Detection of steel phase transition using magneto-resistive sensors in eddy current testing

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Abstract **This article deals with utilization of advanced magnetic sensors for detection of steel phase transformations. Giant-Magneto-Resistive and Anisotropic-Magneto-Resistive sensors are used for the magnetic properties evaluation under harmonic excitation of the eddy currents. Various material specimens are inspected. Gained results will be presented and discussed in the full-paper.**

Keywords **Eddy current, material crack, non-destructive evaluation, austenitic steel, martensite steel.**

I. INTRODUCTION

In recent years, electromagnetic methods, especially eddy current testing (ECT), have attracted increasing attention. Magnetic sensors, based on either Hall effect, Anisotropic-Magneto-Resistance (AMR), Giant-Magneto-Resistance (GMR) effect or SQUIDs have been successfully used for crack detection, Fig.1. They have small dimensions, high sensitivity over a wide range of frequencies (from hertz to megahertz domains), low noise, and they operate at room temperature. The magneto-resistive (MR) sensors' based probes are more convenient for low frequency applications than conventional probes with inductance coils especially when detecting deeply buried flaws. This is because the magnetic sensors are sensitive to the magnitude of the magnetic field. In the case of inductive-based probes, the output voltage is proportional to the time variation of the magnetic field, therefore, their sensitivity is reduced at low frequencies. Although their sensitivities are comparable, GMR sensors have better directional property than AMR sensors, [1]. Both types of sensors detect the component of the magnetic field vector along their sensitive axis. In the case of GMR sensors, fields applied perpendicularly to the sensitive axis have negligible effect on their output. In contrast, the sensitivity of AMR-based probes is lowered by a field perpendicular to the sensitive axis, which, at high values, can even "flip" the sensor response. This property is particularly important in the coil–crack interaction problems, where the electromagnetic field has a complex three-dimensional distribution. The directional property of GMR sensor can be used in a difficult problem encountered in NDE, e.g, detection of edge cracks. All the properties of these MR sensors will be used for different magnetic properties recognition in the material structures.

II. STAINLESS STEEL INSPECTION

The magnetic properties of stainless steels vary from non-magnetic to fully magnetic. All austenitic stainless steels are paramagnetic, non-magnetic, in the fully austenitic condition as occurs in well-annealed alloys. The relative permeability ranges from μ_r = 1.003 to 1.005 when measured with magnetizing forces of H = 16 kA/m. The permeability increases with cold work due to deformation-induced martensite, a ferromagnetic phase. On the other hand, all martensite and most precipitation hardenable stainless steels are ferromagnetic. Due to the stresses induced by the hardening transformation, these grades exhibit permanent magnetic properties if magnetized in the hardened condition. For a given grade, the coercive force tends to increase with increasing hardening, according to these fact it is more difficult to demagnetize these alloys, [2].

Evaluated austenitic steel material samples under ECT inspection will contain local changes of magnetic properties. This will be achieved in several ways: bending, sheet cutting, hardness measurement etc.

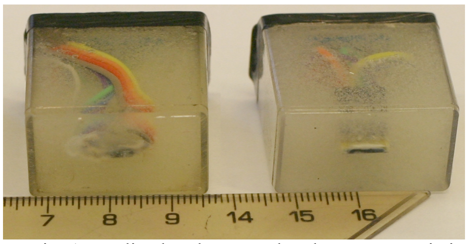

Fig. 1. Realized and encapsulated magneto-resistive sensors

III. CONCLUSION

The main aim of the article is to detect structural changes in stainless steel using magneto-resistive sensors due to variations of magnetic properties of the material. The experiments assume that local changes in magnetic properties of the inspected stainless steel can be detected. Thus it can be possible to reveal the austenitic/martensitic steel grade.

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V. REFERENCES

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