

Eddy Current Magnetic Signature (EC-MS): Experimental tests and Simulations

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Plastic deformations and residual stresses inevitably occur in metallic components due to industrial machining or heat treatment processes. These local changes of the microstructure affect the real-life performance of industrial parts. Measurements and analysis of residual stresses are necessary for quality assurance and maintenance anticipations.

The use of micro-magnetic techniques such as the Magnetic Barkhausen Noise (MBN) [1][2] or the Magnetic Incremental Permeability (MIP) [3][4] has increased exponentially in the industrial field. Recently, an even more sensitive method has been proposed by Matsumoto and al. [5]-[6]. This method named Eddy Current Magnetic Signature (EC-MS) relies on an incremental permeability experimental setup and consists of plotting the imaginary versus the real part of the sensor coil impedance or of the permeability during the magnetization process. The resulting trajectory in the impedance plan is studied. The size, length and direction of this trajectory are highly dependent on the distribution of the residual stress through the tested sample. EC-MS is a relatively new method and up to now the only published articles which focus on this method just comment and discuss experimental results obtained on carbon steel or chromium steel. The development of numerical tools for the simulation of the EC-MS have almost never been proposed [7]. However such simulation results could be particularly useful for the understanding and the interpretation of the EC-MS results.

In this study, EC-MS is tested on pure iron and iron silicon samples, experimental results are proposed such as a numerical method relying on the physical properties for the simulation of the ECMS technique. A link is established between the frequency dependent material hysteretic behavior and the dynamic contribution required for the EC-MS simulation.

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