Journal of ELECTRICAL ENGINEERING, VOL 55. NO 10/S, 2004, 95-96

QUICK MEASUREMENT PROCEDURE FOR QUALITY FLUX DENSITY CHECKING AT 0.3 A/m IN TOROIDAL CORES

R. Pytlech — R. Rygał — W. Pluta — M. Soiński*

To avoid full magnetic testing new method is describe for quick flux density checking. The aim of the paper is to investigate cores production process and treatment to obtain flux density of min. 5 mT at 0.3 A/m, and to ensure transformation with class accuracy 0.1 or better.

Keywords: magnetic flux density, electrical steel, current transformers, ring specimen method, toroidal cores

1 INTRODUCTION

Wound magnetic toroidal cores made of grain oriented electrical strips are commonly used in precision low voltage current transformers [1]. In the case of high current transformers manufactured nowadays the accuracy class shall be protected in testing at 1, 5, 20, 100 and 120% of nominal current I_N [2]. I_N = 600 A and accuracy class of 0.1 mean low rate output (low apparent power SN) and high quality cores with excellent magnetic properties from 6 A up to 720 A of I_N [3].

Magnetic flux density at low magnetic field strength in electrical steel vary however from 64 to 186 mT at 3 A/m [4] and no data is available at lower fields [5]. The aim of the paper is to investigate cores production process and treatment to obtain flux density of min. 5 mT at 0.3 A/m, and to ensure transformation with class accuracy 0.1 or better.

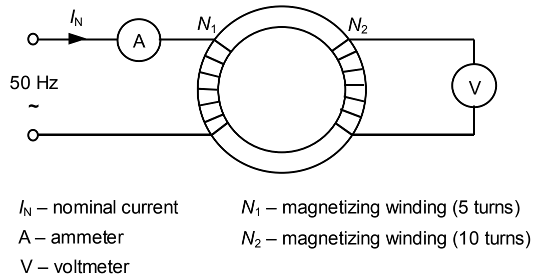

Fig. 1. Circuit of the basic ring method [6]

2 MEASURING PROCEDURE

To avoid full magnetic testing for quick flux density checking at 50 Hz the method shown on the Fig .1 was applied The total harmonic distortion of the induced voltage was less than 5% to avoid distortion of the hysteresis loop. The measurements were made at ambient temperature of 23 +/– 5 oC. Current transformer checking includes demagnetisation before starting the accuracy test because during this test itself premagnetisation should be prevented [3]. This is equivalent to test specimen demagnetisation during measurements of the magnetic properties [6]. The total error of the method is about 3%.

During measurements procedure the test specimen shall be demagnetised from a value of field strength of not less than 10 times of the coercivity by slow reduction of the corresponding magnitude of the magnetising current to zero [6]. In the case of current transformers demagnetisation is always coming from the largest test current downwards, so no residual magnetisation remains during switching off the largest test current [3].

In order to decline the time needed for quick industria quality checking demagnetisation was taken into a decreasing alternating 50 Hz magnetic field of the level of 3 A/m, *ie* 10 times higher than the one used in check-in method (3.0 A/m and 0.3 A/m, respectively). Testing shall be conducted in increasing values of magnetising current, and measurements procedure is shown in Fig 2.

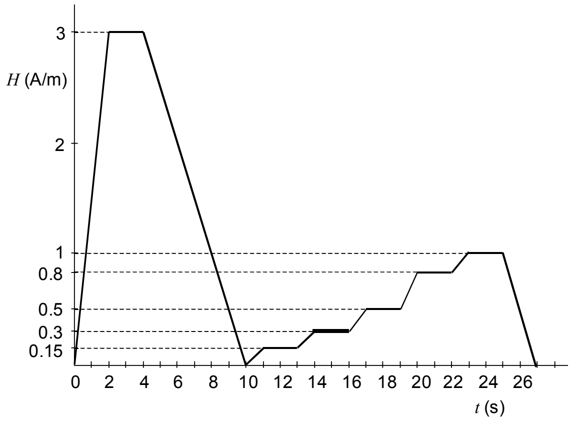

Fig. 2. Standard measurement procedure (according to [6])

Two more procedures were investigated in the paper (Fig. 3a,b).

The aim is to compare flux density from the curve $B = f(H)$ at 0.3 A/m (procedure on Fig. 2) with the value of B at 0.3 A/m from quick checking (procedure on Fig. 3b). Data from procedure as on Fig. 3a obviously are more time consuming.

3 EXPERIMENTAL RESULTS

Experimental results taken from all methods are shown in Table 1. The average value is calculated from 49 cores made of grain oriented electrical steel, with dimension 61 mm x 42 mm x 30 mm.

Results differ significantly only at low magnetic field due to transients after demagnetisation (Fig. 2 and Fig. 3) and some stochastic effect related to the nature of the ferromagnetic material behaviour [7]. This is clearly shown by coefficient of variation V_S (Tab. 1 and Fig. 4).

* University of Technology, Institute of Elektroenergetics, Al. AK 17, 42-200 Częstochowa, Poland, e-mail: PlutaW@el.pcz.czest.pl

$$V_S = \frac{1}{X_{av}} \sqrt{\frac{1}{n} \sum_{i=1}^{n} \left(X_i - X_{av} \right)^2} \cdot 100\ \% \qquad (1)$$

where are: X_i – measured data, X_{av} – average arithmetic value and n – number of measurements

From Fig. 4 it can be seen that the phenomenon V_S reaches similar values, which decrease along with the magnetic field increase.

