Fundamental Characteristics of 2D Equivalent *B-H* Method

Keisuke Fujisaki

Nippon Steel Corporation, 20-1 Shintomi, Futtsu Shi, Chiba 293-8511, Japan

**current affiliation: Toyota Technological Institute, 2-12-1 Hisakata, Tenpaku-ku, Nagoya 468-8511 Japan*

fujisaki@toyota-ti.ac.jp

Abstract — To obtain the precise magnetic characteristics, φ-anisotropic method, which the intermediate magnetism characteristics between φ=0 and 90degree is considered, is applied to the equivalent *B-H* method. The magnetizing characteristics of the equivalent element are introduced by an equivalent element model, in which an external magnetic field with different directions and size is applied to the equivalent element. When the φ-anisotropic method is applied to the two dimensional model with 5 magnetic bars, it is more closed to the detailed conventional method than the two-axis anisotropy method.

I. INTRODUCTION

Magnetic phenomenon has many different physical properties which depend on the scale to be treated, so it is considered to be a kind of magnetic multi-scale phenomenon [1]. To let materials development and electrical machines design reflect the magnetic multi-scale phenomenon, the numerical analysis technique is important.

In the numerical calculation technique, the explosion of the numerical mesh number is an important problem and the homogenization method is considered to be a useful tool to solve it. As a research work on application to electromagnetic field analysis, as equivalent B-H method is shown as having superior characteristics to the others because of the consideration of non-linearity and magnetic anisotropy and shows a good agreement with the measurement data [2].

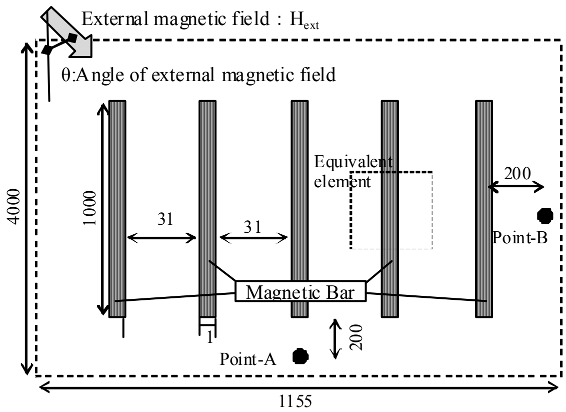
In the previous works, the anisotropy characteristics are modeled so as to divide a magnetic flux density vector into each perpendicular ingredient which is assigned to a different magnetization characteristic (axis-anisotropic method). They are enough as far as obtaining a generous magnetization characteristic and being applied to the behavior in the minute range from a certain axis.

However, when detail observation is necessary, the problem of the application limit occurs. Since φ-anisotropic method takes account of the intermediate magnetization characteristics between the easy magnetization axis and the hard one [3], it is considered to be a more precise calculation method than the axis-anisotropic model. Therefore, φ-anisotropic method is applied to the equivalent B-H method and compared with the conventional axis-anisotropic model as follows.

II. NUMERICAL CALCULATION METHOD AND MODEL

Here, a two-dimensional plane is considered as shown in Fig. 1(a) to evaluate the intermediate φ-anisotropic characteristics. Magnetic bars of 1mm × 1,000mm form a line 5 with 32mm pitch. An external magnetic field excites them with an arbitrary direction magnetically.

In observing the bars in detail, a composite element of 32mm × 100mm, which consists of a magnetic bar and air, repeats itself in X-direction and Y-direction, so that element is considered to be an equivalent element of the equivalent B-H method. Fig. 1(b) shows magnetization characteristics of the equivalent element.



