Application of magnetic force export per tooth: Vibration analysis for Electric Motors at multi-speed

2D Multiphysics Summary

Introduction

This document presents the electromagnetic and vibrational analysis of a surface inset permanent magnet synchronous motor (model IkerMAQ) at multi-speeds. The analysis process will use the following softwares: FluxMotor, Flux, SimLab and OptiStruct. The project files from each software for the example IkerMAQ are provided in this tutorial.

This tutorial includes three parts:

1. A FluxMotor model will be first used for computing the working points at different speeds
2. A Flux project will be then created for exporting the electromagnetic forces on tooth (including the nodal force and the global force) at each speed
3. And the last step is to create a SimLab project to load force information from the Flux project and run a vibration analysis through the OptiStruct solver

Keywords

Applications	Flux main functions	Post-processed quantities
• Transient magnetic (Flux) • FluxMotor • SimLab • OptiStruct	• Simulating the PMSM with a coupling three-phase circuit to analyze the characteristic with the transient magnetic application at different speeds • Computing electromagnetic forces on teeth (including the nodal force and the global force) for each speed	• Electromagnetic forces on teeth

Studied device

The studied device, represented in the following figure, is a surface inset permanent magnet synchronous motor (PMSM) used on traction application with 75 kW power rating. It is a three-phase machine with 45 stator slots and 10 rotor poles made from M800 65A steel.

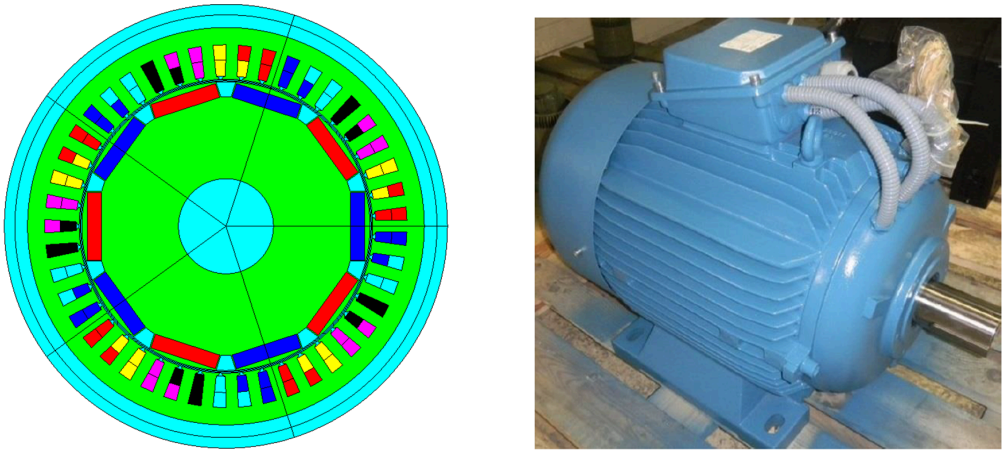

Figure 1: Motor IkerMAQ to be analyzed

Analysis workflow

The electromagnetic and vibrational analysis workflow is presented in the following figure.

This workflow begins with the motor pre-analysis for the motor performance at multi-speeds. Once the multi-speed information is calculated, a Flux project will be then created for further electromagnetic analysis and for exporting the electromagnetic forces on tooth (including the nodal force and the global force) at each speed. And finally, a SimLab project will import the load force information from Flux and run a vibration analysis through the OptiStruct solver.

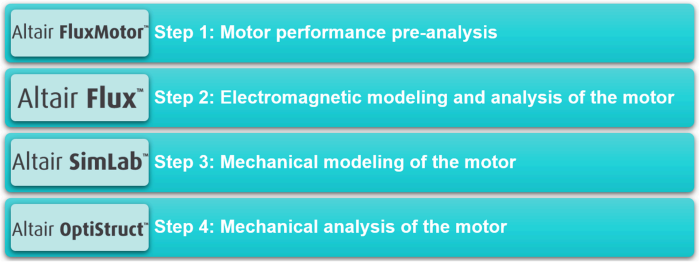

Figure 2: Electromagnetic and vibrational analysis workflow

In practice

Open example = Open Flux + Run the pyFlux command file

- Recommended memory configuration:
  - For FluxMotor project: 3 GB Numerical
  - For Flux project: 3 GB Numerical
  - For OptiStruct project: 4 GB Numerical
- Execution time (one run of the workflow):
  - FluxMotor: 10 min
  - Flux: 1 h
  - SimLab: 15 min
  - OptiStruct: 30 min

Example 1: Exporting electromagnetic forces on teeth

The geometry is built in Flux 2D. Once the transient magnetic analysis is finished, the electromagnetic forces will be computed on teeth by the I/O context.