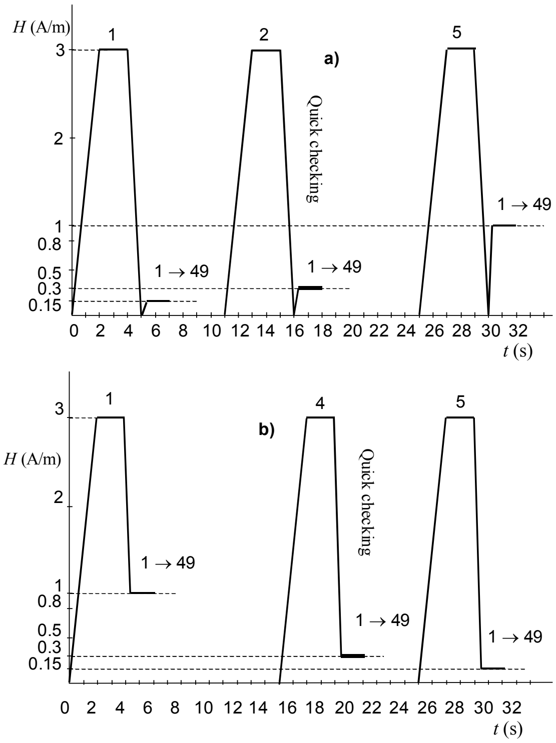

Fig. 3. Standard measurement procedure (according to [6])

Table 1. Flux density measured from method according to procedures shown on Fig. 2 and Fig. 3

H (A/m)	0.15	0.3	0.5	0.8	1
procedure as in:	B (mT)				
	V_S – coefficient of variation in % according to (eq. 1)				
Fig. 2		5.0	9.4	21.2	26.6
	26.9	9.4	6.1`	4.5	4.4
Fig. 3a	1.3	5.2	9.4	21.2	26.5
	23	7.3	5.7	4.5	4.3
Fig. 3b	1.1	5.2	1.0	21.2	26.5
	21.8	7.0	5.8	4.6	4.4

4 CONCLUSIONS

For current transformers manufactured nowadays high quality toroidal cores made of specific grain oriented electrical steel strips are applied. Cores should protect the class of transformers in the wide range of current and their excellent magnetic properties at low magnetic fields are necessary.

No data is available from steel producers catalogues at magnetic field of 0.3 A/m. As full ring specimen method [6] is time consuming, new method of checking was presented in the paper. At the magnetic field of 0.3 A/m flux density in the two methods differs no more than by 4% (Table 1).

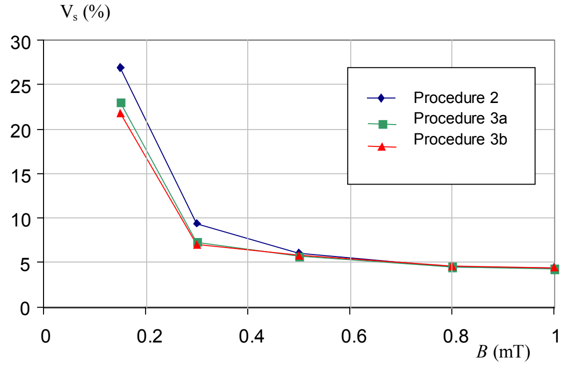

Fig. 4. Coefficient of variation of procedures (according to [6])

Results show full industrial applicability of $B = f(H)$ measurements taken simultaneously with demagnetisation process of ferromagnetic specimen.

Acknowledgement

Authors wish to thank Dr F. Fiorillo from Istituto Elettrotecnico Nazionale Galileo Ferraris in Torino for helpful discussion and suggestions.

REFERENCES

[1] Current Transformers Catalogue, Vilroda, Vilnius, Lithuania

[2] GOST 8.217-99: State system for ensuring the uniformity of measurements. Current transformers-Calibration methods

[3] TB Testing Instruction. Instrument Transformers. Braunschweig – Berlin, ISSN 0341-7964

[4] Lampa H., Testing magnetic characteristics of electrical steel sheets in low magnetisation range, V Symposium of Magnetic Measurement, Kielce, 1997, p. 205-211 (in Polish)

[5] Electrical Steel Catalogue Stalprodukt, Bochnia, Poland

[6] EC 60404-6 Methods of measurement of the magnetic properties of magnetically soft metallic and powder materials at frequencies in the range 20 Hz to 200 kHz

[7] Bertotti G.: Hysteresis in magnetism, Academic Press, San Diego 1998

Received 23 July 2004

Robert Pytlech, (Ing, Msc) was born in 1951 in Czestochowa, Poland and graduated from the Faculty of Electrical Engineering of the Technical University in Czestochowa in 2003, from magnetic measurements.

Roman Rygał (Ing, PhD) was born in 1957 in Czestochowa, Poland and graduated from the Faculty of Electrical Engineering of the Silesian University of Technology in Gliwice in 1991, from high voltage technology.

Wojciech Pluta (Ing, PhD) was born in 1961 in Zytno, Poland and graduated from the Faculty of Electrical Engineering of the University of Technology in Lodz in 2000, from rotational looses in electrical steel sheets.

Marian Soiński (Ing, DSc) was born in 1950 in Czestochowa, Poland and graduated with PhD from the Faculty of Electrical Engineering of the University of Technology in Wroclaw 1981 and graduated with Dsc from Institute of Electrotechnic in Warsaw, in 1988. Since 2002 the academic professor at the Technical University of Czestochowa.