Efficient tool set for modeling Axial Flux Intern Rotor machine (AFIR)

3D Application Note Summary

Introduction

This case of study is devoted to the magneto-thermal modeling of an axial flux machine with one internal rotor and two external stators.

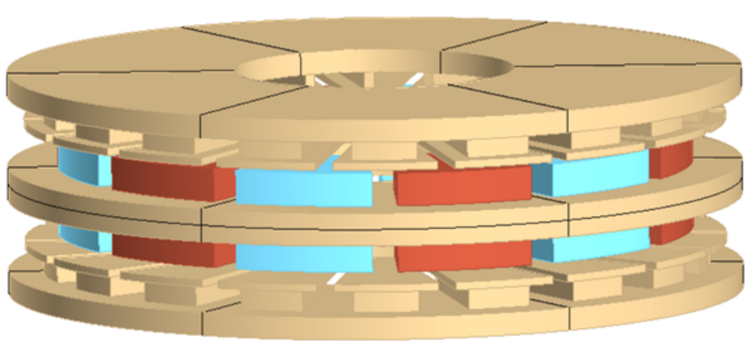
Geometry, meshing, physics definition and solving will be automatically carried out by dedicated set of macros which takes as inputs the material properties and the geometrical features of the machine.

Keywords

Data computed	Applications	Flux main functions
• Torque, Acceleration, Speed, Position • Back EMF • Cogging torque • Current • Losses • Temperature	• Magneto static 3D • Transient magnetic 3D • Steady state thermal 3D • Transient thermal 3D	• Macros • Compose coupling • Multiphysics • Sensors • Efficiency Map

Studied device

The studied device is an axial flux machine with two external stators and an internal rotor, as can be seen in the picture below:



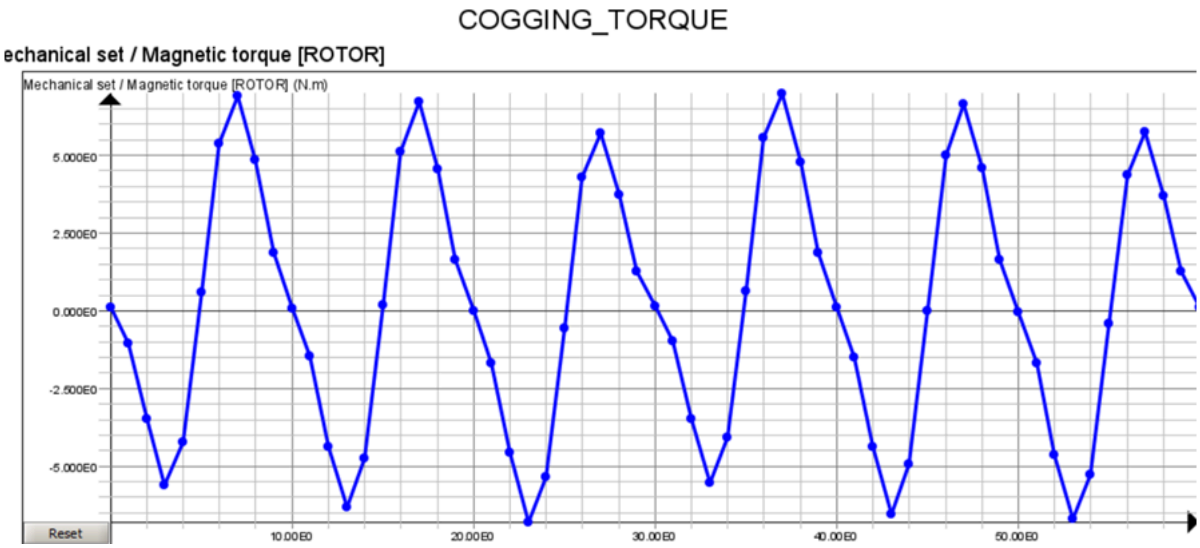
Case 1: Cogging torque and back EMF analysis

