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Nondestructive testing systems with magnetic flux leakage (MFL)

Sargon Youssef, Jochen H. Kurz, Klaus Szielasko, Ralf Tschuncky
Fraunhofer IZFP, Saarbrücken, Germany

Introduction

Ferromagnetic components used in mechanical, automotive and civil engineering are often subject to high mechanical loads. In worst case, cracks which may occur during production or in use may lead to a complete failure of the component (see fig. 1 & 2). Flaw detection after the manufacture or a regular inspection of the components (especially in civil engineering) is necessary. In industrial production of ferromagnetic components crack detection based on magnetic particle testing is used with priority. This is a nondestructive testing method. However, its implementation is linked with high personnel costs and with the use of chemicals (environmental pollution) that require a final cleaning. Automation of the method is complicated, but civil engineering is subject to a lack of nondestructive testing methods for fracture detection and localization. Even if the critical areas are known, the construction currently has to be damaged in order to expose the elements which have to be tested (e.g. by the standard corrosion/crack detection of reinforcements in prestressed concrete poles).

Principle

Magnetic flux leakage (MFL) testing is based on the same physical principle as magnetic particle testing: At the crack mouths in magnetized components an increased magnetic field strength (flux leakage) arises (see fig. 3). By the magnetic field distortion (MFD) method, the distortion of a magnetic field close to the surface – which is caused by local changes in the surface geometry – is evaluated. The sensor-based magnetic flux leakage or magnetic field distortion testing method is used for the detection of cracks and fractures in ferromagnetic materials. Supersensitive magnetic field sensors (see fig. 4) for surface tests which are operated manually or by manipulators are suitable to detect the magnetic flux leakage. Multichannel sensor line arrays (see fig. 4) or matrices thereby enable rapid testing of complex components (e.g. gears).

Measuring procedure and applications

The measuring procedure can be fully automated and integrated into the production process. These features together with further benefits like high detection sensitivity offer various possibilities for implementation in testing systems (e.g. crack detection in the field of the industrial production of ferromagnetic components or after induction hardening). Fig. 5 shows the mobile inspection system "BetoFlux", an MFL-based system for crack detection of reinforcements in prestressed concrete poles. Fig. 7 shows the result indicating a cracked reinforcement. Fig. 6 shows the mobile and wireless inspection system "PipeFlux", which combines MFL with MFD for determination of corrosion flaws for both, the sensor-far (MFL) and the sensor-facing side (MFD & MFL). Fig. 8 shows MFL results of the sensor-facing side of three spherical substitute defects with different depths (10%, 25% and 50% profile reduction).

Fig. 1: Broken concrete pole as a result of stress corrosion cracking (source: Main-Post, B. Diem)

Fig. 2: Corrosion damages on pipes

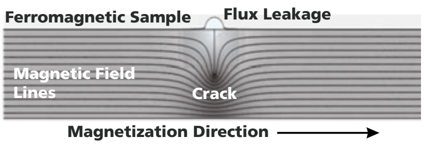

Fig. 3: Principle of magnetic flux leakage

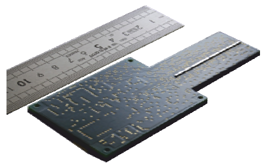

Fig. 4: Linear array of 32 magnetic field sensors (32 channels) with wireless data transfer

Fig. 5: Mobile inspection system BetoFlux (source Uwe Bellhäuser)

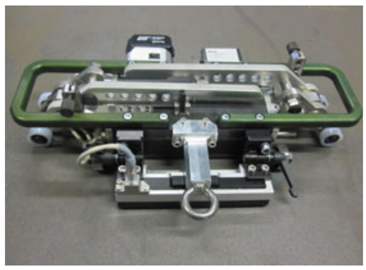

Fig. 6: Mobile and wireless inspection system PipeFlux

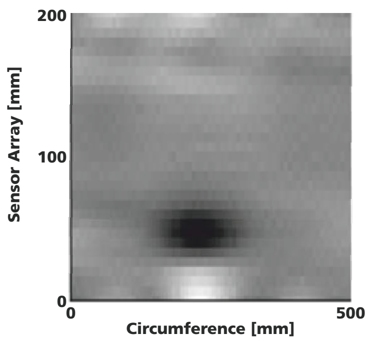

Fig. 7: BetoFlux measurement of broken reinforcement in prestressed concrete pole

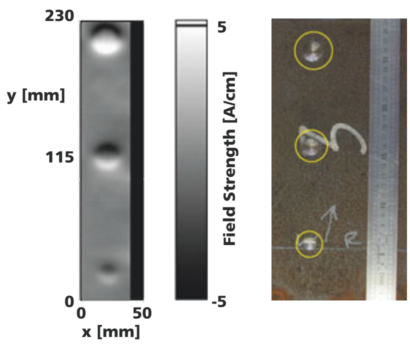

Fig. 8: Corrosion inspection with PipeFlux

info@izfp.fraunhofer.de | www.izfp.fraunhofer.de