Development of Control Methodology for Additively Manufactured Electrical Machines

Summary

Electrical machines are the workhorses of modern industry. Thus, electrical machines are facing challenges in meeting very demanding performance metrics, for example, high specific power, customization, etc. This provides clear motivation to explore the impact of new manufacturing methodologies and its possibilities to enhance electrical machine performance. The use of additive manufacturing to produce electrical machines gives several new possibilities how to design more efficient and higher power density machines. However, to achieve the maximum effect in the design of the machine, it is necessary to consider also the control methods through which it is possible to increase both machine efficiency and controller efficiency. The overall goal of the project is to develop the control methodology for additively manufactured switched reluctance machines. The project focuses on optimizing the selection control method according to the machine design. Also, the control method will be used as an input on the electrical machine optimization to achieve high energy-efficient drive system. The practical part of the work will be testing the control model with a prototype machine in the research laboratory.

Research field:	Electrical power engineering and mechatronics
Supervisors:	Prof. Dr. Anton Rassõlkin Prof. Dr. Ants Kallaste
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, 2025 00:00 and June 30, 2025 23:59 (Europe/Zurich)

Description

Main supervisor: Ants Kallaste

Co-supervisor: Anton Rassõlkin

The research

Within this thesis, the PhD candidate will learn about the control and application of additively manufactured special types of electrical machines, like switched reluctance machines. The main emphasis will be on the development of switched reluctance machine control methodology, which will consider additively manufacturing machine advantages. We will provide the necessary hardware and software for the real-time control of the machine, but the candidate will be responsible for developing and implementing the control algorithms. A working demonstrator will be built and tested at the end of the thesis. 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

- Design of control algorithms for additively manufactured machines
  - Additive manufacturing, also known as 3D printing, is opening up new ground for innovations in low-volume production. Today, the technology is still not widely used in industrial production, but it is gaining more and more popularity. The main challenges for control algorithms for additively manufactured machines are the non-linearity and saturation of the materials used in 3D printing.
- Design of loss reduction control algorithms for switched reluctance machines
  - Usually, the optimization concerns only the motor losses, whereas the converter losses are often neglected. An effective loss minimization strategy will require considering motor and converter losses. Achieving this objective for the novel permanent magnet-assisted reluctance machine could help to improve existing control strategies.
- Real-time simulations
  - Design control algorithms, vision, or plant models in MATLAB/SIMULINK
  - Build a real-time application from MATLAB/SIMULINK for the target machine
  - Set up and tune signal parameters from within MATLAB/SIMULINK during real-time execution

- Practical tests on the test bench

- • The test bench, combining the advantages of real-time software models and real equipment, contributes to the reduction of the number of test runs and safe maintenance. Test benches cover many different areas like energy management, optimal configuration, a combination of different energy sources, etc. Research goals will be achieved by proper verification of the model.

Applicants should fulfill the following requirements:

- a master's degree in electrical engineering (preferably with a focus on electrical machines or electrical drives)
- 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 research 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
- Advanced knowledge in electrical machine control
- Knowledge of advanced electrical machine control theory
- Programming in MATLAB, Python, C++
- Working knowledge of optimization theory
- Knowledge of vector calculus and linear algebra

The candidate should submit a research proposal for the topic, including the overall state of research, identifying blind spots, open and real research questions, theoretical and methodical approaches and concepts, giving reasons for choosing these approaches., detailed research and time plan (laboratory work, data gathering, data analysis, interpretation of findings, writing up plan), and expected outcomes. 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 diagnostics

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.

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 Department of Electrical Power Engineering and Mechatronics conducts research within seven research groups and operates state of the art laboratories with high end equipment, offering also accredited services in the fields of lighting and different electrical measurements.

The departments' focus areas are related to both domestic and global developments, such as increasing digitalization and decarbonization, decentralization, and decentralization of electricity generation, and the increasing use of renewable energy sources. The department conducts research in the following relevant areas tackling the energy transition:

- optimization of electrical systems and system analysis to find possibilities for electrification and decarbonization
- diagnostics and monitoring of equipment and systems
- cyber security, 5G data communications, and artificial intelligence
- energy networks and research on hydrogen technologies, including energy storage, renewable energy, low carbon technologies, consumption management, IoT applications in energy
- implementation of smart industry, including industrial robotics, automation, 3D printing, machine vision
- implementation of energy and resource efficiency, including digitization of supply chains, mapping of opportunities to optimize systems and reduce energy consumption
- development of smart city solutions, including environmentally friendly and self-driving vehicles, drones, and digital twins applications.

Additional information

For further information, please contact Prof. Ants Kallaste ants.kallaste@taltech.ee and Prof. Anton Rassõlkin anton.rassolkin@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/975 or scan the the code on the left with your smartphone.