Studied case

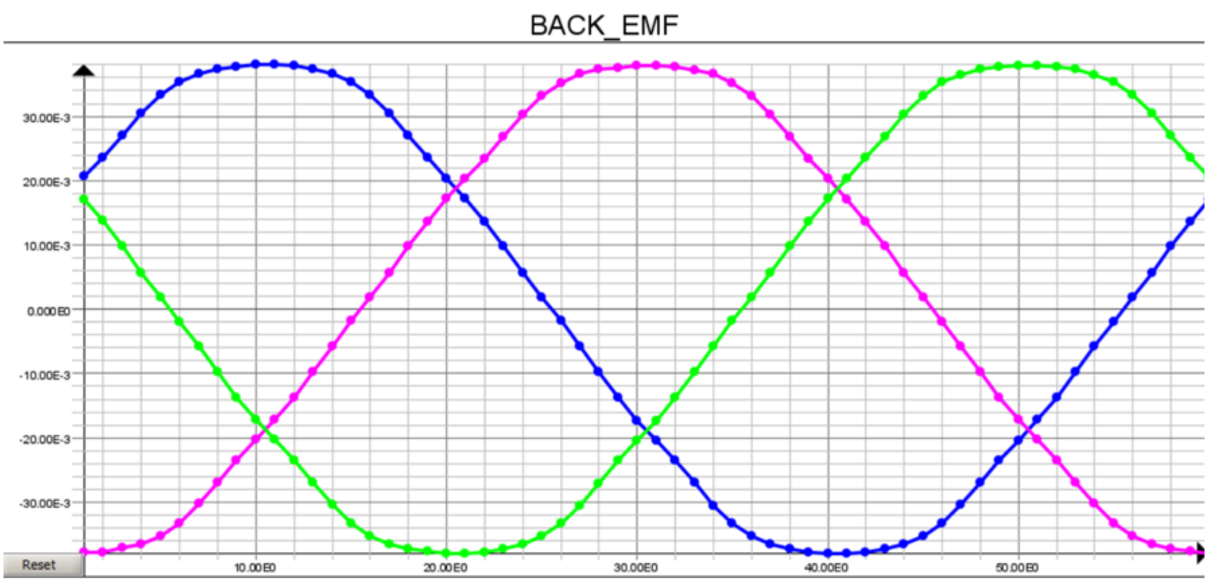
Cogging torque and back EMF analysis: Geometry is generated through dedicated macro. Then meshing, physics and solving are carried out by a second macro. In this scenario no current is flowing through the stator coils while rotor turns at constant speed.