The torque curves at multi-speed are displayed:

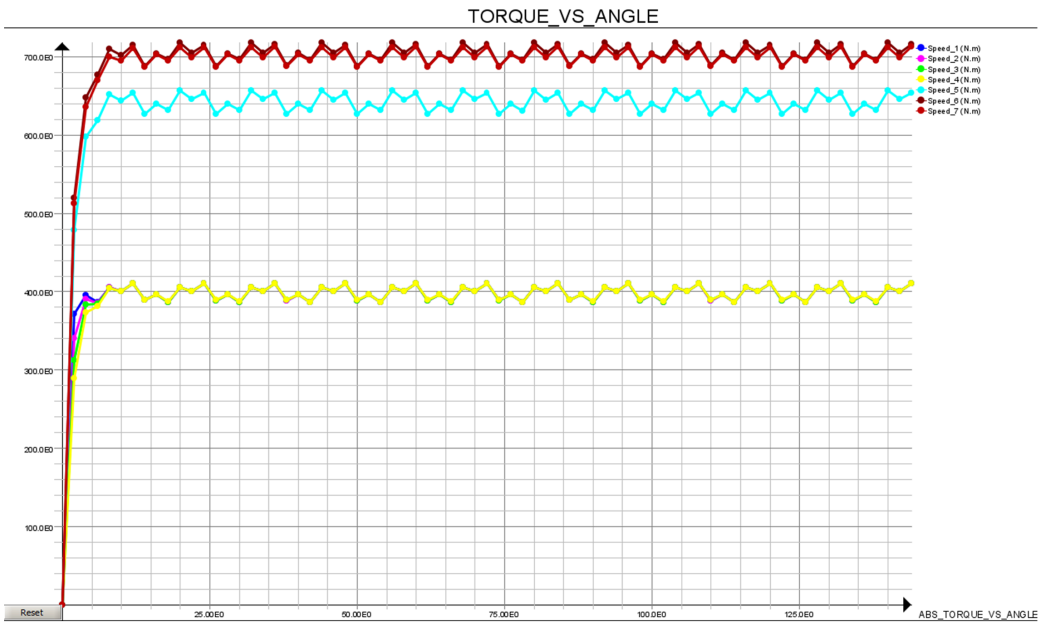

Figure 3: Electromagnetic torque curves (multi-speeds) vs angle

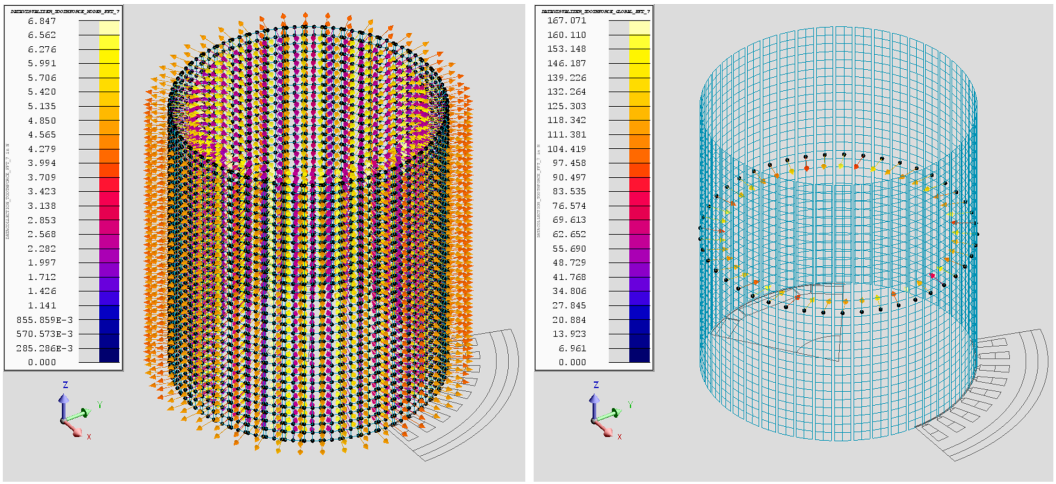

Figure 4: Illustration of electromagnetic force computation on teeth (nodal forces and global forces)