Master thesis project, 2023 – 2024

Machine Learning-Based Material Modeling for Electric Motor Design

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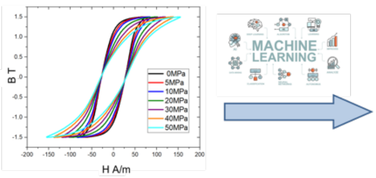
Context

Efficiently optimizing the energy performance of modern electrical motors, particularly in industrial and electric mobility applications, relies on the availability of precise design tools. A critical component in achieving this goal is accurate material modeling, specifically for electrical steels used in the magnetic circuits of these motors. These materials' properties are instrumental in defining overall performance and energy efficiency during the energy conversion. However, the intricacies of manufacturing processes and the demanding operating conditions of these electrical motors require the consideration of the multi-physical behaviors exhibited by electrical steels.

In contemporary applications, electrical steels' mechanical and thermal stresses significantly impact properties crucial to energy conversion, such as magnetic constitutive laws and iron losses. The complex multi-physical couplings inherent to electrical steels, including magneto-mechanical and magneto-thermal interactions, often lead to property degradation, ultimately affecting motor performance. Conventional approaches to modeling these materials under manufacturing processes and operating conditions tend to result in complex and computationally intensive models. These models could be more practical for design tools, especially during optimization procedures.

Objective

$\boldsymbol{f}: \mathrm{H}_i \rightarrow \mathrm{B}_i \quad 1 \leq \boldsymbol{i} \leq \mathrm{N}$



$\mathrm{B} = \boldsymbol{f}(\mathrm{H})$

This internship aims to address these challenges by focusing on innovative approaches to material modeling, specifically through machine learning techniques. The primary objective is to compare and evaluate different conventional machine-learning techniques for constructing surrogate models of electrical steel properties. Two key scenarios will be explored: one considering the influence of mechanical effects and the other excluding them.

Work steps

1 Evaluating and comparing the performance of various machine learning methods for constructing surrogate models of electrical steel properties.
2 Investigating the impact of mechanical effects on the accuracy of material modeling.
3 Identifying the most suitable machine learning approach for creating surrogate models that strike a balance between accuracy and computational efficiency.

Keyword

Machine learning techniques, material modeling, multi-physics

References

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