December 2014 Date of Issue: December 18

Superconductivity Web21

Published by International Superconductivity Technology Center
KSP, Kawasaki, Kanagawa 213-0012 Japan Tel:+81-44-850-1612, Fax:+81-44-850-1613

Feature Article: SQUID Application
- Recent Progress in SQUID Detection System for Metallic Contaminants

Saburo Tanaka, Professor
Department of Environmental and Life Sciences
Graduate School of Engineering, Toyohashi University of Technology

The author and his research group have long since been advancing the development of metallic contaminants detection systems designed for food products. Up to now, a joint R&D collaboration with industry has successfully realized a system incorporating a high-temperature superconducting DC-SQUID for processed cheese block product applications. The system has now been in operation at a food-processing factory for more than ten years. With an aim to design improved reliability, R&D has been progressively initiated via a "The Knowledge Hub of Aichi" project (5yr-term) back in 2011.

SQUID detection, eddy current tests and X-ray methods are currently employed to detect foreign matter contamination in food products. Amongst these methods, eddy current testing is widely employed for food product testing applications. However, its sensitivity is influenced by metallic contaminant conductivity or the conductivity of the food product itself. Although X rays are also a valuable technology and extensively employed, they have a minimum detection limit of around 1mm and have other drawbacks associated with food product ionization, extermination of good bacteria and deterioration in food flavor. These issues can be overcome by employing SQUIDs. The principle of contaminant detection is shown in Figure 1 and is based upon the detection of remnant magnetization of metallic contaminants using a SQUID magnetometer. Figure 2 shows an outline of the system developed in 2014.

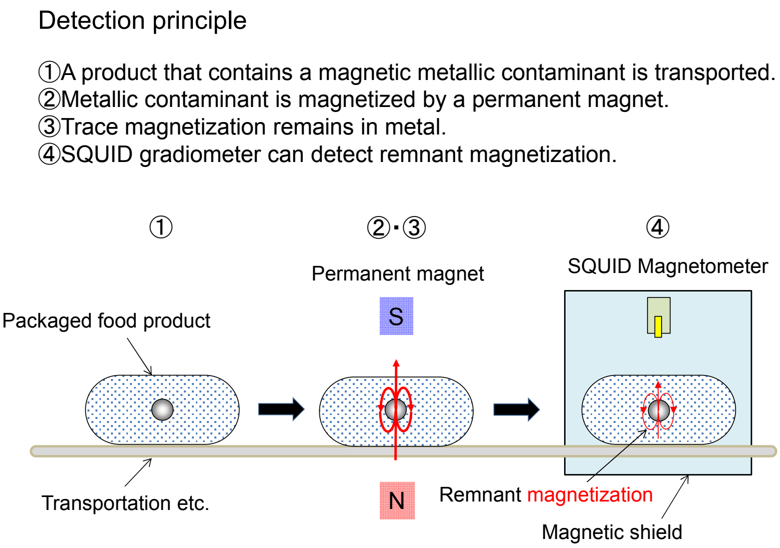

Fig. 1 Principle of contaminant detection

Fig. 2 Appearance of system

December 2014 Date of Issue: December 18

Superconductivity Web21

Published by International Superconductivity Technology Center
KSP, Kawasaki, Kanagawa 213-0012 Japan Tel:+81-44-850-1612, Fax:+81-44-850-1613

With special considerations for practicality and reliability, an RF-SQUID was selected as part of the Aichi prefecture project. High-temperature superconducting SQUIDs require an everyday top-up of liquid nitrogen. Here, some moisture entering the system during liquid nitrogen filling is unavoidable and regular maintenance is therefore necessary to defrost and eradicate the moisture. Cable deterioration and failure cannot be avoided in long-term DC-SQUID operations of more than ten years. Instead, an RF-SQUID comprising of a single coaxial cable is proposed since it performs with relatively greater reliability (cable deterioration over the long term is not clear since there is no installation track record). The magnet was designed having a maximum flux density of 0.34T (0.1T for conventional systems), and exceed 0.3T along all the parts of the 150mm-width belt conveyor. A liquid nitrogen (LN_2) dewar comprising of individual three glass dewars maintained the RF-SQUID temperature at 77K, as shown in Figure 3. In this way the base of the dewar can be further thinned compared to an integrated large dewar, thereby reducing the distance between the magnetometer and the specimen. The outputs from the RF-SQUIDs are recorded with a low pass filter having a 20Hz cut-off frequency and a high pass filter (HPF) having a 0.2Hz cut-off frequency, and later sent to an A/D converter.

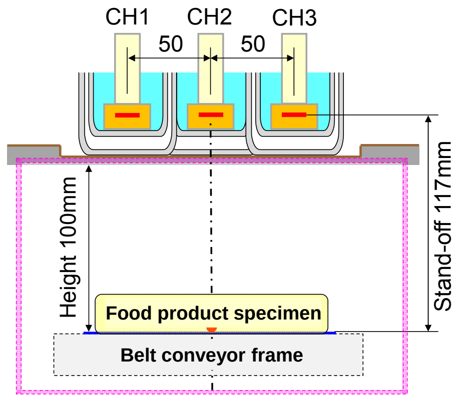

Fig. 3 Cross-sectional diagram of detection system

Figure 4 (a) shows the time-domain magnetic signals from three SQUID magnetometers. These signals were measured when the standoff distance (distance between the iron ball and the SQUID array) was set at 64 mm. The amplitude signal from ch2 is greater than the signal from the other two magnetometers since the iron ball passes just below. A signal to noise ratio (SNR) of >3 was measured for an iron ball larger than ϕ0.4 mm, and a SNR>2 was obtained for a ϕ0.3 mm-iron ball. Figure 4 (b) shows the relationship between the specimen diameter and the measured peak signal amplitude of the SQUID magnetometer. The signal increases three-times the diameter of the specimen, implying that this is proportional to the volume of the specimen.

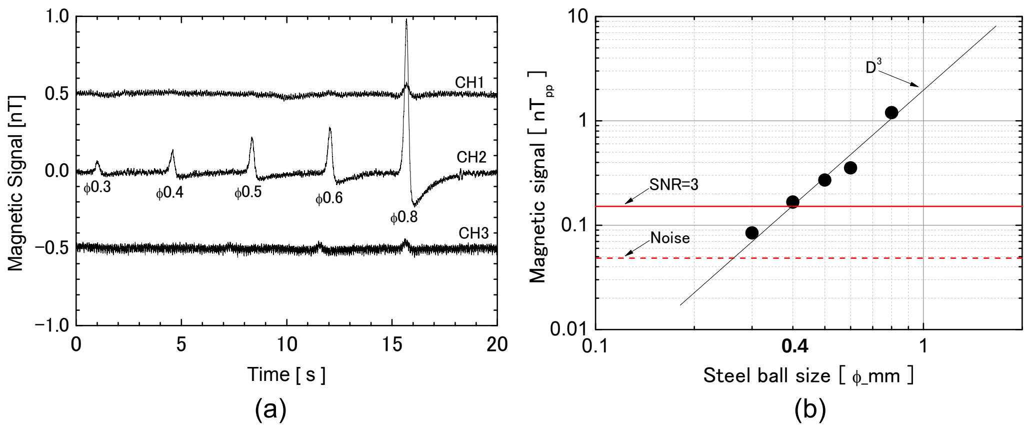

Fig. 4 (a) Time-domain magnetic signal, (b) Relationship between the measured signal amplitude and diameter of contaminated specimen

Top of Superconductivity Web21

