Application of Dielectric Coatings on Laser Additively Manufactured Silicon Steel Soft Magnetic Cores

Summary

Additive manufacturing technologies support the sustainable manufacturing goals of EU by facilitating the production of next-generation electrical machines (EM) and simplifying the involved logistics. The main advantage of AM systems is their capacity to cost-effectively produce parts with complex topologies that have previously been out of reach of traditional methods. Current laser powder bed fusion additive manufacturing facilities in Taltech are capable of producing high quality metallic parts with useful mechanical, magnetic and electric properties. What is lacking is the multi-material option, e.g. the possibility of adding insulating layers on specific surfaces of a 3D-printed part. The project will explore the possibility applying such coatings on 3D-printed soft magnetic stator cores in order to suppress the induced eddy currents. The work on this project will include both theoretical and practical work, including operating a laser powder bed fusion (L-PBF) system to 3D-print 6.5% silicon steel and the study of different processes (such as dipping, electroplating, PVD or CVD coating methods) to enhance its performance characteristics.

Research field:	Electrical power engineering and mechatronics
Supervisors:	Prof. Dr. Maarja Grossberg-Kuusk Dr. Hans Tiismus
Availability:	This position is available.
Offered by:	School of Engineering Department of Electrical Power Engineering and Mechatronics
Application deadline:	Applications are accepted between June 01, 2024 00:00 and June 30, 2024 23:59 (Europe/Zurich)

Description

Main supervisor: Researcher Hans Tiismus

Co-supervisor: Tenured Full Professor Maarja Grossberg-Kuusk

Within this thesis, the PhD candidate will learn about different modelling methods and practical skills, which include operating a laser additive manufacturing system and laboratory work in material and electrotechnical science domains. The work will include a large hands-on applied research component: identifying the optimal 3D-printing and coating methods through practical work, with the goal of maximizing core flux transfer and minimizing losses while accounting for the insulation uniformity and reliability. The candidate is responsible for developing and implementing the core optimization procedures. We will provide the necessary hardware and software for simulation and prototyping work. At the end of the thesis, a prototype demonstrator motor will be built which will utilize the 6.5% silicon steel cores with integrated insulating coatings. The candidate will present his/her work at international conferences and publish journal papers required to complete the thesis within the PhD studies.

Responsibilities and tasks

- Determining the optimal processing parameters and design rules for 6.5% FeSi
  - Learning to operate the SLM-280 printing system.
  - Optimizing the printing and post processing of 6.5% FeSisoft magnetic material
  - Determining the material specific design rules 6.5% FeSi and measuring the material properties for the design database.
- Study of insulating coatings on 3D-printed parts
  - Determining the state of the art, possibilities and limitations for applying coatings on 3D-printed parts
  - Practical work with different coating methods, including dipping, electroplating, physical vapor deposition (PVD), and chemical vapor deposition (CVD) methods.
  - Identifying the most reliable methods to apply an insulating layer on the surface of 3D-printed magnetic cores with varying topologies.
- Prototyping

- The developed combination of the 3D-printed 6.5% FeSiwithinsulating coating will be tested in a practical electrical machine prototype (developed by other research group members).
- The prototype magnetic cores will be tested through exhaustive measurements of the demonstrator machine.

Applicants should fulfil the following requirements:

- a master's degree in physics, electrical engineering, or material engineering
- prior experience with 3D-printing or coatings
- a clear interest in the topic of the position
- excellent command of English
- strong and demonstrable writing and analytical skills
- capacity to work both as an independent researcher and as part of an international team
- capacity and willingness to help in organizational tasks relevant to the project

The following experience is beneficial:

- Theoretical and experimental basics of electrical machines and metallurgical processes
- Knowledge of electromagnetic phenomena
- Programming in C++/ MATLAB

We offer:

- 4-year PhD position in the leading electrical machines research group in Estonia with a large portfolio of dedicated research, industrial and study-oriented projects
- The chance to do high-level research in one of the most dynamic Universities and research groups in the region
- Opportunities for conference visits, research stays and networking with globally leading universities and research centers in the fields of electrical machines and material sciences.

About the department

The Department of Electrical Power Engineering and Mechatronics of Tallinn University of Technology is an interdisciplinary research center that focuses on socially relevant and future-oriented research and teaching issues related to power engineering and mechatronics. The mission of the Department is to be a leader in electrical engineering and technical studies and development projects in Estonia, known and valued in society, and a respected partner in both national and international cooperation networks and organizations.

TalTech's electrical machines research group (EMG) deals with calculations, modeling, control, testing and development of electrical machines (motors, generators, transformers). In addition, the group conducts expertise, consultations and trainings.

FOCUS FIELDS:

- Electrical machines calculations, modelling and testing
- Determination of electric and loading parameters
- Thermal analyses in calorimetric chamber and wind tunnel
- 3D printed electrical machines
- Modelling and experimental detection of electrical machine faults
- Digital twins for electrical machine control and diagnostics
- Artificial intelligence (AI) in electrical machine design and diagnostics

Additional information

For further information, please contact Dr. Hans Tiismus hans.tiismus@taltech.ee or visit https://taltech.ee/en/electrical-machine-group

To get more information or to apply online, visit https://taltech.glowbase.com/positions/793 or scan the the code on the left with your smartphone.