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DETECTION OF MICRO FLAWS ON THIN COPPER TUBES USING SQUID-NDI SYSTEM

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Recently, thermal exchange copper tubes have been formed thinner (less than 1mm) in order to gain higher performances. Because of the thinner forming, micro flaws with less than several ten-μm in depth have caused the leakage of cooling medium. At present, eddy current testing (ECT) is major nondestructive inspection (NDI) technique applied to detect flaws in the nonmagnetic metallic tubes. However, there is an inferior limit of detectable flaw depth by ECT at market: about 50-100 μm. Therefore, more sensitive detection technique is strongly desired in aspects of quality control, safety and economy.In this study we constructed a SQUID-NDI system based on ECT technique for inspection of micro flaws on copper tubes employing HTS SQUID gradiometer and Helmholtz-type coil. The HTS SQUID gradiometer was cooled by a coaxial pulse tube cryocooler. The detection of artificial flaws with several ten-μm in depth on copper tubes of 6.35 mm in outer diameter and 0.825 mm in thickness was demonstrated using the SQUID-NDI system. With excitation field of 1.6 μT at 5kHz, the 30 μm-depth flaw was successfully detected with SN ratio of 20, where the conventional eddy current testing should fail to detect. The magnitudes of the magnetic signals due to the flaws were proportional to both the excitation frequency and the square of the flaw depth. Taking into account of the system resolution, the measurement results indicate that sub-10μm-depth flaws will be detectable by the SQUID-NDI system.