QUANTITATIVE EDDY CURRENT VARIANTS FOR MICROMAGNETIC MICROSTRUCTURE

MULTIPARAMETER ANALYSIS (3MA)

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INTRODUCTION

Most of the eddy current techniques applied in steel-, machinery building- and automobile-industry for steel grading and microstructure characterization use encircling coils in a differential arrangement. The coil impedance of the test piece is compared with the coil impedance of a "good" masterpiece. The contribution reports recent developments in eddy current testing which contributes with a pick-up-technique to a generalized concept of a micromagnetic structure evaluation (3MA).

PICK-UP-CUP-COIL

In order to use pick-up-coils instead of circumferential coils to characterize steel microstructure states it should be stated, that these sensors should have a good spacial resolution against microstructure changings lateral in the inspection plane and axial into the material depth. By the physical basics to eddy current inspection we know that these microstructure changings only can be detected if they result in changings of the electrical conductivity $\sigma$ and the initial magnetic permeability $\mu$ as far as not additionally an external magnetization is applied. Air-pick-up-coils which can be modeled extremely good [1] are only sensitive against $\sigma$- and $\mu$-changes ($1 \text{m/} \Omega \text{mm}^2 \leq \sigma \leq 5 \text{m/} \Omega \text{mm}^2$, $10 \mu \leq 200$) in the higher frequency range $f \geq 500$ kHz. Unfortunately the impedance changes caused by these ($\sigma,\mu$)-changes are in the same direction in the impedance plane so that they cannot be observed independently.

In order to overcome the problem a ferrite-cup-coil was developed. Fig.1 shows in the upper part the upright projection of the ferrite cup-coil-kernel and in the lower part the finite-element-mesh which was applied to calculate the coil-impedance and its change with ($\sigma,\mu$)-changings. For the calculation we have used a computer code, obtained in cooperation with EPRI and developed by W. Lord and R. Palanisamy [2].

Fig.2 shows the advantage of the ferrite-cup-coil related to a conventional air-pick-up-coil. In the upper part the normalized impedance for both types of coils is discussed for one steel specimen ($\sigma=3.7 \text{ m/} \Omega \text{mm}^2$, $\mu=86$) as function of the frequency. In the same frequency range the cup-coil has an impedance change which is near five times the change of the air-pick-up-coil. In the lower part of Fig.2 both coils are compared in...
Fig. 1. Cup-coil and FE-mesh for modeling.

Fig. 2. Comparison: air-pick-up-coil and cup-coil.