Study of the temperature dependency of electrical steel losses

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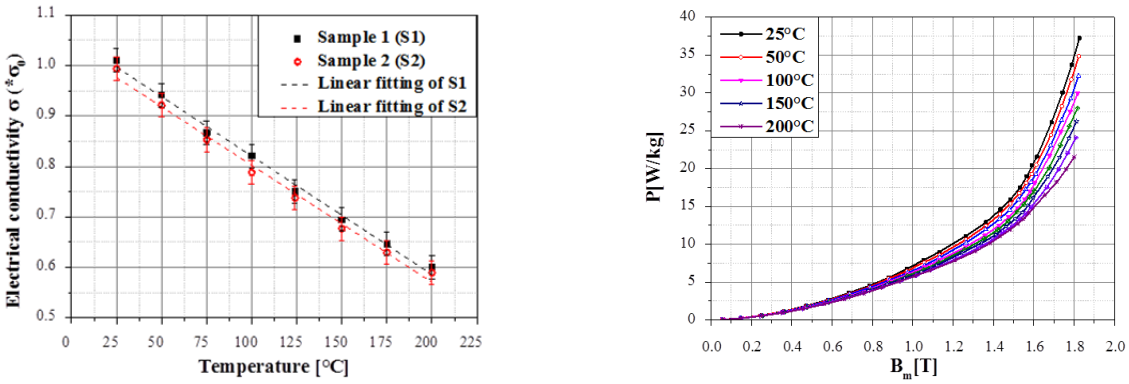
Context

The L2EP is developing an experimental device for soft magnetic materials characterization to study the influence of temperature on the hysteresis and dynamic losses (eddy currents). The device has been used to characterize samples extracted from the massive magnetic steel of claw pole rotors employed in automotive alternators (Fig. 1-a). In the considered range of temperature (up to 200°C) the dynamic losses are significantly influenced (decreasing tendency) whereas the hysteresis losses are less impacted. Analyzing the dynamic loss evolution shows that it is strongly correlated to the decrease of the electrical resistivity with increasing temperature (Fig. 1-b).

The experimental characterization of losses with temperature requires specific equipment and considerations in the measurement protocol, especially when accurate behavior is needed to represent adequately the thermal behavior of an electrical machine. Therefore, a numerical model of a lamination, taking into account the hysteresis and eddy currents effects, is in development with the aim of predicting the iron losses depending on the temperature. This dependency relies on the identification of the losses at room temperature and the temperature dependency of the electrical conductivity, which is easier to characterize experimentally.



(a) (b)

Fig. 1 Influence of the temperature on the (a) Electrical resistivity and (b) Iron Losses

Objectives

In a similar way as for the massive magnetic sample, the main objective of the internship is to study the evolution of losses with temperature for an electrical steel lamination used in electrical machines for electric mobility. The work will be focused on the experimental measurement of iron losses and electrical conductivity with the temperature. The numerical model will be used to propose an experimental protocol requiring a minimum of experimental measurements to be able to accurately predict the losses variation with the temperature.

Progress

The work should follow the steps:

1- Bibliographic research work on iron losses and temperature effects
2- Experimental characterization of losses and electrical conductivity with temperature
3- Numerical modelling and validation with the most adequate experimental protocol

References

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[2] Jamil Meryeme, Benabou Abdelkader, Clénet Stéphane, Arbenz Laure, Mipo Jean-Claude, "Development and validation of an electrical and magnetic characterization device for massive parallelepiped specimens", International Journal of Applied Electromagnetics and Mechanics, Vol. 61, N°. S1, pages. S31-S38, 2019.
[3] Hussain Sajid, Benabou Abdelkader, Clénet Stéphane, Lowther David A., "Temperature Dependence in the Jiles-Atherton Model for Non-Oriented Electrical Steels: An Engineering Approach", IEEE Transactions on Magnetics, Vol. 54, N°. 11, 2018.