Measurement of Magnetic characteristics in arbitrary directions of grain-oriented silicon steel

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MEASUREMENT OF MAGNETIC CHARACTERISTICS IN ARBITRARY DIRECTIONS OF GRAIN-ORIENTED SILICON STEEL

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1. Introduction

It is necessary to measure precisely B-H curves in arbitrary directions up to high flux density, in order to analyze numerically flux distributions in transformer cores made of grain-oriented silicon steel. If 3-dimensional flux distribution is analyzed using only B-H curves in the rolling and transverse directions (this is a usual way) [1], the flux densities at a corner joint and a T-joint of transformer core become unacceptably high. It was difficult to measure the B-H curves in arbitrary directions precisely up to high flux density using conventional methods, because of difficulties in controlling waveforms and in increasing flux density due to spread of flux in a specimen [2].

A new method for measuring B-H curves in arbitrary directions has been developed. Using the new method, B-H curves in which the flux density B_R in the rolling direction is up to 2.0 T, the flux density B_T in transverse direction is up to 1.7 T and the flux density in magnetic hard axis is up to 1.6 T can be measured.

2. New Measuring Method

Fig.1 shows the measuring equipment. The optimal construction and dimension of the equipment are determined using the numerical analysis. The symmetrical double yokes (upper and lower yokes) are used so that the flux distribution in the specimen becomes uniform. A fairly large square specimen (150×150 mm) is used in order to avoid the effect of domain size. In order to measure B-H characteristics at higher flux density, both laminated auxiliary yokes ① and auxiliary yokes ② made of a single sheet are used so that the flux does not spread from the specimen. The modified probe [3] is used instead of the ordinary search coil in order to avoid the disturbance due to holes. The both H-coils which measure the magnetic fields in the rolling and transverse directions are wound on the same epoxy glass plate in order to decrease the angle error between the two H-coils. The so-called "two H-coil method" [4] is adopted.

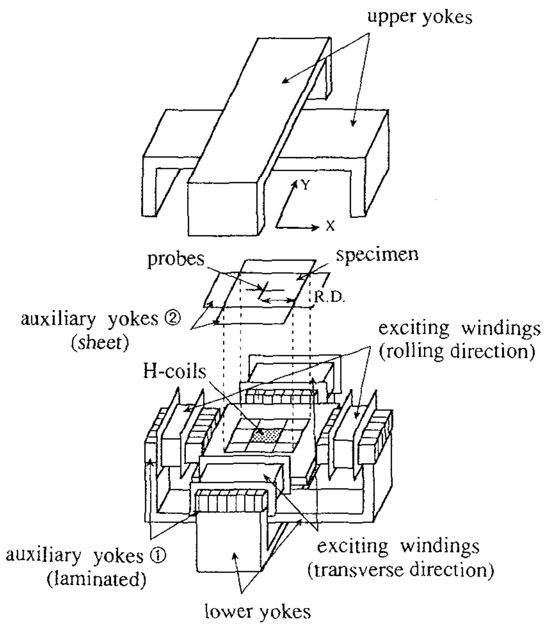

Figure 1. Measuring equipment.

B and H in arbitrary directions are measured under ac (50Hz) excitation without waveform control. If B and H at the instant when the exciting current becomes the maximum are taken as a point of B-H curve, the precise B-H curve can be obtained up to high flux density although the waveform of flux density is considerably distorted. This is, because the amplitude of eddy current can be neglected compared with that of the exciting current at this instant.

3. Results

Fig. 2 shows an example of the measured B-H curve of highly grain-oriented silicon steel (AISI:M-0H). H_R and H_T denote the magnetic field strengths in the rolling and transverse directions. Using the new measuring method, B-H curves up to B_R=2.0T and B_T=1.7T can be obtained.

References

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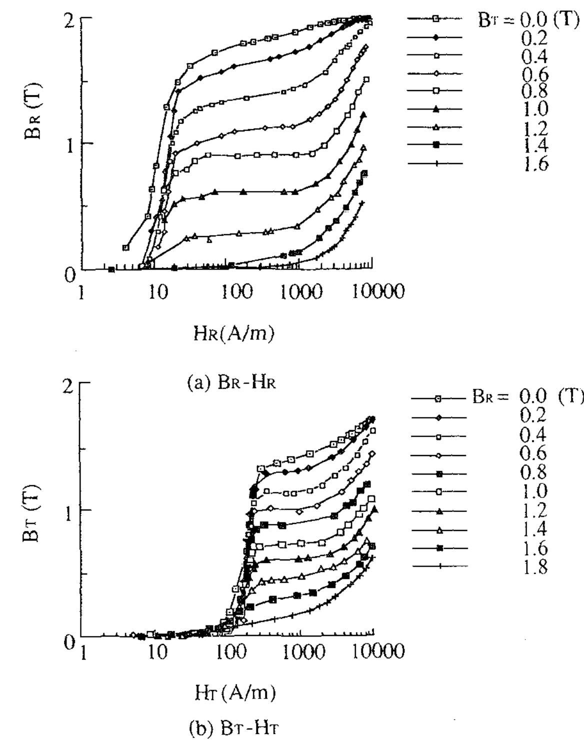

Figure 2. B-H curves.