JUSTIFICATION OF AN ALTERNATIVE SYSTEM FOR ONE- AND TWO-DIMENSIONAL MAGNETIC MEASUREMENTS

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Introduction

The Epstein frame as a common standardized device for one-dimensional magnetic measurements has comparatively large errors. Although there is no standard for two-dimensional characterization of magnetic sheets the Rotational Singe Sheet Tester (RSST) [1] appears to be the most common device for this purpose. The RSST has a number of shortcomings. The magnetic field strength H diverges at the poles involving a non-homogeneous field distribution in the sample. A considerable part of the magnetic flux leaks through the perpendicular poles [2]. For these reasons, the field is nearly homogeneous only in the middle of the sample sheet. This means that the pick-up coil for the flux density B has to be small, which in turn yields a very small induced voltage. A small air gap between the poles and the sample is used to reduce the field inhomogeneity, but air gaps involve high field losses. In conclusion, it is difficult to obtain high fields especially in 45° and 135° . The locus of H is rhombic for a circular B -vector [1,3] and the hysteresis loops are deformed. A novel two-dimensional measurement set-up has been designed and constructed that does not have the above-mentioned problems. The experimental verification [4] shows that the inhomogeneity of the magnetic flux through the sample was smaller than the measurement error, whereas the required electric excitation decreased considerably. Recent measurements showed that the hysteresis loops under rotational field condition on non-oriented and grain-oriented silicon iron sheets look reasonable and are easier to explain than the corresponding loops obtained with the RSST. The aim of the paper is to prove that the new measurement system is superior to the Epstein frame and the RSST and can be recommended. Controlling H instead of B is also justified.

The measurement principle

Consider the homogeneous electric field between two capacitor plates. An analogous magnetic field was obtained by arranging two U-shaped yoke pairs symmetrical to each other, where the drive coils for the magnetomotive force are situated on the horizontal part of the yokes. For the y -direction a similar yoke pair is placed in perpendicular direction onto the first yoke pair. Compared to a primitive embodiment [5] a number of improvements have been incorporated. The perpendicular yokes touch each other such that the sample area is closed in order to maximize the used sample area and to make the overall device small. The yokes are electrically and also magnetically anisotropic, such that there is virtually no flux leakage through the perpendicular yoke pair and the yokes can be used up to some kilohertz.

Opposite to common praxis, the field strength H is controlled and the flux density B is captured. Controlling B is always done by adjusting the magnetomotive force, which is proportional to H . This means that H is applied in any case. Another reason is that the magnetic field strength H is analogous to the electric field strength E and the magnetic flux through a magnetic material behaves like a current through a conductor. Controlling a current would imply delays due to time constants in the feed-back loop, whereas a voltage can be applied directly. In oriented material H can be applied, but it is not really possible to control the B -vector, which always tries to align parallel to the grain-orientation.

Results

Fig. 1a shows that the measured magnetic field pattern obtained with iron powder is as homogeneous as the electric field between two capacitor plates. Fig. 1b proves that in non-oriented material the rotating field H has no maximum in 45° and 135° when the B -vector describes a circle. Fig. 1c illustrates for controlled H -vector how the B -vector jumps from the rolling direction to the opposite (rolling) direction.

Fig. 1 Measurement of the magnetic field distribution in one yoke pair (left) and the rotational field H (inner circles) and the resulting flux density B in non-oriented (middle) and oriented (right) steel sheet, H : (600 A/m)/div, B : (0.5 T)/div.

References

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