Analysis of results

- Plot 2D curve of cogging torque



- Plot 2D curve of Back-EMF



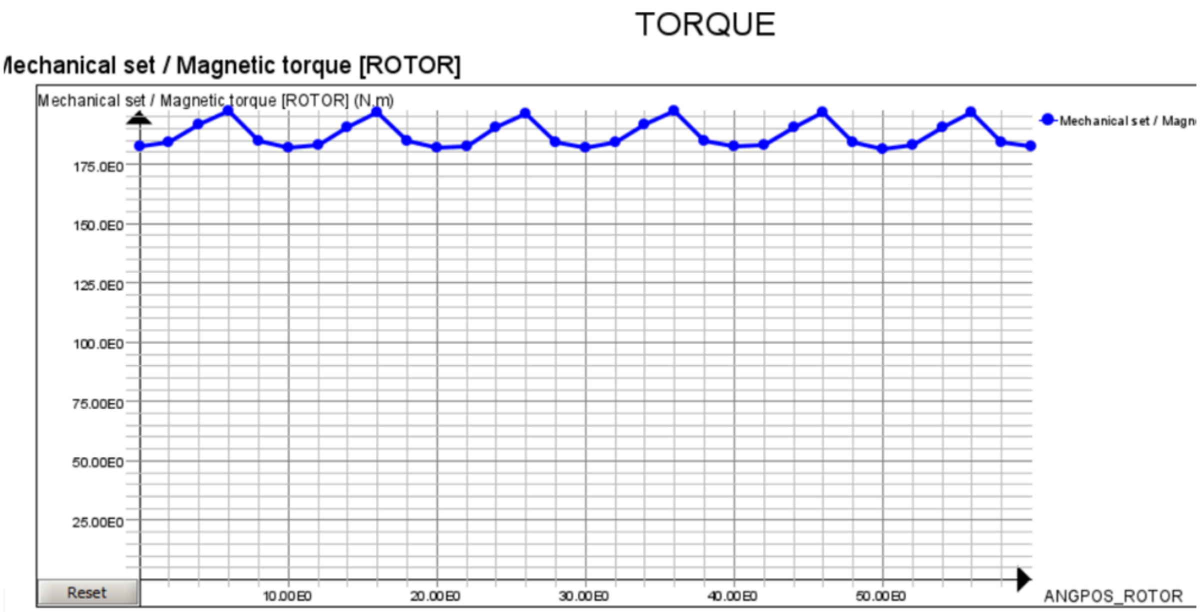
Case 2: Constant speed analysis

Studied case

Constant speed analysis: Geometry is generated through dedicated macro. Then meshing, physics and solving are carried out by a second macro. Axial flux machine is simulated at normal working conditions: at constant speed and fed by sinusoidal current sources forming a balanced three-phase system.

