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Using the Barkhausen Effect to Measure the Microstructure of Ferromagnetic Materials

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The magnetization M(T,B) of a ferromagnetic material as calculated from standard models of magnetism makes a couple of theoretical assumptions that are not fulfilled in a real lattice. One consequence of this is the Barkhausen effect which experimentally verifies the existence of ferromagnetic domains. From the energy of the domain wall its thickness, the energy per unit area, the restoring force, and the coercitivity are calculated and compared with experimental data. Magnetization curves M(H) are plotted for both the easy and the hard axis of anisotropic materials. Magnetic anisotropy furthermore affects the domain structure of a ferromagnetic material. It is shown that magnetoacoustic emission and magnetostriction data are only correlated in the case of isotropic materials. In general such a correlation does not exist.

Summary

The magnetization curve M(H) as calculated from the Heisenberg model is only a correct description for the first magnetization stage of the hysteresis loop. When a magnetic field is applied the size of the domain changes. This domain wall motion is in general irreversible as domain walls are preferably located at impurities and lattice defects that restrict their motion. Magnetoacoustic emission data are potentially useful for detecting microstructural features in magnetic materials. Electromagnetic techniques in non-destructive evaluation have a special role to play here as both electromagnetic and mechanical properties are influenced by the same microstructural parameters and the way they change during material processing and degradation.

Primary author: Dr NOLTING, Volkmar (Vaal University of Technology)

Presenter: Dr NOLTING, Volkmar (Vaal University of Technology)

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