Determination and minimization of losses in 3D printed magnetic circuits

TN02000028/4-V21 (O)

The project TN02000028 Center for advanced machines and technology is co-funded with the state support of the Technology Agency of the Czech Republic under the National Centres Programme.

FACULTY OF ELECTRICAL ENGINEERING
UNIVERSITY OF WEST BOHEMIA

RICE

REPORT

Determination and minimalization of losses in 3D printed magnetic circuits

Department:	Research and Innovation Centre for Electrical Engineering
Research report no.:	22190-026-2025
Report type:	Research report
Authors:	Ing. Jan Kaska, Ph.D., Ing. Tomáš Paveza, Ing. Michal Freisleben, Ing. Zdeněk Frank, doc. Ing. Roman Pechánek, Ph.D.
Project leader:	doc. Ing. Roman Pechánek, Ph.D.
Pages:	22
Release date:	19. 12. 2025
CEP Classification:	2.2 Electrical engineering, Electronic engineering, Information engineering - Electrical and electronic engineering

Customer:

Supplier:

University of West Bohemia in Pilsen
Regional Innovation Centre for Electrical Engineering
Univerzitní 8
306 14 Plzeň

Contact person:

Ing. Tomáš Paveza
tel. +420 377 634 412
pavezat@fel.zcu.cz

This research has been supported by the Technology Agency of the Czech Republic under the project TA ČR NCK 2 CAMAT TN02000028

Abstract

This report focuses on iron-loss behaviour of additively manufactured FeSi3 electrical steel produced by laser powder bed fusion (PBF-LB) and evaluated on experimental toroidal cores. Because AM FeSi3 is typically manufactured as a bulk, electrically conductive solid, its dynamic performance is strongly affected by eddy currents, leading to losses that are substantially higher than those of conventional laminated electrical steels.

The study therefore combines systematic loss measurements on wound toroid's covering quasi-stationary hysteresis characterization, dynamic 50 Hz tests at fixed induction, and extended loss mapping across frequency and induction and numerical simulations aimed at loss reduction by topology optimization, where material distribution is modified to disrupt eddy-current paths while maintaining magnetic performance.

The experimental results demonstrate that high-temperature heat treatment (1100 °C) significantly reduces coercivity and produces a modest but measurable reduction in dynamic losses at 50 Hz, while the simulation work shows that carefully designed topologies can strongly reduce eddy-current loss density, albeit often at the cost of increased magnetizing current. Together, the measurement methodology and optimization framework provide a practical pathway for closing part of the performance gap between AM FeSi3 bulk cores and conventional laminated steels.

Keywords

Additive manufacturing, Eddy currents, FeSi3, Heat treatment, Iron losses, Magnetic properties, Toroidal cores, Topology optimization, 3D printing