(238)

Evaluation of High Spatial Resolution Imaging of Magnetic Stray Fields for Early Damage Detection

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Metal magnetic memory (MMM) technique with associated ISO 24497-1:3 [1] is gaining considerable interest in the magnetic NDT community. In contrast to traditional Magnetic Flux Leakage (MFL) testing, the inspection objects are not intentionally magnetized by an external magnetic field [1,2]. Due to the physical coupling between mechanical stress and magnetization of ferromagnetic materials [3], it is assumed that the distribution of the residual MFL correspond to the internal stress of the specimen [2,4], or in the most general sense, to a degradation of the material [1,2].

Usually, MMM measurements are performed by relatively bulky magnetic inspection sensors [2]. The evaluation of local magnetic field distribution is limited thereby. High precision GMR (Giant Magneto Resistance) measurements in the micrometer regime can provide a higher degree of information due to better spatial resolution [5].

We present a concise summary of studies on the correlation of magnetic structure and microstructure of steels. In particular, we compare residual stress measurements in S235JRC steel welds by means of neutron diffraction with high resolution magnetic field mappings. Results indicate a qualitative correlation between residual stresses and local stray field variation. In addition, stray field measurements of plastically deformed specimens for quasi-static and cyclic loading cases are discussed. The present study concludes that GMR sensors can detect inhomogeneous plastic deformations of S235JR steel in a very early stage, without specific signal processing according to the ISO 24497-1:3.

References:

1. ISO 24497-1:3:2007-11, Non-destructive testing - Metal magnetic memory, Beuth Verlag GmbH, Berlin, 2007.
2. A. Dubov, A. Dubov, S. Kolokolnikov, “Application of the metal magnetic memory method for detection of defects at the initial stage of their development for prevention of failures of power engineering welded steel structures and steam turbine parts”, *Weld World* **85** (2) (2013) 225-236.
3. D. C. Jiles, “Theory of the magnetomechanical effect”, *J. Phys. D. Appl. Phys.* **28** (8) (1995) 1537–1546.
4. M. Roskosz, M. Bieniek, “Evaluation of residual stress in ferromagnetic steels based on residual magnetic field measurements”, *NDT&E Int.* **45** (3) (2012) 55–62.
5. M. Pelkner, “Development, analysis, and application of GMR sensor arrays for non-destructive evaluation of ferromagnetic components” (in German), PhD-Thesis, Saarland University (2014).