INFLUENCE OF MAGNETIC CORE MATERIAL ON THE ERROR OF CURRENT TRANSFORMERS WITH A HALF-WAVE RECTIFIED PRIMARY CURRENT

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Abstract. The purpose of the present work is to determine the influence of the magnetic core material on current error of current transformers with a half-wave rectified current. Based on this, the criteria for selection of an appropriate magnetic core material will be substantiated. The analysis is carried out by the software product PSpice. The results are compared with experimental data of the error of current transformers at differenet types of magnetic materials in the regime considered.

Keywords: current error, current transformers (CT), half-wave rectified primary current.

INTRODUCTION

In many applications of current transformers (CT) there is a requirement for operating with a half-wave rectified primary current [1], [2], [3]. One such application is their use as connecting measuring transformers in static electronic watt-hour meters.

The analytical description of physical processes proves the thesis that if dimensioned in an appropriate way CT may operate in the presence of a direct component in supply voltage [4]. As it was mentioned in previous publication [4], the necessary general condition for their operation in such a regime, where the requirements of standards are also met [2], [3] consists in the magnetizing current of transformer core being higher than the reduced average value of primary current. This can be realized only if the core material has a suitable hysteresis loop. Then only, the requirements of the corresponding standards regarding current transformers operating in this regime can be met, too [2], [3].

In known publications there are no discussions treating the influence of the magnetic core material on current errors of CT with a half-wave rectified primary current [1], [4], [5], [6].

The purpose of the present work is to determine the influence of the magnetic core material on current error of current transformers with a half-wave rectified current. Based on this, the criteria for selection of an appropriate magnetic core material will be substantiated. The analysis is carried out by the software product PSpice. The results are compared with experimental data of the error of current transformers at differenet types of magnetic materials in the regime considered.

DEFINING THE PROBLEM

For a periodic non-sinusoidal input action the processes are investigated by applying the methods of harmonic analysis. The first harmonic component of the secondary current of CT is determined by means of the Fourier analysis. This component is of importance for determining the electric power and energy by electronic watt-hour meters. Having in mind these, two analogous circuits by means of the software product of Design Center (PSPice) [7], [8], are developed. The circuits shown in Figures 1 and 2 are used:

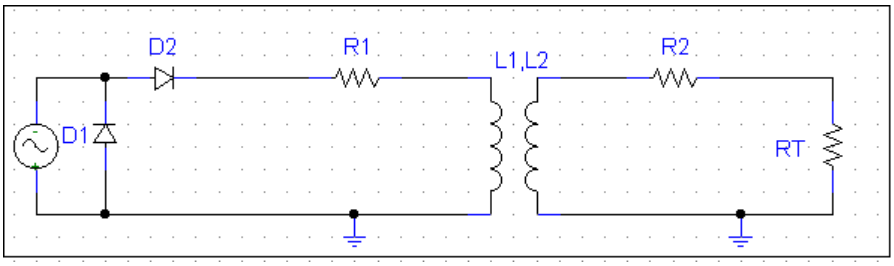

Figure 1. The circuit for determining the experimental current I_2 (calculated)**.**

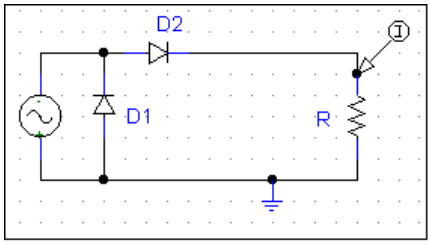

Figure 2. The circuit for determining the theoretical current I_{2T} (calculated)**.**

Both circuits use a source of sinusoidal current as a power supply source and two diodes by which a half-period mode is simulated in the circuit. The preset values of the circuit components are based on preliminary calculations of experimental specimens which are in conformity with the requirements of standards [2], [3].

The current error of the current transformer ε is calculated from expression (1) that gives the percentage deviation of obtained experimental current I_2 (calculated) with respect to theoretical current I_{2T}.

(1) $$\varepsilon = \left(\frac{I_2 - I_{2T}}{I_{2T}} \right) \cdot 100, [\%]$$

RESULTS

CT with linear and non-linear magnetic characteristics are investigated, determining the current error with time for various magnetic permeability values of magnetic materials,

various numbers of turns in the secondary winding, and diverse values of the load resistance of CT. The results are compared with experimental data from real test specimens.

