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La soutenance a lieu Publiquement

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Composition du Jury

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Résumé

Electrical steel is an iron-silicon alloy with specific magnetic properties such as low power loss and high permeability. Electrical steels are massively used for the iron core of motors in electric vehicles. During manufacturing, mechanical stresses and strains are inevitably induced, leading to a degradation of the magnetic performance. Non-destructive testing solutions exist; they indirectly observe material states by setting conformity thresholds and removing all unsatisfactory specimens. Local properties can be observed with X-rays or advanced imaging techniques (such as EBSD), but their cost and complexity make them questionable in the industrial context. Considering that the working principle of the motor core is converting electrical energy to kinetic energy through electromagnetic interaction, this work proposes to use magnetic techniques. The IEC international standards describe classic experimental setups for magnetic characterization (Epstein frame, single-sheet tester, etc.). These methods enable the evaluation of magnetic behaviors via hysteresis curves, but it is destructive, non-local, and incompatible with in-line production. Besides, different mechanisms overlap during the hysteresis cycle characterization, making the influence of stress complex to be evaluated. Current studies on the electromagnetic properties affected by mechanical loading combine the hysteresis curve and magnetic Barkhausen noise (MBN) measurements. However, a comprehensive exploration of the magnetic behavior influence caused by mechanical issues and the corresponding mechanism still needs further understanding. In this work, a combination of several techniques was considered. Integrating multiple detection methods provided more information and support for the integrated analysis of magnetic behavior but also introduced more parameters accordingly. These parameters, introduced more information into the system, leading to complementary conclusions and a very accurate estimation of the mechanical properties and degradation status.