Analysis of results

- Plot 2D curve of machine's torque



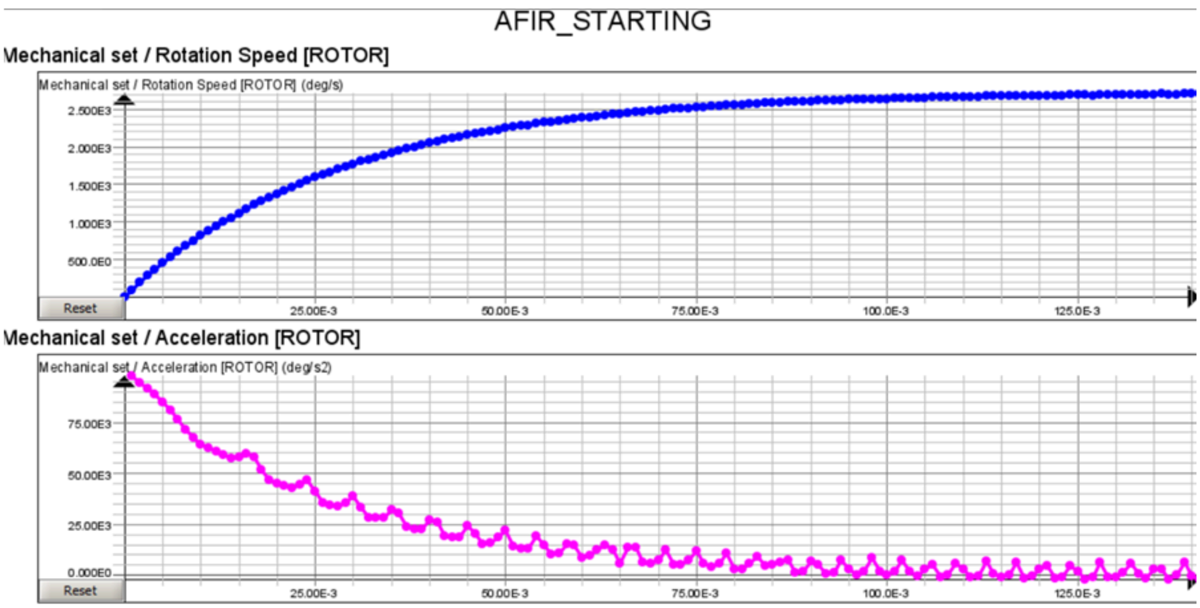
Case 3: Start up analysis

Studied case

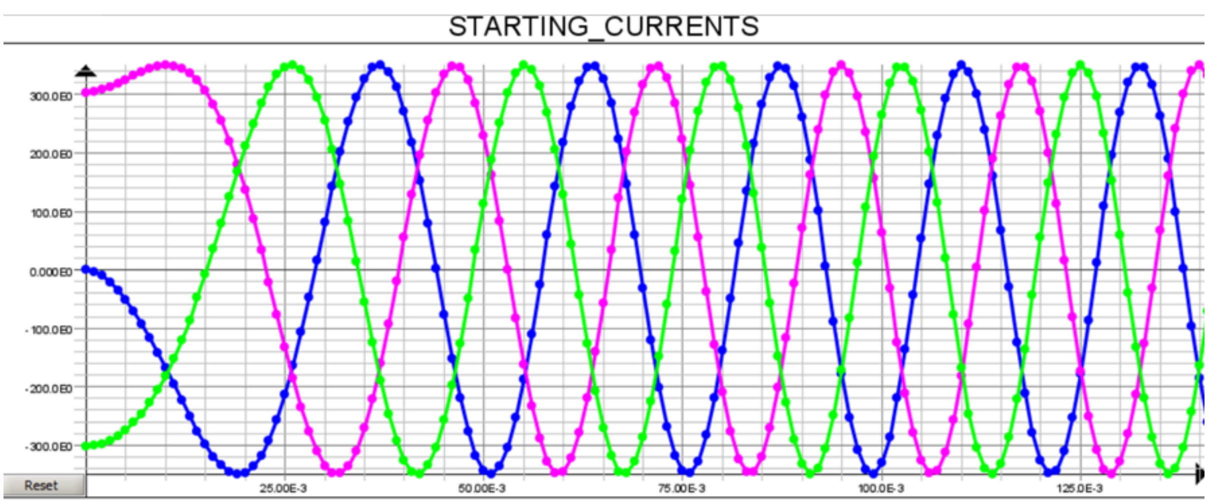
Start up simulation: Geometry is generated through dedicated macro. Then meshing, physics and solving are carried out by a second macro. Axial flux machine is simulated during the start up process with a proposed current control strategy. The winding is supplied in current depending on the rotor position.

Analysis of results

- Plot 2D curves of rotational speed and acceleration



- Plot 2D curves of the currents flowing through the coils



Case 4: Short-circuit analysis

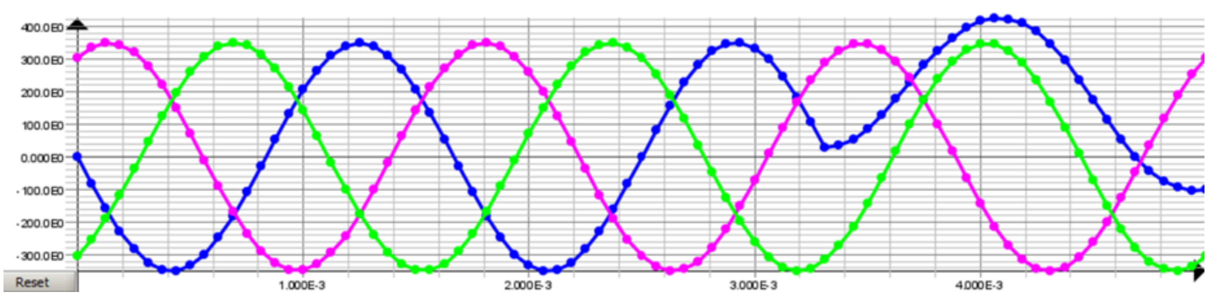
Studied case

Short-circuit simulation: Geometry is generated through dedicated macro. Then meshing, physics and solving are carried out by a second macro. Axial flux machine is simulated in short-circuit failure conditions; more precisely the short-circuit of A phase is modeled and their effects over the machine behavior analyzed.

Analysis of results

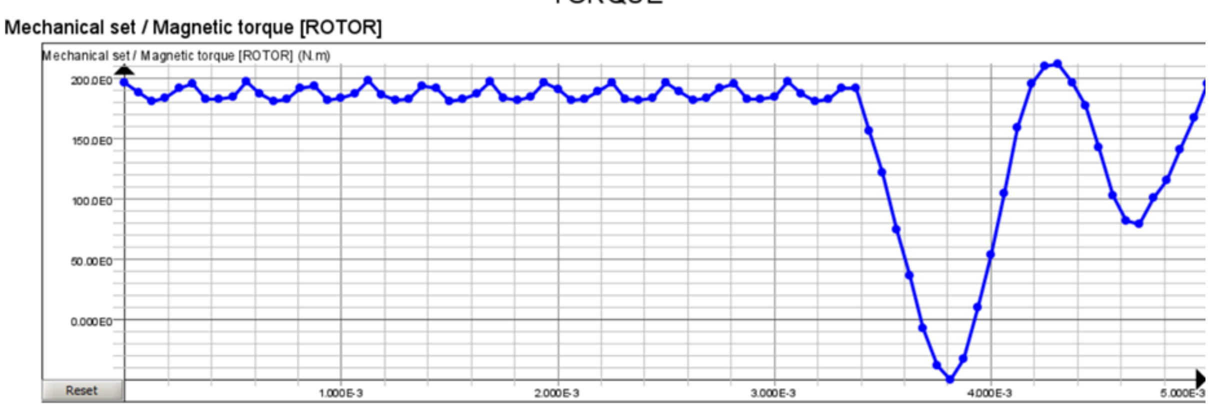
- Plot 2D curves of the currents flowing through the coils

