Karlsruher Institut für Technologie

ENERGY LAB 2.0

Master's Thesis Position

Superconducting Motor Modelling and Control

In recent years there has been increasing interest and focus on the topic of the electrification and decarbonization of commercial aviation aircraft. Key aspects of this include the exploration of the use of liquid hydrogen (LH2) as an energy carrier that can be used to power fuel cells with no harmful emissions and can be produced with renewable energy. In aircraft, where weight and efficiency contribute disproportionately to the viability of embedded technologies, high temperature superconducting (HTS) components are of particular interest. A superconducting electrical propulsion chain consisting of HTS motor, cables and cryogenically cooled power converters has the potential to be lighter and more efficient than the equivalent copper- or aluminum-based components, especially when LH2 fuel is on-board that can be used for cooling. However, significant technological development is needed to realize such solutions, both on component level and in system integration.

In this context, Airbus and KIT are cooperating on the topic of modelling and simulation of superconducting propulsion systems. An opportunity for a Master's project has emerged in this area on the topic of superconducting motor modelling and control.

The project will cover the following topics:

- 1D modelling of a 500-kW permanent magnet rotor, HTS stator winding motor in MATLAB/Simulink/Simscape including:
  - Effects of current and temperature on the different parts of the motor
  - Cooling system interface
- The control of the motor, with emphasis on the special properties of the superconducting machine and control during transients
  - Variation of the natural electrical time constant of the motor (R/L) depending on the temperature and current
  - Impact of temperature and current on the PI control
  - Impact of the PWM on the electrical behaviour of the motor
  - Simulation of different scenarios: acceleration/deceleration, fast/slow dynamics, Speed/Torque control, Loaded/Non-loaded
- Analysis of fault behaviour within the stator windings
  - Short-circuit scenario
  - Loss of cooling capacity
  - Error on the position measurement feedback (loss of synchronism)

The project will be supervised by Ali Khonya and Dr. Wescley de Sousa, with regular progress meetings with specialists at Airbus. To apply, please send your CV alongside a cover letter (one-page max.) via email to ali.khonya@kit.edu with the subject "Master's Thesis Application". The acceptance process will be rolling-based; therefore, the applications will be evaluated as they are received. In case of an interesting application, the candidate will be invited for an interview.