Ecole doctorale
Sciences de l'Ingénierie et des Systèmes
EGENGSYS

Title: CHARACTERIZATION AND MODELLING OF ELECTRICAL STEEL USAGE PROPERTIES UNDER MAGNETIC AGEING CONDITIONS

Funding: ANR (Project MASTERMIND2)

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Research Group: Laboratoire d'Électrotechnique et d'Électronique de Puissance (L2EP) de Lille - ULR 2697
Team OMN (Outils et Méthodes Numériques) "Numerical Tools and Methods"

Global context:

In electrical machines, ferromagnetic materials are key components for the efficiency and performance of the energy conversion process. However, in modern applications, severe operating conditions, such as thermal constraints, influence their usage properties and may induce the so-called magnetic ageing. Thus, the electrical machine performances may be significantly impacted, especially in terms of efficiency. Indeed, during the electromechanical conversion, the different sources of losses (iron losses, Joule losses) may lead to an overheating of the machine. In some applications, the temperature increases significantly reaching up to 200 °C in some locations of the machine. Combined with the time factor, this variation of the temperature can activate the ageing physical mechanisms that will modify irreversibly the magnetic properties of the electrical steel. This process is usually defined as the magnetic ageing. Therefore, to predict accurately the electrical machine performances during their lifetime, it is necessary to investigate the magnetic ageing in electrical steels, starting by characterizing and modelling its impact on the usage properties.

Existing works in the literature are mainly focused on the experimental evaluation of the magnetic ageing with limited investigations on the models adapted for electrical devices study. Moreover, the complex mechanisms leading to the "magnetic ageing" require having a modelling approach that links the relevant microstructural parameters to the macroscopic properties of interest for energy conversion (magnetic permeability and iron losses). The OMN team of the L2EP has been working on this subject since few years, especially with macroscopic magnetic characterization approaches and the associated models. To fulfil the objective of accurate modelling of the ageing process in electrical steels, the MASTERMIND2[1] project (2023-2026) has started with complementary actions on the multi-physical micro- and macro-characterizations of electrical steels subjected to magnetic ageing as well as on the associated micro- and macro-modelling of the relevant physical mechanisms leading to magnetic ageing. The global objective is to be able to predict the ageing of electrical steels within the context of energy conversion device subjected to severe operating conditions.

Objectives:

The proposed PhD will be mainly focused on the macroscopic magnetic characterization and modelling of electrical steels subjected to magnetic ageing. However, a strong interaction with other actions in the MASTERMIND2 project (PhD and Post-doctoral research) is expected, especially with the microscopic characterization and modelling tasks, in order to develop relevant multi-scale and multi-physical models for the magnetic ageing prediction in electrical steels.

The work will be focused on three main axes:

- Experimental characterization of the magnetic ageing of electrical steels,
- Macroscopic modelling of the magnetic ageing including the link with the microstructural properties,
- Implementation of the developed models in numerical tools and experimental validation with prototypes.

Candidature:

Education/Experience:

- Master or Engineer diploma in electrical engineering, materials science or related fields in applied physics.
- Knowledge in magnetic materials would be a strong asset.

Candidates are requested to submit (applications that do not meet these requirements will not be considered):

- a **CV**,
- a **motivation letter** (that highlights your strengths and reasons why you should be appointed to the position),
- at least **two recommendation letters** (including the contact details of the referees),
- the **academic grades and ranks of the last three years**.

Contacts:

Applications are only accepted through email. All documents must be sent to:

- Abdelkader Benabou (abdelkader.benabou@univ-lille.fr)
- Oualid Messal (oualid.messal@univ-lille.fr)

[1] The MASTERMIND2 project includes the L2EP, MSMP and IM2NP research groups