Technical University of Denmark

Popular science summary of the PhD thesis

PhD student	Bruno Resende Ferreira Rende
Title of the PhD thesis	Investigation of thermal effects in rotors levitated by magnetic bearings via coupled multiphysical models – Theory and experiment
PhD school/Department	DTU Construct

Science summary

Rotating machines are vital to modern society, especially in the energy sector, where turbomachinery is essencial to power generation. Climate goals, advances in materials, and improved computational tools are driving the demand for higher efficiency, often achieved by increasing rotational speed. At such speeds, conventional bearings face limitations from friction, while magnetic bearings provide a contactless alternative by levitating the rotor with magnetic forces. Magnetic bearings are classified as passive (PMBs), using permanent magnets, or active (AMBs), using electromagnets controlled by feedback systems. AMBs allow real-time adjustment of stiffness and damping, offer low maintenance due to the absence of contact and lubricants, and are used in applications such as gas turbines, compressors, expanders, high-speed spindles, turbo-blowers, and flywheel energy storage systems. In high-temperature or vacuum environments, the temperature increases on rotors and AMBs can degrade performance and even cause vibration instabilities. This thesis addresses these challenges by developing multiphysical models that combine rotordynamics, electromagnetism, control theory, and thermal analysis into a single system of equations solved simultaneously.

This work presents two examples. The first applies the methodology to a vertical rotor supported axially by one AMB and radially by two PMBs. The model can accurately predict that the reduction in load capacity due to the temperature increase will cause vibration instability until the rotor drops. The second applies the approach to predict the thermal effects for a laboratory-scale flywheel test rig with a vertical rotor, an axial passive magnetic bearing, and two radial active magnetic bearings. The model's predictions correlate well with experimental data.

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Please email the summary to the PhD secretary at the department