Highly sensitive magnetic nondestructive testing using magnetoresistive sensor for diagnosis of steel structures

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To ensure the safety of civil infrastructures, simple and accurate inspection methods have been in high demand. Many types of nondestructive testing (NDT) methods are used in the diagnosis of steel structures. Corrosion and cracks often occur in steel structures, and ultrasonic testing (UT) is usually applied. Compared with UT, magnetic NDT such as eddy current testing (ECT) is limited to surface testing. Recently, we developed highly sensitive magnetic NDT using magnetic sensors to detect defects not only on the surface but also in deep regions of steel. By using an extremely low-frequency operation and highly sensitive magnetic sensors instead of pickup coils, we could also detect magnetic signals from deep regions. In the case of UT, surface treatment such as paint or rust stripping is necessary to obtain acoustic matching contact. By contrast, magnetic NDT is not affected by these types of interference materials. Based on this advantage, we developed an extremely low-frequency eddy current (ELECT) system using an anisotropic MR sensor to detect the reduction in thickness due to both surface and inner corrosion. In general, magnetic measurements for steel are difficult because of the high permeability of the material and the variations in their residual magnetization as compared with nonmagnetic material such as aluminum. To solve this problem, magnetic spectroscopy analysis was developed to achieve precise thickness measurements. The steel thickness of severely corroded steel structures of a dam and bridge, to which UT could not be applied, were successfully measured by the ELECT system. Related to the corrosion of steel structures is the collapse of lighting and road marker poles as a result of corrosion in underground locations, which has become a social problem as it sometimes results in major traffic accidents. To detect steel corrosion in hidden parts by soil or concrete, an integrated sensor probe consisting of two tilted magnetic sensors was developed. Results of field testing show that 1-mm thinning was successfully detected even at a depth of 50 mm. Furthermore, the magnetic results measured from the ground surface correlated well with directly measured results after ground digging operations were performed. As another defect of steel structures, cracks must be detected at an early stage. Cracks sometimes occur in welded parts and can be very difficult to detect. To detect cracks in these complicated parts, we developed two types of magnetic NDT systems. One is an unsaturated AC magnetic flux leakage (USAC-MFL) testing method that uses a gradiometer with AMR to detect inner cracks, and the other involves a small ECT probe that employs tunneling MR for use with complicated structures. The USAC-MFL is used to inspect inner and surface cracks in welded parts of rail. The small ECT probe is used to inspect surface cracks in welded angles such as U-shaped ribs used in steel decks of expressway bridges.

Reference

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Fig. 1 Inspection of underground corrosion at a road marker pole.

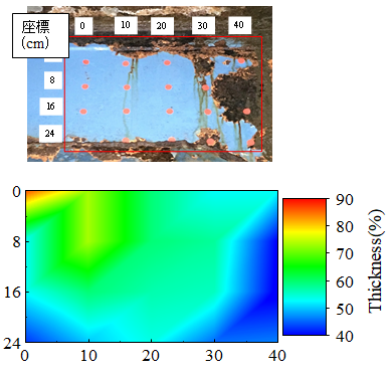

Fig. 2 Multipoint measurement of thickness reduction of bridge.