An open magnetic path type of single sheet tester for measurement of magnetostriction of electrical steel sheet

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AN OPEN MAGNETIC PATH TYPE OF SINGLE SHEET TESTER FOR MEASUREMENT OF MAGNETOSTRICTION OF ELECTRICAL STEEL SHEET

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Introduction

It is important to measure the magnetostriction to investigate the acoustic noise of transformers. A closed magnetic path type of single sheet tester (SST) is usually used in the measurement of magnetostriction of electrical steel sheet [1]. In this type, however, the measurement accuracy is very sensitive to the electromagnetic force between specimen and yoke. Although an open magnetic path type of SST having a single magnetizing winding is proposed to overcome such a difficulty, the uniformity of flux distribution is not sufficient [2].

In this paper, an SST having main and compensating windings, which are excited individually, is proposed. The construction and feature of the proposed SST are described, and a technique for making the flux distribution uniform by controlling the applied voltages of both windings is discussed. The magnetostrictions obtained from the open and closed types are compared.

Open Magnetic Path Type of Single Sheet Tester and Method of Waveform Control

Figure 1 shows the proposed open magnetic path type of SST. The compensating winding is wound at the edges of main winding to get the uniform flux distribution. The compensating winding is composed of three layers and they are connected in series. The configuration of windings is determined with the help of magnetic field analysis.

In order to establish a method of waveform control, the flux distribution in a specimen is examined by using B coils wound directly on the specimen shown in Fig. 1(b). Figure 2 shows the effects of the amplitude V_{main} of voltage v_{main} of main winding on the maximum value B_m and the phase angle θ_B of flux density when the amplitude V_{comp} of voltage v_{comp} of compensating winding is fixed. Both B_m and θ_B increase with increase of V_{main}, and the rates of change of both quantities at the center are larger than those at the edge. The effects of V_{comp} and a phase difference φ_v between v_{main} and v_{comp} are also measured. Summarized results are shown in Table 1. According to those results, a method of waveform control is developed.

Figure 3 shows finally obtained waveforms of v_{main} and v_{comp}. Two of B coils shown in Fig. 1(b) (B1 at the edge and B6 at the center) are used to control the flux waveforms. A highly-oriented silicon steel sheet (JIS 27P100, thickness: 0.27mm, $W_{17/50}$: ≤1.00W/kg) is used as a specimen. B_m and frequency are set at 1.9T and 50Hz, respectively. There is a large difference between the final waveforms. Errors of B_m and form factors FF of induced voltage are within ±2% and ±1%, respectively.

The details of construction of SST, a method of waveform control and a digital measuring system will be described in the full paper.

Comparison of Magnetostrictions Obtained from Open and Closed Types

Figure 4 shows the comparison of magnetostrictions obtained from the open and closed types with various conditions. It is shown that the measurement accuracy of the magnetostriction obtained from the open type is comparable to that from the closed type with a glass plate between specimen and yoke [1]. When there is no glass plate and B coils are wound directly on the specimen, the closed type gives the extremely large error.

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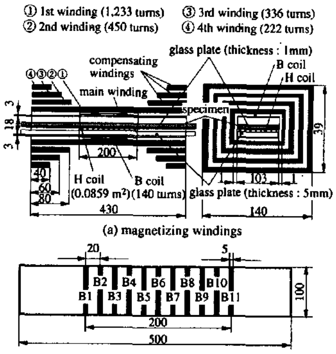

(a) magnetizing windings

(b) B coils wound directly on a specimen

Fig. 1. Open magnetic path type of single sheet tester.

Table 1. Effects of applied voltages.

applied voltage			flux density edge ··· center	
V_{main}	↗	B_m, θ_B	↗ ··· ↗	increase
V_{comp}	↗	B_m, θ_B	↘ ··· ↘	decrease
φ_v	(-) ↗ (+)	B_m	↗ ··· ↗	increase
		θ_B	↘ ··· ↘	decrease

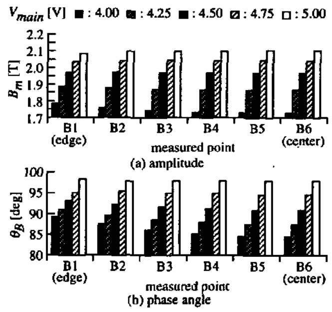

Fig. 2. Effect of amplitude of applied voltage of main winding on flux distribution (V_{comp} = 4.5V, φ_v = 0deg).

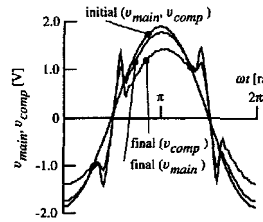

Fig. 3. Waveforms of applied voltages (27P100, B_m = 1.9T, f = 50Hz).

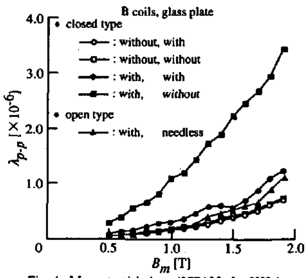

Fig. 4. Magnetostrictions (27P100, f = 50Hz).

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