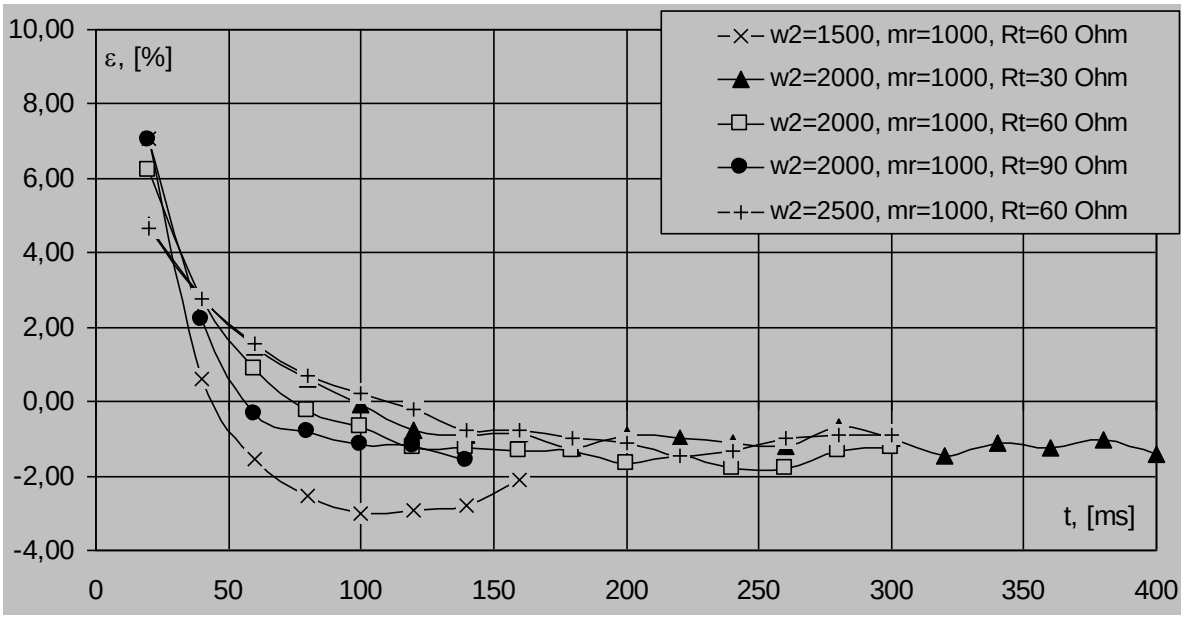

Figure 3. The current error depending on time**.**

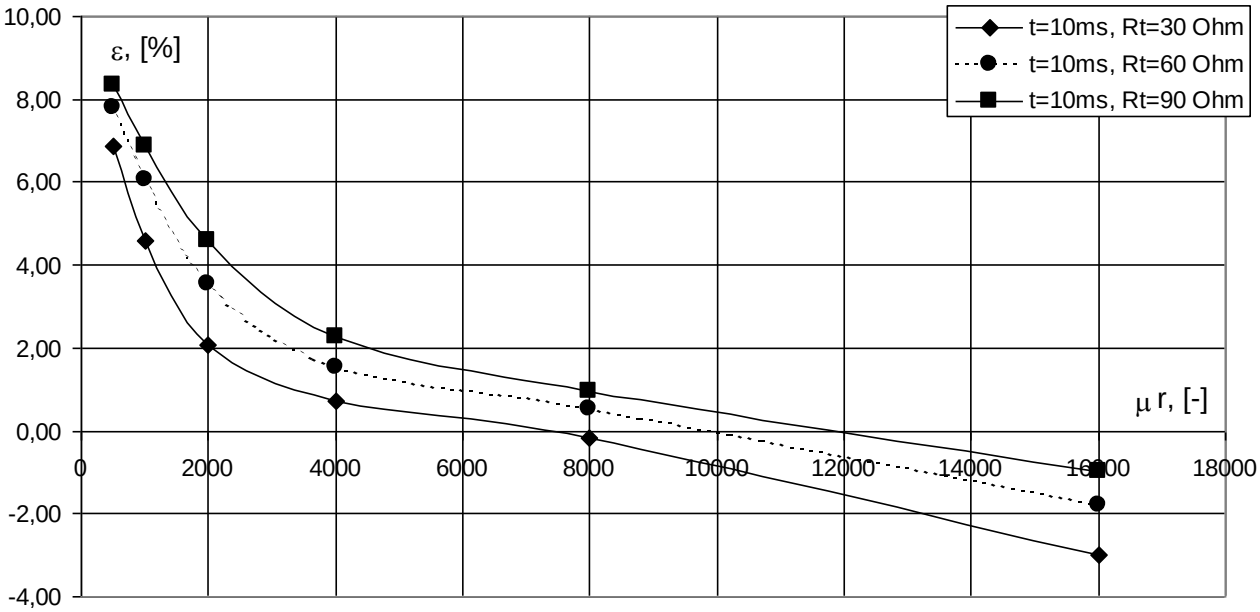

Figure 4. The current error depending on the relative