Monitoring of structures and material characterization of steel using electromagnetic nondestructive evaluation method

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Fundamental structural constructions such as bridges, highways and power generation plants are typically used for long term period after their constructions, and not easy to replace them frequently. However, a degradation and decrepit of structures progress during long term operation which may cause a failure of structures. Meanwhile, steel companies require the detection of nonmagnetic inclusions and defects during steel fabrication to enhance the reliability of their steel products for structural components. In both cases, inspection must be conducted nondestructively. Most of steels include iron and they therefore exhibit ferromagnetic property which indicates a potential of nondestructive evaluation using magnetic measurement. The ferromagnetic properties of materials are characterized by a magnetization hysteresis loop, and its magnetization process results from magnetic domain wall motions and magnetization rotations. Several parameters, coercivity, initial permeability, Barkhausen noise, defined on the magnetic measurements are used for evaluation (See Fig. 1). Since lattice defects like dislocations, precipitations and grain boundaries have interactions with domain wall motions and magnetization rotations¹), the magnetic hysteresis loop is subjected to changes in the microstructures. On the other hand, degradations and mechanical properties of steels also depend on the microstructures, which means degradations and mechanical properties of steel have good correlation with the magnetic properties (See Fig. 2). As to detection of small inclusions or defects in steels, companies aim to detect defects less than 50 µm. Recent progress in development of a magnetic field sensor offers high sensitive and miniaturised sensor³, which enable us to detect small sized defects in steel by the magnetic flux leakage method. In our experiments, defect with up to 30 µm can be detected using a commercialized magnetic field sensor. Example of detection small defects using high sensitive GMI and GMR sensor will be introduced in the presentation.



Fig. 1 Parameters for magnetic measurements.



References

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