Non-destructive evaluation of stress in carbon steel based on magnetic methods

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The use of technical objects usually results in the occurrence of stresses in the structure of these objects. The increase in stress in steel constructions causes elastic and plastic deformation and, ultimately, material rupture. Therefore, non-destructive evaluation of stress is very important for the safe operation of steel structures. Material fatigue, overrun of permissible stresses or plastic deformation results in a qualitative and quantitative change in magnetic properties of steel elements. Changes in the magnetic properties of materials cause changes in the magnetic field recorded around diagnosed objects. Magnetic parameters can therefore be sensitive and comfortable diagnostic symptoms.

In this paper, two magnetic non-destructive evaluation methods, Magnetic Barkhausen Noise (MBN) and Magnetic Flux Leakage (MFL), are studied via experiments to investigate and compare their practicability and usefulness for evaluation of stress in carbon steel. Research has been done on the tensile testing machine. A special testing system integrating used magnetic methods was established to measure the magnetic property of test pieces with different stress. Measurements were realized using pick-up coils, magnetoresistive sensors and fluxgate magnetometers. Analysis of signals was primarily focused on stress evaluation in analyzed elements. Analyzes were also conducted to determine the degree of degradation and changes in the technical condition (plastic deformation, crack) of test pieces. The measurement results show that the change of stress state can cause significant change of magnetic properties in the carbon steel, and measured signals of MBN and MFL methods depend on the levels of stress. Adequate analysis of the signals obtained using selected magnetic methods also enabled the acquisition of diagnostic information concerning the degree of technical degradation of the tested elements.

The results show that there is a good possibility to evaluate the stress and the degree of technical degradation in carbon steel elements by using MBN and MFL methods. In addition, as these selected magnetic methods have different features in term of precision and resolution, an integrated testing system and result fusion may improve the stress and technical degradation evaluation.