Effect of texture residual stress and stress relief annealing on magnetic properties anisotropy of non-grain oriented electrical steel for e-mobility

Edivânia M. M. Alves[a,d]; Carolina. C. Silveira[a]; Dirceni S.C. Amorim[a]; Marco Antônio da Cunha;[b] Nelson Lima [c] Fernando J. G. Landgraf[d]

[a] Aperam South America. Research Center Department, Timoteo. Brazil. [b]Cunha consultoria ltda. Timoteo, Brazil. [c] Instituto de Pesquisas Energéticas e Nucleares- IPEN. [d]University of São Paulo, São Paulo, Brazil.

Non-grain oriented electrical steel (NOES) is constantly having its magnetic properties improved for higher core efficiency. During the final annealing process of these materials, although the steel is fully processed, small levels of residual stresses may be present and will influence on the performance of stress relief annealing (SRA). This work compared how a 0.30 mm thick NOES behaved with SRA when only the effect of shearing cutting is present (New evaluation) and when the effect of both material processing and shearing cutting (Standard condition) are influencing the rolling and transverse directions. The results showed that SRA did not modify the grain size/texture of the material, thus not significant change on the magneto crystalline anisotropy occurred. On the other hand, the magnetoelastic anisotropy energy is reasonably reshaped. In the present research, SRA reduced the magnetic core loss anisotropy (1 T/ 400 Hz) from 11% to 3-4%, this can be attributed due to the elimination of residual (tensile or compressive) stresses. These findings provide noteworthy contributions for better understanding the correlation of materials magnetic properties and processing.

Keywords: Non-Grain Oriented Electrical Steel; Residual Stress; Magnetic Anisotropy; SRA; Texture.

1. Introduction

Residual stresses can originate from different sources like mechanical or thermal processing of electrical steels. The level of tension or compression stresses might positively or negatively influence on the magnetic properties such as core loss, relative permeability, magnetic anisotropy, coercivity, etc.

Stress relief annealing (SRA) are well known to influence on the magnetic properties specially by altering the level of residual stresses present on the material.

2. Experiments

Non-grain oriented electrical steel 0.30 mm thick was used in this study. The samples had their magnetic properties measured before and after stress relief annealing with temperature of 840°C and soaking time of 60 min, under protective atmosphere of 90% N_2 + 10% H_2 with dew point= -20 °C.

Epstein frame is a measurement method to determine the magnetic properties of electrical steel strips, according to the standard IEC60404-2 [1]. This paper compares two different ways of sampling the strips in order to verify the effect of SRA on the magnetic properties of rolling and transverse direction separately and mixed. The standard condition (samples cut in Epstein dimensions (305 x 30 x 0.30 mm) and stress relief annealed) and the new evaluation (In which the samples are cut in larger size, stress annealed and then cut to Epstein dimensions) are compared. This new evaluation is proposed to compare what is the effect of SRA on the magnetic properties when only the effect of shearing cutting is present (New evaluation) and when the effect of both material processing and shearing cutting (Standard condition) are influencing.

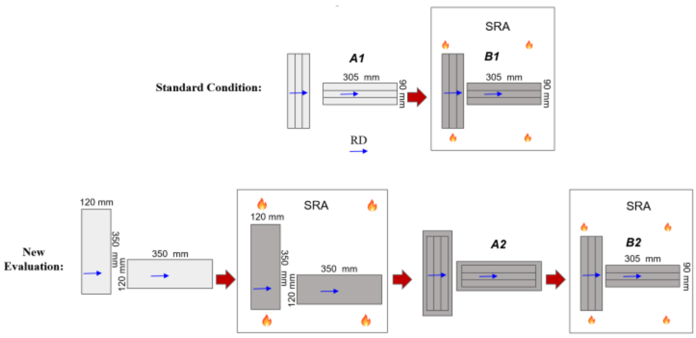

Figure 1: Scheme comparing the standard cutting conditions and the new evaluation with stress relief annealing to analyse the magnetic properties of NO30-16. (Blue arrays show RD)

3. Results and discussion

Table 1 shows the significant magnetic core loss anisotropy variation (LAF %) for each condition investigated. Comparing the *conditions A1* and *A2*, it is possible to conclude the significant reduction on the magnetic anisotropy core loss for 1 T/400 Hz.

Table 1: Magnetic properties results before and after SRA for each measured condition

Condition	$W_{(10/400)}$ W/kg			μr $_{(10/400)}$			LAF $_{(10/400)}$(%)
	RD	TD	Mixed	RD	TD	Mixed	
A1	13.2	16.5	14.8	9750	5000	6830	11
B1	13.5	14.3	14.0	8150	7490	7790	3
A2	14.5	15.4	14.9	6980	6690	6920	3
B2	13.2	14.3	13.8	8750	7910	8320	4

References

[1] Magnetic materials - Part 2: “Methods of measurement of magnetic properties of electrical steel sheet and strip by means of an Epstein frame”- International Standard IEC 60404-2. 1996.

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