

Inductance self-heating transient modeling.

L. Morel, A.T. Bui, F. Sixdenier, N. Burais.

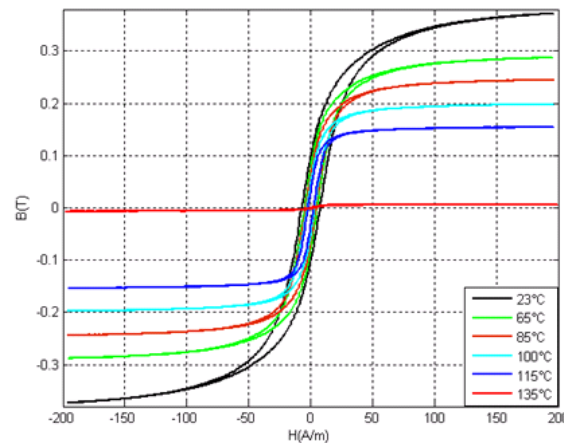
Université de Lyon, Université Lyon 1, F69622, France;
CNRS UMR5005 AMPERE, 43, Bld du 11 Novembre 1918, Villeurbanne, F69622

This paper focuses on the thermal stress on magnetic materials under thermal constraint. Temperature influence on all standard static and dynamic magnetic properties is studied. The Jiles-Atherton model model is used in order to reproduce the static and DSF model for dynamic hysteresis loops for material ferrite MnZn N30 (Epsco). The six model parameters are optimized from measurements for each temperature. The model parameters variations are discussed. Finally, the electromagnetic model is associated with a simple thermal model to achieve a coupling between three physical domains: electric - magnetic – thermic in order to reproduce of self-heating of an inductance. The simulation results are compared with measurements.

***Index Terms*—Magnetic dynamic hysteresis, Magnetic materials, Magneto-thermal properties, Magneto-thermal coupling.**

Even though there are a large number of applications where a linear model of magnetic circuit is enough for circuit simulation, some others, for example, switching power suppliers, require an accurate model of the magnetic material. The model should consider nonlinearities, magnetic saturation, dynamic hysteresis, temperature effects. Moreover magnetic circuit in the electromagnetic system is a key element of an efficient energy conversion. In reality, the properties of ferromagnetic material are quite sensitive to temperature variations, which may induce a change in the electromagnetic system performance.

To quantify this influence, a self-heating of an inductance is proposed. The magnetic material is a ferrite MnZn N30 very sensitive to temperature, with low Curie temperature is 135°C. A new hysteresis model is firstly presented to model the variation of magnetic behavior under the influence of temperature. Then, a classic thermal model is proposed to estimate the operating and transient temperature from the Joule copper losses and iron losses. Finally, a coupling between electric – magnetic – thermic domains is performed to simulate the component behavior of an inductance.



EVOLUTION OF B(H) LOOP AS A FUNCTION OF TEMPERATURE IN STATIC REGIME (1Hz)

A dynamic thermal-electromagnetic model to study self-heating of an inductance is proposed. To do this, a classic thermal model is coupled to a new dynamic hysteresis model. The transient temperature of the magnetic core and the coil are estimated with accuracy. To do this, the dynamic hysteresis model presented takes account the variation of magnetic behavior under the influence of temperature up to the Curie one. The experimental and simulation results proved the consistency of this methodology.