VECTOR MAGNETIC HYSTERESIS CHARACTERISTICS OF ELECTRICAL STEEL SHEET

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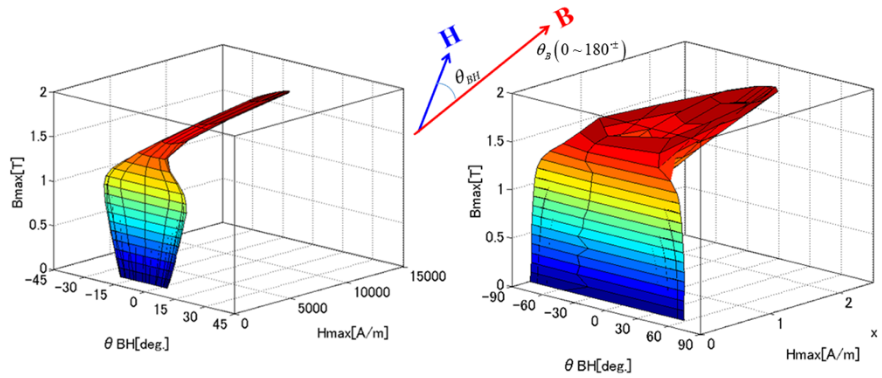
Abstract. This paper describes the new expression of vector magnetic hysteresis loop characteristic of arbitrary direction. The conventional magnetic hysteresis loop characteristic was limited in the case of the magnetic flux density vector **B** parallel to magnetic field strength vector **H**, which can be named scalar characteristic. The vector magnetic hysteresis can be expressed □BH-|**B**|-|**H**| characteristic. The □BH is the spatial difference phase angle between vector **B** and vector **H**.

Introduction

The magnetic characteristics of magnetic materials have vector relation on constitute equation generally. However, conventional hysteresis characteristic is only rolling direction of steel sheet and is not general characteristics. It is due to orientation, rolling anisotropy, and crystal anisotropy. Therefore, magnetic flux density vector **B** is not parallel to magnetic field strength vector **H** and difference phase angle between vector **B** and vector **H**, which can be definite spacific phase angle θ_{BH} . In this paper the magnetic characteristic from the viewpoint of the vector relation is reviewed.

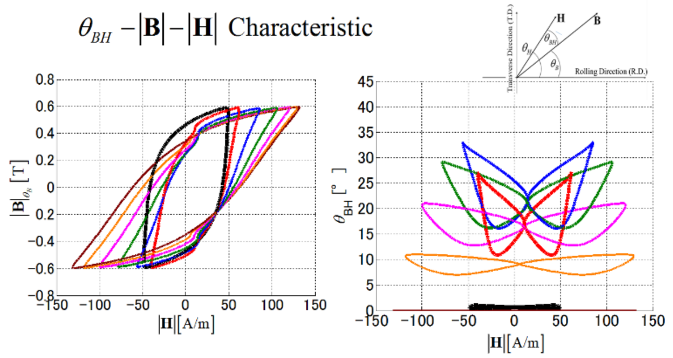
Figures 1(a) and (b) show the |**B**|$_{max}$-|**H**|$_{max}$-θ_{BH} curve instead of conventional **B-H** curve about non-oriented electrical steel sheet and grain-oriented electrical steel sheet, respectively. This is possible to know the essence of the magnetic characteristic by showing vector hysteresis property by the 3D scatter diagram. Especially, handling of θ_{BH} is necessary. By being dependent on time-related phase angle and spatial phase angle, the hysteresis property changes [1], [2].



(a) Non-oriented electrical steel sheet (b) Grain-oriented electrical steel sheet.

Fig. 1 Vector magnetic charcteristics, |**B**|$_{max}$-|**H**|$_{max}$- ▼BH curve

What kind of hysteresis characteristic the vector magnetic characteristic is shown in this session. The waveform of each parameter of vector magnetic characteristic can be shown in order to draw two kinds of hysteresis property, as shown in B_x-H_x loop and B_y-H_y loop. Figure 2 described relationship between |**B**| and |**H**|, θ_{BH} and |**H**| independently. The θ_{BH}-|**H**| characterization, both rolling direction and transverse direction are described for 0 planes of θ_{BH} , because both vectors are parallel. Therefore, θ_{BH}-|**H**| hysteresis is not appearing. The characteristic of the optional direction except for the this shows the hysteresis property.



(a) |**B**|-|**H**| hystrsterssis characteristi (b) θ_{BH}-|**H**| hysteresis characteristic

Fig. 2. |**B**|-|**H**|-θ_{BH} characteristic of arbitrary direction

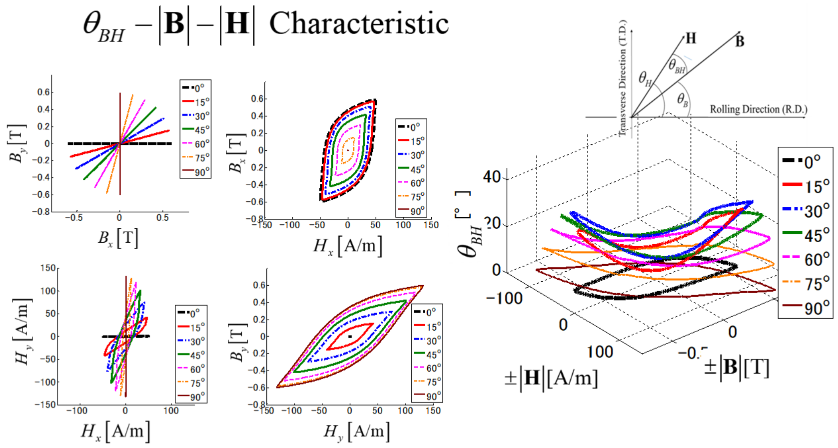


Fig. 3. Relation between vector locus and θ_{BH} -|**B**|-|**H**| - vector magnetic hystrsterssis characteristic

Figure 3 shows the hysteresisloop characteristics of vector magnetic property. This hysteresisloop characteristic of the curved surface shape is shown, when θ_{BH} increases. The increase of the surface area of hysteresis loop is connected with the increase in the magnetic power loss. Figure 4 shows the relationship between the vector locus characteristic both vector **B** and vector **H** and vector magnetic hysteresis characteristic. The expression of loss characteristic as W-θ_B-|**B**|$_{max}$ as shown in Fig. 4.

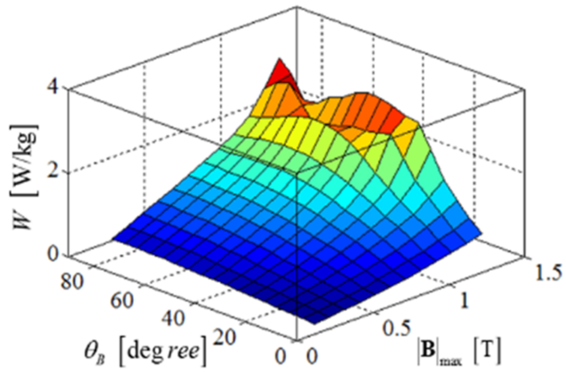


Fig. 4 W-θ_B-|**B**|$_{max}$ characteristic

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