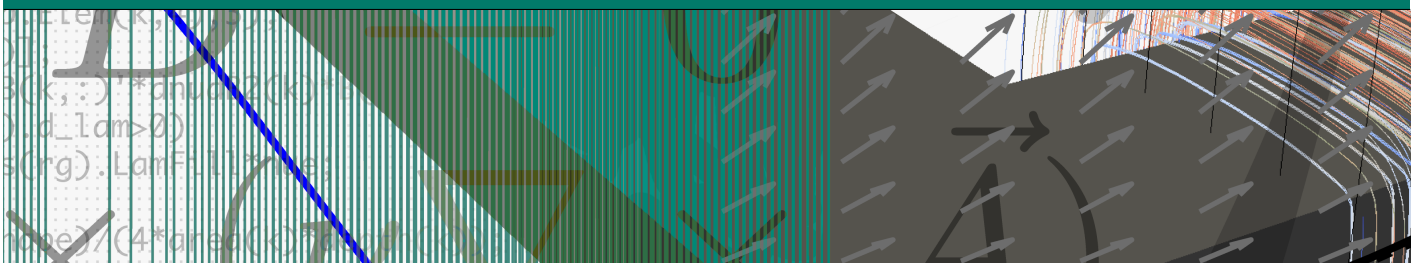
Simulation and shape optimization for 3D printing of permanent magnet synchronous machines

TECHNISCHE UNIVERSITÄT DARMSTADT

Proposal for a Bachelor's thesis | Master's thesis
Study field: Computational Engineering | Electrical Engineering | Mathematics



Description

This project shall explore simulation and shape optimization methods for the design of electromechanical energy converters. Thereby, the possibilities and requirements of three-dimensional printing shall be exploited to design permanent magnet synchronous motors (PMSM). Currently, PMSM are designed conservatively, i.e. without free forms and using standardized (e.g. magnet) geometries. However, additive manufacturing processes (3D printing) will allow more complex stator and rotor geometries to be produced in the future, which could reduce the rare earth magnet content in particular.

In order to enable an optimal, computer-aided design of electrical machines, the project aims to develop so-called *isogeometric*, i.e. methods based on the spline formulations commonly used in computer-aided design (CAD) for geometry representation, are to be developed within the scope of this project, with which the coupled electromagnetic-mechanical behavior of PMSM can be simulated and the machine shape can be optimized under consideration of the manufacturing process.

Work plan

- Development of an isogeometric finite element method with strong coupling of the electrical, magnetic and mechanical model equations; quasi-static modeling considering non-linear effects; evaluation of torque, noise, vibration and roughness.
- Efficient gradient based optimization of PMSM for different objective functions, e.g. magnetic ratio or weight reduction, power maximization, and constraints, e.g. minimum torque, maximum NVH (Noise Vibration Harshness).
- Consideration of the properties and limitations of additive manufacturing processes, e.g anisotropy of materials, overhang constraints, feature sizes, residual stresses and distortions; formulation of appropriate constraints for the optimization problem.
- Demonstration of the practical applicability, e.g. optimization of a concrete PMSM with realistic geometry, material and manufacturing parameters.

Prerequisites

Interest in finite elements and optimization, knowledge of electrical machines helpful.

Contact:
Prof. Dr. Sebastian Schöps
schoeps@temf.tu-...

Office: S2|17 29
Computational Electromagnetics Group, Electrical Engineering

Contact:
Melina Merkel, M.Sc.
merkel@temf.tu-...

Office: S2|17 33
Computational Electromagnetics Group, Electrical Engineering

Contact:
Prof. Dr. Oliver Weeger
weeger@cps.tu-...

Office: S4|10 411
Cyber-Physical Simulation, Mechanical Engineering

CEM