CURRENTS



- Plot 2D curve of the torque

TORQUE



Case 5: Efficiency map analysis

Studied case

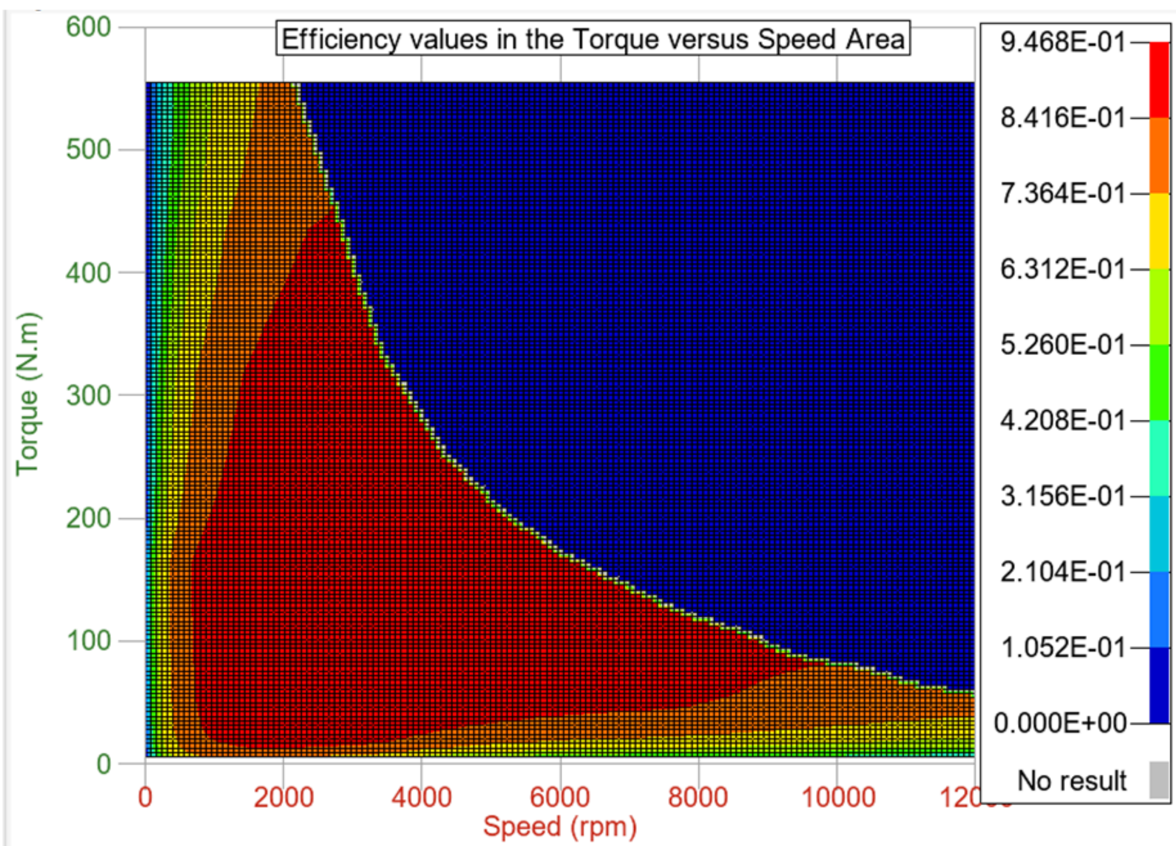
Efficiency map calculus: Geometry is generated through dedicated macro. Then meshing, physics and solving are carried out by a second macro.

In this case a parametric magnetostatic analysis is carried out at fixed rotor position: currents in D and Q axis play the role of inputs, while the flux in these axes are the outputs.

Finally, Altair Compose use these fluxes as inputs in order to represent the efficiency and the losses maps of the axial Flux machine.

