Study Interpretation Phenomenon Magnetostriction and Noise of Lamination FeSi Sheets for Transformer

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Abstract – One of the main problems using a transformer is the vibration and noise. This phenomenon occurs due to deformation/ magnetostriction of lamination sheets transformer core. In this research, the analysis of difference the hysteresis curve, noise and magnetostriction between the rolling direction & the transverse direction have been done. Magnetostriction was measured by gauge of deformation. Acoustic noise was measured by microphone. Magnetic saturation of the rolling direction was higher than in the transverse direction. In contrast, the magnetostriction & acoustic noise of transverse direction was higher than the rolling direction. Harmonic frequency noise measurement had similarities with harmonic frequency magnetostriction: 100, 200, 300, 400 Hz. With increasing current/voltage, the amplitude of the harmonic frequencies noise and magnetostriction will increase.

Index Terms – Magnetic flux density, magnetic field, magnetostiction, noise

INTRODUCTION

One of the main problems using a transformer is the vibration and noise [1]. This phenomenon is a result of occurs due to deformation/magnetostriction of lamination sheets transformer core. If lamination sheets deforms, vibration will occur and noise will be appear. This deformation of lamination sheet is caused by a phenomenon magnetostrive properties. It will change shape when subjected to a magnetic field. The magnetostriction is in the order of 10^{-6} in FeSi sheets, it can be source of noise in transformers [2]. Noise has relation to the magnetostriction in electromagnetic devices [3,4]. With increasing magnetic flux, deformation of magnetosriction was bigger [5]. Lungdrgren told that saturation of rolling direction is greater than the transverse direction but magnetostriction of transverse direction is greater than the rolling direction [6]. The appearance of a 180 degree (rolling direction) wall isn't followed by any magnetostriction change, but 90 degree walls are [7].

Magnetostriction λ corresponds to the dimensional variation of a sample under different induction levels. Details of the λ (B) curve can be associated with peculiar changes of the domain structure. In particular, 180^o domain wall motion does not produce any dimensional change. The reverse is true for domain nucleation, 90^o domain wall motion and magnetization rotation. In general, the analysis of the magnetostriction curve starts from the λ value corresponding to that inside a domain:

$$\frac{\Delta l}{l} = \left(\frac{3}{2}\right)\lambda 100\left(\alpha_1^2\beta_1^2 + \alpha_2^2\beta_2^2 + \alpha_3^2\beta_3^2 - \frac{1}{3}\right) + 3\lambda_{111}(\alpha_1\alpha_2\beta_1\beta_2 + \alpha_1\alpha_3\beta_1\beta_3 + \alpha_2\alpha_3\beta_2\beta_2) \quad (1)$$

Where the α_i and β_i are the direction cosines of the magnetization and strain measurement direction with respect to the cube axis, respectively; λ_{100} is the saturation magnetostriction (λ_s) in the [1 0 0] direction and λ_{111} is the λ_s in the [1 1 1] direction. [8]

The aim of this research is to study the phenomenon of magnetostrition and noise on rolling & transverse direction of multiple sheet FeSi Non-Grain Oriented (NGO).

METHOD

Experiment were performed on lamination sheets of non grain oriented $FeSi_{3\%.}$ Samples (0,35 mm thick steel 250x250 mm sheets long rolling and transverse direction) produced by Accelor Mittal.

1) Magnetic characterization test will trace the relationship B (H) and then derive the saturation magnetization. Here, the values of quantities magnetic will be taken from oscilloscope which sampling the voltages induced by the Bcoil [2].
2) Test of magnetostriction trace the relationship between magnetic induction and magnetostriction. Here, the values of quantities magnetostriction will be taken from oscilloscope which sampling the voltages induced by gauge of deformation [3].

Noise test will trace the relationship between tension, magnetic induction and noise. Here, the values of quantities noise will be taken from oscilloscope which sampling the voltages induced by microphone.

RESULT AND DISCUSSION

Figure 3.1 shows that saturtaion of rolling direction curve (blue) slightly higher than the transverse direction (red). It is caused by the different directions of magnetic domains between the rolling and transverse direction. Difference magnetic domains direction will greatly affect the flux density (B) generated. If the magnetic domains of material has the direction of the flow of magnetic induction, the magnetic domains will not be much change direction domain. In the other hand, if the magnetic domains form angle to the direction of flow of magnetic induction, the magnetic domains should equate gradually to the direction induction.

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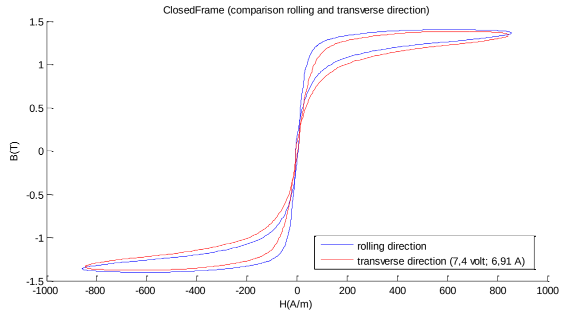

Figure 1. Comparison hysteresis curve at phase saturation: rolling direction (blue) and transverse (red) direction on voltage 7,4 volt

Figure 3.2 shows that graphic with using 7,4 volt. In top graphic, it was looked flat. It is because of starting saturation. In previous discussion, the saturation begins 7,4 volt. Like magnetic flux density, it is not much change or grow when it has reached the saturation phase, as well as magnetostriction deformation, when it reached saturation, magnetostriction deformation changing wasn't seen significant. The amplitude of magnetostriction of rolling and transverse direction are 4,35 $x10^{-6}$ and $5,79x10^{-6}$ m/m.

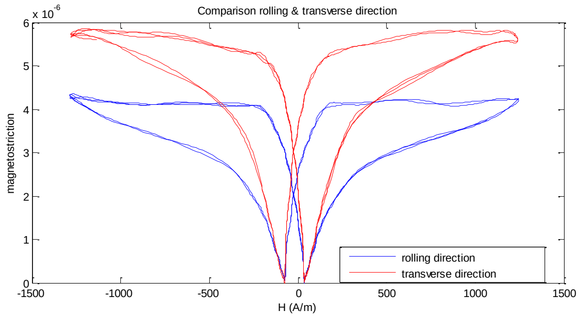

Figure 2. Comparison magnetostriction between rolling (blue) and transverse (red) direction on voltage 7,4 volt

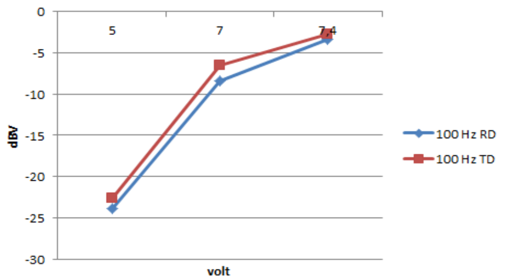

Figure 3. Comparison fft noise (dbv) rolling (blue) and transverse (red) diretion at 100 hz

CONCLUSION

Magnetic saturation of the rolling direction was higher than in the transverse direction. In contrast, the magnetostriction & acoustic noise of transverse direction was higher than the rolling direction. Harmonic frequency noise measurement had similarities with harmonic frequency magnetostriction: 100, 200, 300, 400 Hz.

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