Interlaboratory comparison of 1-D and 2-D loss measurements in NO Fe-Si sheets

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A comparison of the magnetic energy loss measurement in non-oriented Fe–Si sheets under alternating and rotational polarization was conducted by four European laboratories using different Rotational Single-Sheet Testers (RSSTs) and sample shapes. The laboratory-averaged RSST alternating loss figures differed by around ± 5 % from the reference values obtained according to the IEC 60404-2 measuring standard. The degree of homogeneity of the effective field, the difference between applied and demagnetizing fields across the RSST sensing area, critically affects the dispersion of the laboratories' best estimates. This is eventually quantified by the empirical standard deviations s = 4.5 % and s = 3.6 % for the alternating and rotational loss figures, respectively. A significant improvement of the lab-to-lab dispersion is nevertheless obtained with respect to a previous international comparison launched in the '90s.

Keywords: International magnetic comparison; magnetic losses; magnetic measurements; rotational induction.

1. Introduction

Standard investigations on the energy loss behavior of magnetic steels focus on alternating induction, while the design of compact and efficient electric motors calls for additional reliable data on the magnetic response of the material under bidimensional flux loci [1]. In this work, INRIM (Torino), Ampère Lab. (Lyon), Politecnico di Torino, and SATIE Lab. (Paris Saclay) participated in a rotational/alternating loss comparison aimed at creating an up-to-date background for the development of improved measuring standards.

2. Results and discussion

The four laboratories used different RSSTs with independently developed hardware and software tools and methods. Open and closed magnetic circuits were employed, using circular, cross-shaped, and single-strip samples. The alternating and rotational magnetic losses were measured by the field-metric method in NO Fe-Si sheets at peak polarization values J_p = 1.0, 1.25, 1.4, 1.5 T, across the frequency range 5 Hz $\leq f \leq$ 200 Hz.

Systematic differences among the lab results, stemming from the different magnetic circuits and setups, generate the observed lab-to-lab scatter of the measured loss values. Fig. 1 summarizes the obtained $W^{(ROT)}(J_p, f)$ behavior. The corresponding dispersion of the labs' best estimates is quantified by an empirical standard deviation $s^{(ROT)}$ = 3.6 %, remarkably reduced with respect to $s^{(ROT)}$ = 10.4 % obtained in a previous intercomparison carried out in the 90's [2].

A detailed analysis of the alternating loss vs. J_p, comparing the RSSTs results to the reference ones, associated with numerical simulation of the field and induction distribution in the sensing area, allowed us to identify the free poles arising in the disk/strip sample as the main source of systematic uncertainty and lab-to-lab dispersion of the loss figures.

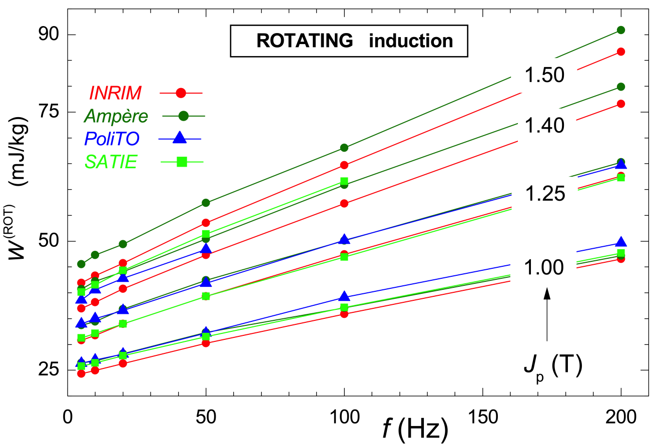

Figure 1: Energy loss $W^{(ROT)}(J_p, f)$ measured by the participating labs vs. peak polarization J_p and frequency f under rotating induction.

Be the magnetic circuit open or closed, the free poles modulate and drive the field generated by the magnetizer across the measuring area, resulting in a non-uniform effective field over such a region. This compounds with the practical geometrical requirements of the H and B sensing coils. In the present comparison, all labs adopted a 20 mm × 20 mm sensing area, a compromise between the strength and uniformity of the signals. This is an intrinsic drawback of the RSST approach, possibly hindering further progress.

References

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