Optimization of Additively Manufactured 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 the capacity to cost-effectively produce parts with topologies that have been previously out of economical feasibility or even completely unattainable through traditional methods. One of the main challenges yet to be solved in 3D-printing EMs is the suppression of the forming eddy currents when switching or rotating magnetic fields are involved. This is because of difficulties in the formation of electrical insulation layers within the printed parts which results in excessive iron losses. The overall goal of the project is to reduce these losses to a manageable level and includes both theoretical and practical work. The project focuses on the modelling of eddy currents, optimization of core topologies based on the capabilities of the laser powder bed fusion system, printing of samples, extensive laboratory testing of the developed material and the validation of the methodology through analysis of all the mentioned steps.

Research field:	Applied physics and mathematics
Supervisors:	Prof. Dr. Jaan Kalda Dr. Hans Tiismus
Availability:	This position is available.
Offered by:	School of Science Department of Cybernetics
Application deadline:	Applications are accepted between October 02, 2023 00:00 and October 23, 2023 23:59 (Europe/Zurich)

Description

Within this thesis, the PhD candidate will learn about different modelling methods and practical skills, which include operating laser additive manufacturing systems and laboratory work in material and electrotechnical science domains. The main emphasis will be on the development of analytic tools that can estimate the effect of various design parameters on the magnetic behavior of the cores and their experimental verification. 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 optimized cores. The candidate is responsible for developing and implementing the core optimization procedures. 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

- Optimization tools
  - Determining the state of the art, possibilities and limitations for AM magnetic cores
  - Different optimization methods to improve the existing core designs will be studied and best ones will be selected. Limitations and complexity of the algorithms are investigated. Selected algorithms will be implemented in Matlab environment.
- Geometrical optimization
  - Novel core topologies will be simulated both analytically and numerically, with the goal of maximizing the core energy transfer. MATLAB and COMSOL environments will be selected for this purpose.
- Determining the optimal processing parameters and design rules
  - Learning to operate the SLM-280 printing system.
  - Optimizing the printing and post processing of $FeSi_{6.5}$ and $FeCo_{50}V_2$ soft magnetic powders
  - Determining the material specific design rules when printing $FeSi_{6.5}$ and $FeCo_{50}V_2$.
- Testing and validation
  - Finally, the optimized cores will be 3D printed, tested and validated through exhaustive measurement and analyses.

Applicants should fulfil the following requirements:

- a master’s degree in physics, electrical engineering, or material engineering

- 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:

- Knowledge of electromagnetic phenomena
- Programming in C++/Python/MATLAB
- Working knowledge of optimization theory and methods

The candidate should submit a research plan for the topic, including the overall research strategy. The candidate can expand on the listed research questions and tasks, and propose theoretical lenses to be used.

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 practical part of the project will be performed at the Department of Electrical Power Engineering and Mechatronics of Tallinn University of Technology, 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. The department educates future energy leaders and engineers at the bachelor's, master's and doctoral level. Through training courses, the department ensures lifelong learning and continuous development.

The department carries out large-scale interdisciplinary scientific research, development and professional projects, thanks to which the competence in the field of electrical energy and mechatronics continues to grow. With research, application and development services, the department increases the competitiveness of companies in both the domestic and international markets, keeping knowledge in Estonia. The department has coordinated or been a partner in numerous international projects, such as Horizon 2020, INTERREG, 7FP, Nordic Energy Research, etc.

The modelling and theoretical analysis will be performed at the Department of Cybernetics of Tallinn University of Technology, an interdisciplinary research center with extensive experience in the modelling of the physics of complex systems, continuous media, turbulence, etc., as well as in the analysis of complex nonlinear time series.

Additional information

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

To get more information or to apply online, visit https://taltech.glowbase.com/positions/696 or scan the the code on the left with your smartphone.