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IMPROVEMENTS OF SINGLE SHEET TESTERS FOR MEASUREMENT OF 2-D MAGNETIC PROPERTIES UP TO HIGH FLUX DENSITY

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Introduction

When anisotropy of silicon steel is investigated, measurement of 2-D magnetic properties is required. Various single sheet testers (SSTs) have already been proposed [1]-[4]. However, those SSTs cannot measure the 2-D properties at high flux densities due to a structural limitation of magnetizing windings for the rolling and transverse directions. In order to overcome the difficulty, a new type of SST is developed. It has crosswise overlapped magnetizing windings and nearly complete closed magnetic paths. Moreover, an ordinary SST for the measurement of 1-D properties is improved by introducing crosswise overlapped H coils. Then, it also can measure the 2-D properties.

In this paper, the constructions and principles of newly proposed 2-D SSTs are described, and the 2-D properties measured under various flux conditions are illustrated. Furthermore, results measured by both SSTs are compared to validate themselves.

Single Sheet Testers for Measurement of 2-D Magnetic Properties

Two different types of single sheet tester (SST) are newly developed to measure 2-D magnetic properties. SST shown in Fig. 1(a) has two magnetizing windings for the rolling and transverse directions. A square specimen is required. As two windings are installed, both alternating and rotating flux conditions can be realized. Therefore, this SST can be called a general type of 2-D SST. A remarkable structural feature is that the two windings are crosswise overlapped and nearly complete closed magnetic paths are composed by preparing various auxiliary yokes.

SST shown in Fig. 1(b) has only one magnetizing winding. Unlike an ordinary SST to measure 1-D properties, crosswise overlapped H coils are introduced. Several strip specimens are required, of which the cutting directions are different from the rolling direction to get the properties along the cutting directions. As there is one winding, measurements are limited under the alternating flux condition. Therefore, this SST can be called a limited type of 2-D SST.

The details of constructions of two SSTs, principles of methods of measuring 2-D properties and a digital measuring system will be described in the full paper.

Results and Discussion

Figure 2 shows the $|B|-|H|$ curves and $|B|-\theta_{HB}$ curves of oriented silicon steel sheet (JIS 35G165, thickness: 0.35mm, $W_{1/50}$: 1.65W/kg) measured at 50Hz under the alternating flux condition by means of the general type of 2-D SST. θ_{HB} is an angle between H and B . H are measured changing $|B|$ at fixed θ_B (an angle of B from the rolling direction). Measure quantities, $|B|$, $|H|$, θ_B , θ_{HB} can represent the full permeability tensor [2] and are very useful to model the anisotropy in magnetic field analysis [5]. Although $|B|-\theta_{HB}$ curves at $\theta_B=0$ and 90deg are oscillated due to the measurement error, that is not a problem in the magnetic field analysis, because θ_{HB} can be set at zero essentially. It is demonstrated that the proposed SST can measure the 2-D properties up to 1.9T. When the conventional SSTs are applied, the reachable maximum flux density is about 1.2T.

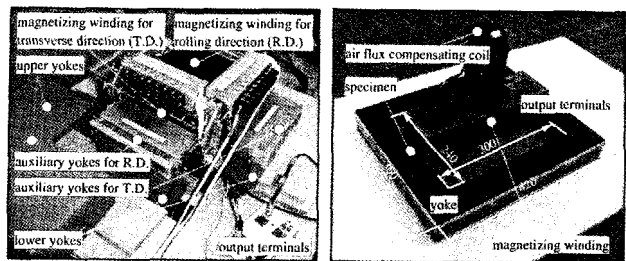
Results measured under various rotating flux conditions and the comparison between the newly developed two SSTs will be described in the full paper.

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(a) general type (upper yokes are removed) (b) limited type
 Fig. 1 Newly developed single sheet testers for measurement of 2-D magnetic properties.

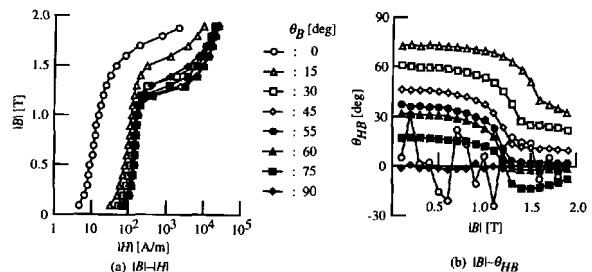


Fig. 2 2-D magnetic properties under alternating flux condition (JIS 35G165, f=50Hz, general type).