

Real-time detection of small metal contaminants with diameters ranging from a few to several tens μm in lubricating oils is expected. This detection requires high sensitivity, high spatial resolution, and high temporal resolution, which can be provided by an HTS-SQUID magnetic sensor. For the detection of magnetic metal contaminants, magnetization of the magnetic metal contaminants is required. On the other hand, HTS-SQUID becomes unstable when it is operated in strong magnetic fields. Therefore, in previous researches on detection of magnetic metal contaminants using HTS-SQUIDs, the magnetic metal contaminants were pre-magnetized and their remanent magnetizations were detected[1)]. Magnetic metal contaminants with a diameter of about several tens μm have been detected using this method, but detecting smaller contaminants requires increase in signal strength.

In this study, we developed a method for detection of magnetic metal contaminants by using a ring-shaped permanent magnets, while placing an induction coil inside the magnets, passing the contaminants through it to detect them in their magnetized state, and transmitting the signal due to the contaminant to an HTS-SQUID using a room-temperature flux transformer. For verifying this technique, we constructed a measurement system consisting of the permanent magnets, the induction coil, the flux transformer, an HTS-SQUID gradiometer module with an input coil, an ADC, a computer, and oil transport equipment. We used the equipment to circulate oil containing magnetic metal microparticles with diameters of 25–32 μm and 50–53 μm through a small tube at a velocity of 1.1 m/s using a rotary pump. We wound a differential detection coil around the tube with total 86 turns and placed two ring-shaped permanent magnets in series around it. The surface magnetic field of the magnets was about 400 mT. The detection coil was connected to the input coil of the SQUID gradiometer, and the SQUID output was recorded on the PC using the ADC at a sampling rate of 0.5 ms. When the oil with the contaminants was circulated at 1.1 m/s, we were able to measure magnetic signals from iron microparticle with diameter of 25–32 μm at an S/N of about 5, as shown in Figure 1.

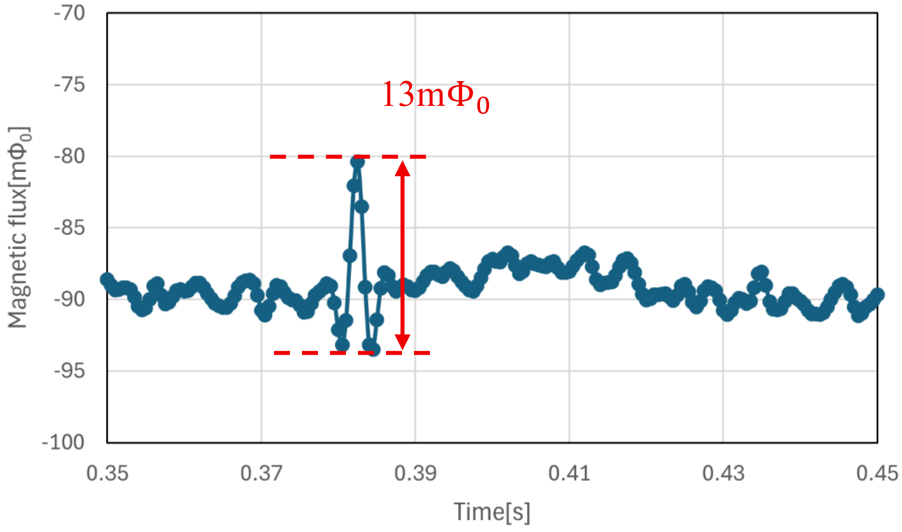

Figure 1 Signal waveform from iron particle with diameter of 25–32 μm

References
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Keywords: HTS-SQUID, contaminant detection, metal microparticles in oil