Analysis of results

- Efficiency map
- Losses maps
- Current and voltage maps



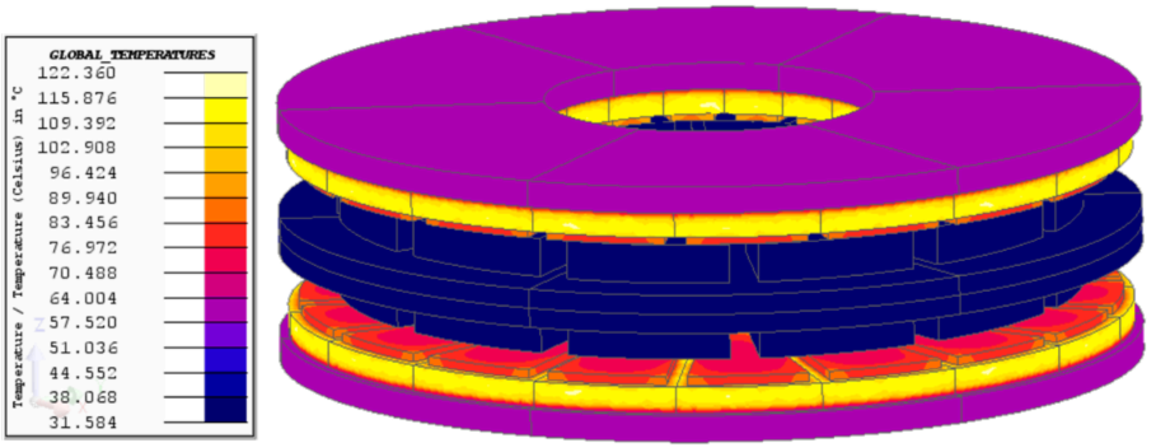
Case 6: Steady state thermal analysis

Studied case

Steady state thermal: One dedicated macro translates the geometry generated for the magnetic problem into another suitable for the thermal one. Then meshing, physics and solving are carried out by a second macro. Thermal behavior is studied at normal working conditions, providing iron and eddy current losses as inputs.

Analysis of results

- Temperature in all the domain represented as isovalues



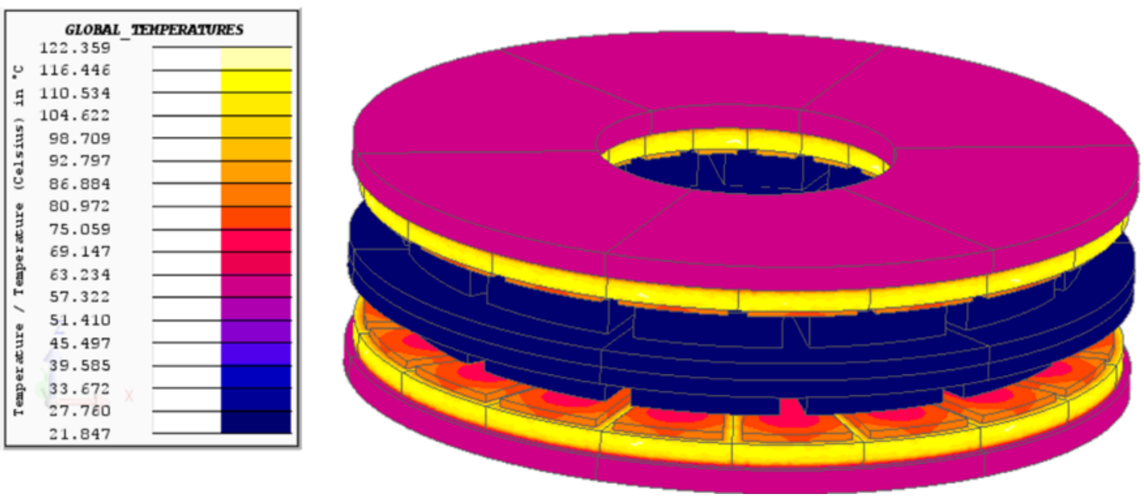
Case 7: Transient thermal analysis

Studied case

Transient thermal: One dedicated macro translates the geometry generated for the magnetic problem into another suitable for the thermal one. Then meshing, physics and solving are carried out by a second macro. Thermal behavior is studied at normal working conditions. Initial motor temperature is constant and equal to 20ºC. Simulation ends when thermal steady state is achieved.

Analysis of results

- Temperature in all the domain once final motor temperatures have been reached



- Maximum temperature in the coils for each step of time, enregistered by a dedicated sensor