Non-Destructive Determination of the Magnetic Properties of Ferritic Steel Strip and Plate Products

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There are well documented links between the magnetic properties of steels and their mechanical and microstructural parameters. Consequently magnetic testing provides a potential route for non-destructive testing of these parameters. Much information can be gathered from the measurement of the magnetic hysteresis of the material under inspection, but this requires a coil to be wrapped around the sample to measure the magnetic induction, forming a closed magnetic circuit. However, for the inspection of steel strip and plate, access to a closed magnetic circuit is not possible, therefore an open magnetic circuit (open-loop) arrangement must be used. Unfortunately, open-loop measurements are strongly affected by geometric and flux leakage effects. This usually renders the absolute determination of magnetic properties of a test piece by open loop methods impossible and systems applying these methods typically must rely on extensive calibration to known reference samples. In this work, the behaviour of a strip steel sensor was modelled using a combination of commercial finite element software, magnetic circuit models and simplified 2D models using the Jiles-Atherton hysteresis model. The models allowed for variations in the shape of measured magnetisation curves relative to the actual magnetisation curves to be described and the underlying physical mechanisms for these to be determined. The sensor was constructed and modelling results were verified experimentally using laboratory scale samples. These simulations have facilitated the development of an optimisation based inversion process to estimate absolute material magnetisation characteristics from open loop measurements. Early implementations of this technique have yielded favourable results, as reported in this paper. This research has potential to lead to practical systems capable of accurate magnetic characterisation of ferritic steel strip and plate products with minimal use of calibration samples.