magnetic permeability for different loads.

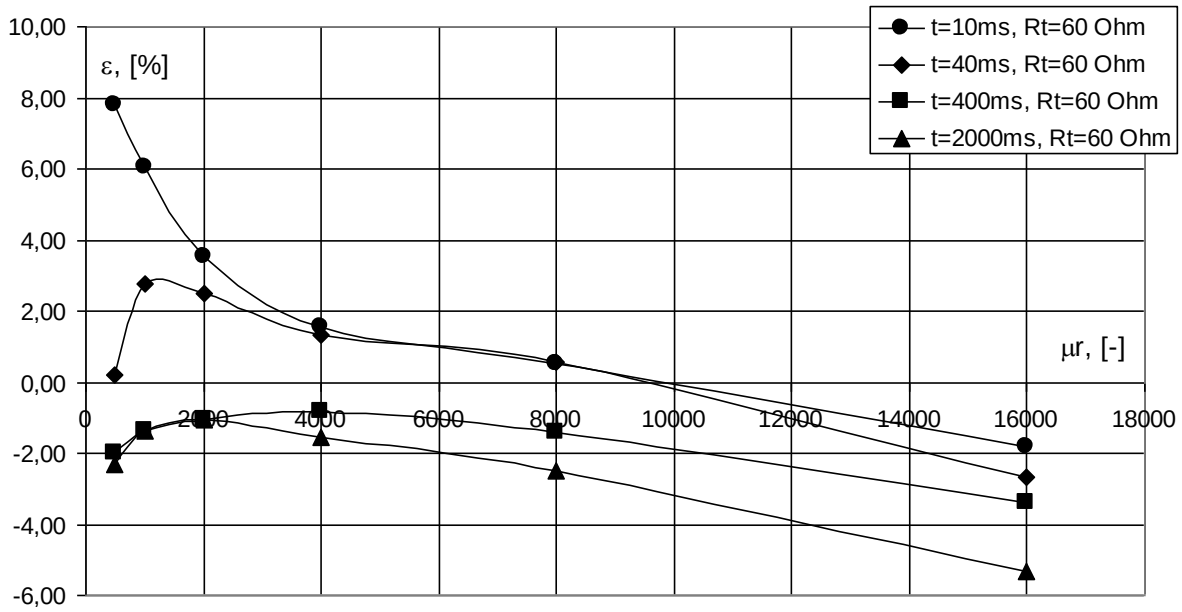

Figure 5. The current error depending on the relative magnetic permeability for different times.

