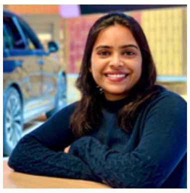
Using Multiphysics Tools to Fit a PMSM Simulation Model with Experimental Results

SPEAKERS



Lavanya Vadamodala
Senior Application Engineer
Altair Engineering

Philippe Wendling
Vice President-EM Applications
Altair Engineering

About The Speakers:

Lavanya Vadamodala:
Lavanya Vadamodala received her Ph.D. in Electrical Engineering from the University of Akron in 2021. She is working as a Senior Application Engineer at Altair Engineering, Inc since 2020. Her main fields are low-frequency electromechanical device design and analysis. Her current interests are Electromagnetics, Electric motor design, Optimization, and Multiphysics analysis. She is participating in IEEE conferences like ECCE, ITEC, APEC as an author, presenter, reviewer, session chair, and topic chair since 2018.

Philippe Wendling:
Philippe Wendling received his master's degree from Ecole Central de Lille, Lille, France in 1979. He is working as Vice President, GTT Electromagnetics Applications at Altair Engineering Inc. He is a Senior Lifetime Member of IEEE. His focus is modeling power generation, power distribution, and electromechanical power conversion applications in their Multiphysics environment. Modeling for evaluation, design, or optimization in a sustainable world. He has been involved in Finite Element modeling technics of Electromagnetic Fields and Power conversion devices and processes since the early 1980s. He is leading the technical support and training activity. He is a frequent participant, session chair, committee member, and author at IEEE conferences, including CEFC, IAS, IEMDC, ECCE, and ITEC.

ABSTRACT

Permanent Magnet Synchronous Machines (PMSM) are widely considered for different applications such as electric vehicles (EV), industry, or electric appliances. Some PMSMs are designed for versatility across environments to meet complex requirements. Making machine models align with real-world measurements is crucial. A fitted Multiphysics simulation model helps predict machine behavior, even in adverse conditions like short circuits, eccentricity, and overloads, preventing motor damage during testing. Fitting complex models with measurements in the Multiphysics domain is challenging, requiring specialized knowledge for real-world experiments. To fit complex models, identifying geometric and physical tolerances is essential for proper fitting. Then, the most relevant variables should be selected for each model. Adjust the variables in the tolerance range to fit with measurements. This tutorial proposes a complete Multiphysics model, which includes electromagnetic, thermal, and vibration domains, fitting them with experimental results. The variables significant in various domains will be identified and adjusted for each part. This will enhance model robustness, making it the ideal candidate for designing strategies and fault analysis.

A practical example using a PMSM machine called IkerMaq will be proposed as an example case. Below fittings are performed on the IkerMaq machine from Experiment and Simulation:
1. Electromagnetic fitting:
a. Goals: Torque, Flux through teeth, Maxwell forces
b. Relevant variables to be adjusted: Magnet remnant Flux density, Airgap length, and Airgap length with eccentricity
2. Thermal analysis:
a. Goals: Inset coils, End winding, Frame temperatures
b. Relevant variables to be adjusted: Insulator thermal resistance, Cooling air speed, Contact resistance, Stator-housing
3. Vibroacoustic analysis:
a. Goals: Maxwell pressures, Natural Frequencies
b. Relevant variables to be adjusted: Stator geometric tolerances, Winding Mass, Housing
To obtain measurements, the Ikermaq machine is coupled to traction motor test bench, which is equipped with sensors to measure required quantities.
For the simulation of Ikermaq, Altair Flux, FluxMotor, and Hyperstudy tools are used.