

Calorimetric measurement and modeling of iron losses in Silicon Iron current sensor

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Abstract- This paper analyses the magnetic losses in a supply current sensor dedicated to circuit breakers. Measurements were performed using a suitable calorimeter able to detect 1 mW to 10 W. Several frequencies and voltages were tested. These conditions were also used to simulate the device by 3D FEM in which the iron losses were determined using the LS (Loss Surface) dynamic hysteresis model. Comparison between experiments and simulation shows a high concordance that leads to conclude about the reliability of the LS model to predict the sensors behavior.

Key words—Iron losses modeling, calorimetry, soft magnetic materials, Iron Silicon sheets, current sensor.

1. INTRODUCTION

The continuous improvement of Schneider Electric's sensors requires different approaches. In this paper two methods are presented: an experimental characterization using a calorimetric bench and modeling using the LS (Loss Surface) model integrated in the software FLUX. This study was conducted on the iron-silicon sensors installed in the current breakers Masterpact® devices. Depending on the complexity of the sensor load and the adopted approximations, the results of the model are more or less reliable. Thus, predictions are compared to experimental measurements.

2. CALORIMETRY

Developed at G2Elab, the calorimeter [1][2] used in this experiment is primarily devoted to characterize power electronic components up to 3 kV and 1 MHz and within the temperature range of -50 to +150 °C. It is based on radiation energy transfer and uses a suitable vacuum enclosure (Fig. 1) which contains the heater and all temperature sensors. Moreover, given that a perfect isolation is impossible, a differential measurement method is adopted. In these conditions the calorimeter offers a measurement range from 1 mW to 10 W with an accuracy of 2 %.The power supply

devices are outside the enclosure. This condition imposes some strict constraints regarding electrical cables and connections to ensure the stability of the vacuum while avoiding any heat transfer in both ways.

The studied current sensor is dedicated to ensure the power of a self-supplying circuit breaker. It is designed to operate from 80 A to 2 kA and its secondary coil supplies the electronic circuit of the circuit breaker (Fig. 2). Because of the current limitation (1 A) imposed by electrical connections inside the calorimeter, the sensor can't be supplied as in its real working conditions. In this case, we decided to consider the sensor in a reversed situation in which it is magnetized through the secondary coil.

Measurements of losses were done at several excitation voltages and frequencies.

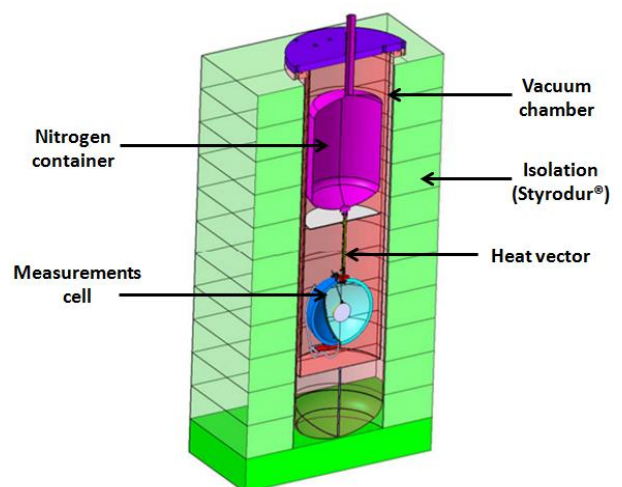


Figure 1 General presentation of the calorimeter

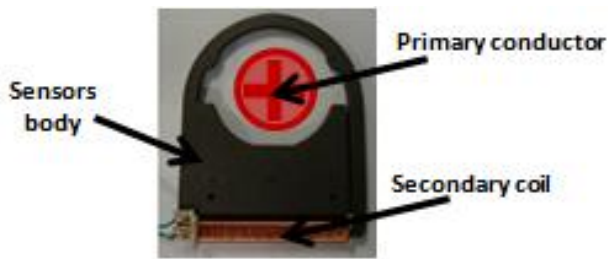


Figure 2 General presentation of the Masterpact® NW sensor

3. IRON LOSS PREDICTION, LS MODEL

The LS model [3][4] is a scalar and global hysteresis model including all dynamic effect in soft magnetic materials. It is an $H(B, dB/dt)$ model based on an experimental characterization. It links the magnetic field H to the induction B in the cross section of the material. This model allows a reconstruction of any hysteresis loop. The sensor modeling is a very useful tool to estimate the yield of actual versions and future prototypes. But how far can we rely on the LS model results? Following the calorimetric tests, the same signals have been simulated using FEM calculation and LS Model.

4. RESULTS AND CONCLUSIONS

Regarding the fact that the LS model data base doesn't contains the precise materials that constitutes the sensor, two close material models have been simulated and compared to the calorimetric results. The comparison shows high concordance between the experimental and simulation results (Fig. 3).

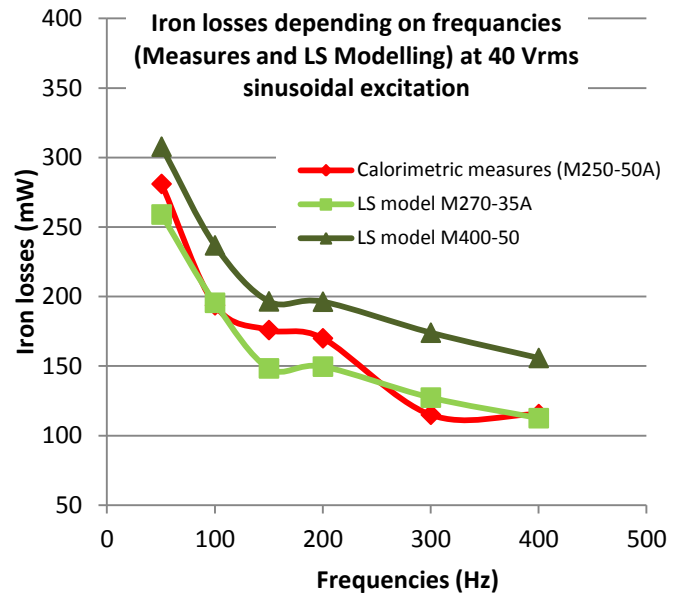


Figure 3 Iron losses versus frequency at 40 V, comparison between calorimetric and LS model results

5. REFERENCES

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