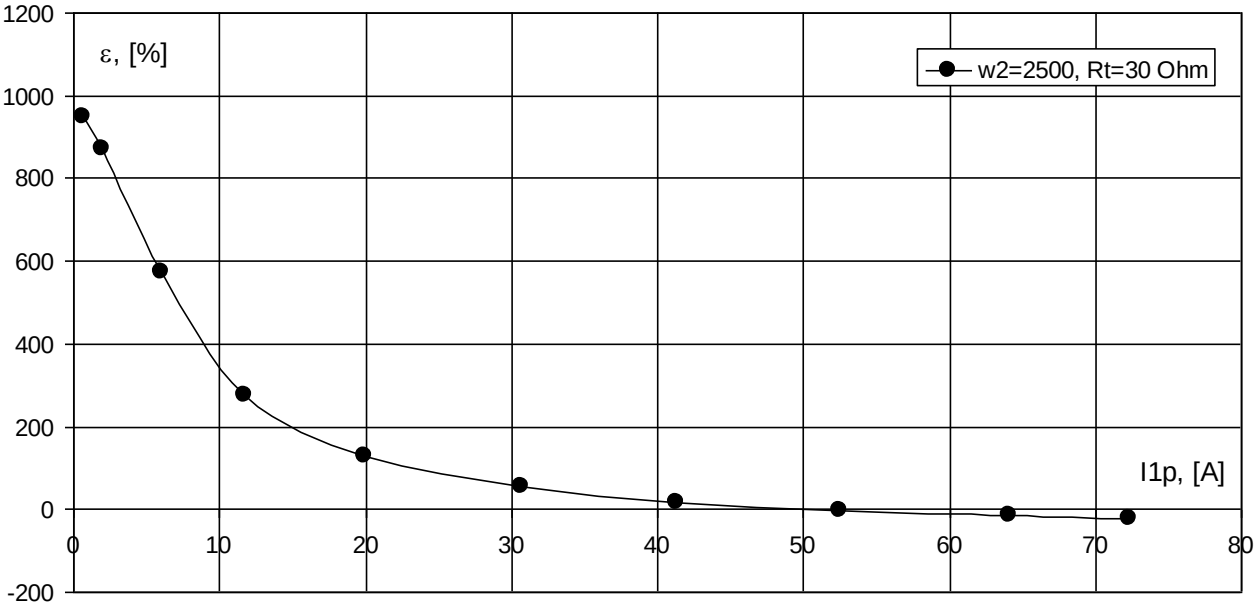

Figure 6. The current error of CT, with magnetic core with rectangular hysteresis loop, depending on the reduced primary current (I1p).

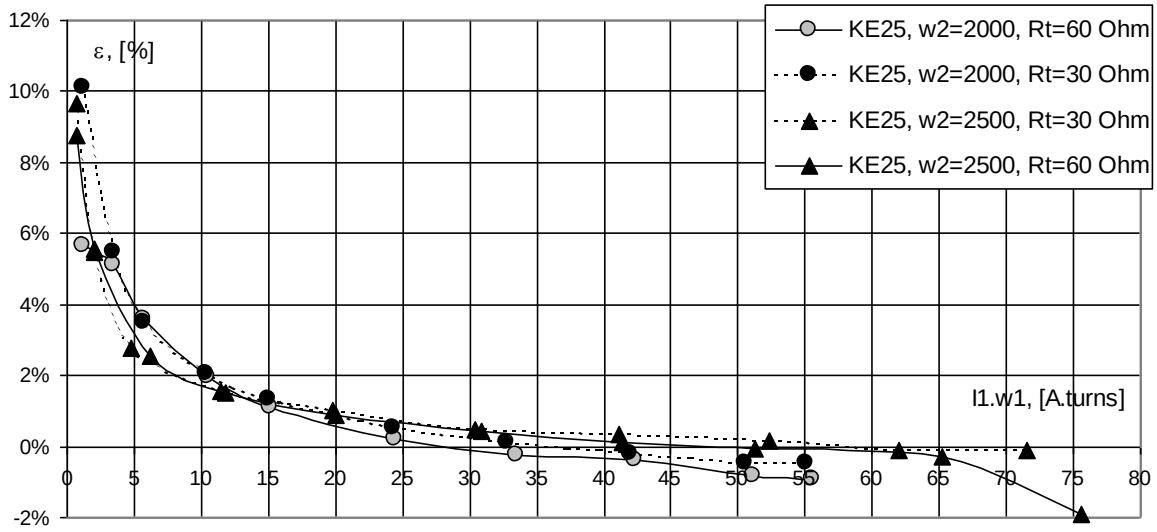

Figure 7. The current error of real CT with linear magnetic core.

ANALYSIS OF THE OBTAINED RESULTS

Magnetic cores with rectangular hysteresis loop cannot operate in the presence of a large direct current component in the power supply circuit due to the extraordinarily high error of CT.

The current depends also on the value of the relative magnetic permeability of magnetic core material as in the steady-state regime there exists an optimal value of this material parameter at which the CT error is minimal for preset other parameters of the transformer.

The comparison of experimental results with those obtained by analyzing with PSpice shows that for sufficiently large fields, where the real CT has a linear characteristic, there is an agreement between the current error results.

The current error at first switching on is larger than the current error, which is obtained at steady-state regime. It depends on the transient process of the variation of operating point of the core.

CONCLUSIONS

Current transformers may operate with a half-wave rectified primary current if they are dimensioned in an appropriate way. This can be realized only if the magnetic core material has a linear hysteresis loop. Then only, the requirements of the corresponding standards regarding current transformers operating in this regime can be met, too.

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