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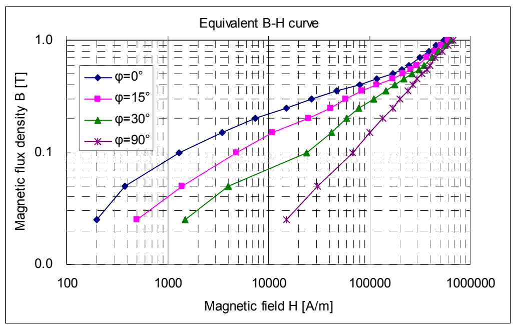

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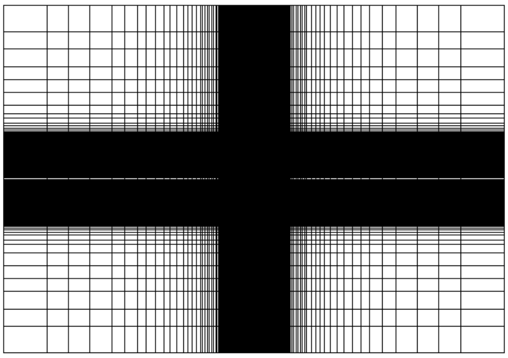
Fig.1. Two-dimensional model to evaluate φ-anisotropic characteristics of equivalent *B-H* method. (a) Calculation model, (b). Magnetization characteristics of equivalent element.



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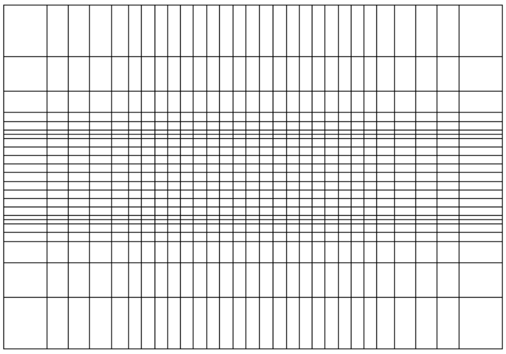

(b)

Fig. 2. Divided mesh. (a) conventional method (element number: 52,488), (b) equivalent *B-H* method (element number: 667).

III. ANALYTICAL EVALUATION

Fig. 2 shows the divided mesh to be used here. By using the equivalent element, element number reduces dramatically. The φ-anisotropic as well as two-axis anisotropic method in the equivalent B-H method is analyzed and evaluated for comparison.

An external magnetic field is supplied to the 5 bars and its direction is inclined from the X-axis to the Y-axis gradually. Point A and B are used for evaluation of the analytical results.

Analytical results are shown in Fig. 3. Horizontal axis is an angle (θ) of external magnetic field. The φ-anisotropic method has more closed magnetic flux density to the detailed conventional method than the two-axis anisotropy method has. Especially, the difference becomes big when the angle of the external magnetic field is small.

Therefore, it is concluded that the φ anisotropic method, which considers the intermediate magnetism characteristic between θ =0 and 90degree, reflects the detailed conventional model more precisely than the conventional two-axis anisotropic method.

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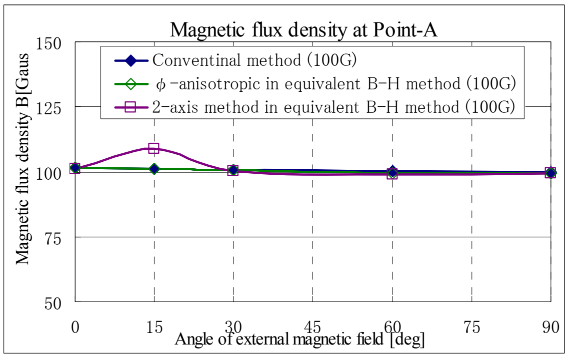

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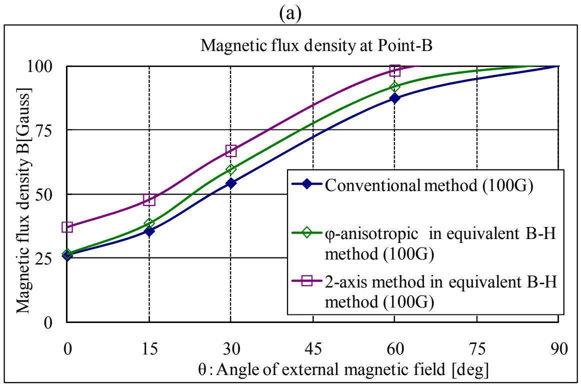

(b)

Fig.3. Magnetic flux density characteristics when angle of external magnetic field (θ) changes. (a) A-part, (b) B-part.

IV. REFERENCES

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