Cogging torque and meshing - Axial flux motor

3D Example Summary ***(Qualified with Delaunay mesher and User memory mode)***

Forewords

This document is a spin-off of the **« Axial Motor Flux »** technical example.

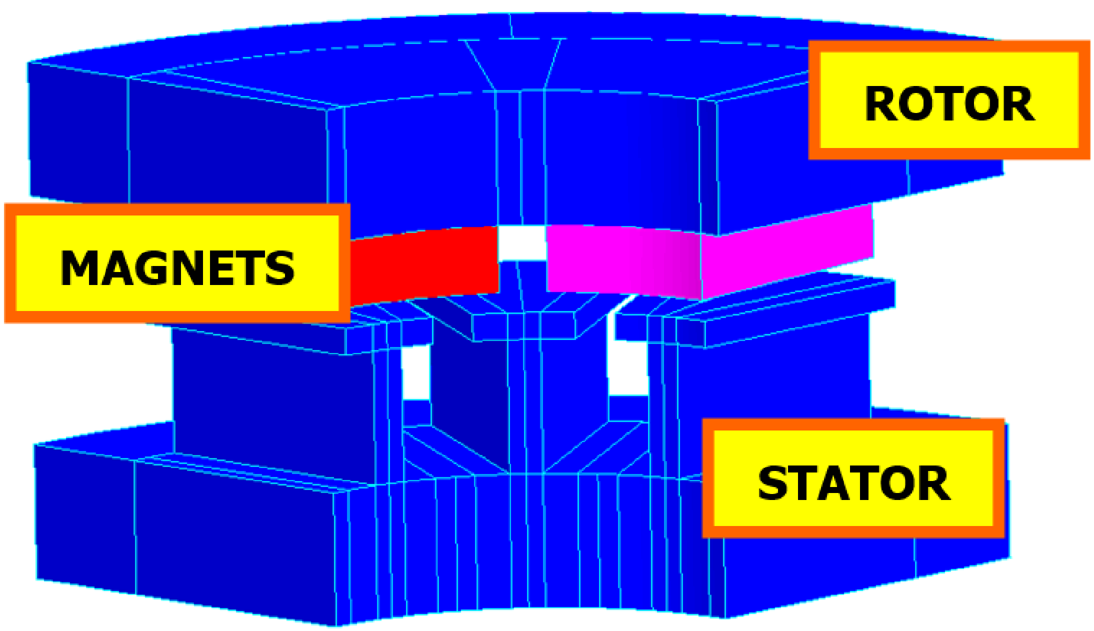
Introduction

The « Axial Flux Motor » is an example about a machine in which the magnetic field flows along the rotating axis of the motor. This kind of device is mostly used in spaceless environment such as hoistway.

In this document, we are going to focus on the computation of the cogging torque. We will detail a meshing method called « Mesh Line » which suits to this kind of computation.

Model

The geometry is imported from a CAD tool.



Performances of the motor are computed using the transient magnetic 3D application. A circuit coupling is not needed in this case.

Methods

General

The computation of the cogging torque can be very tricky in the 3D context. Indeed the amplitude of this quantity is almost the same as the numerical noise. It is therefore obvious that the meshing has to be very thin, but not too much to avoid indecent computation time. For this purpose we will notice that a simple « mesh point » is not enough, although it suits to most of the case dealing with electric machines computations.

In order to achieve a good « Precision/Time » compromise we will use a « mesh line » tool.

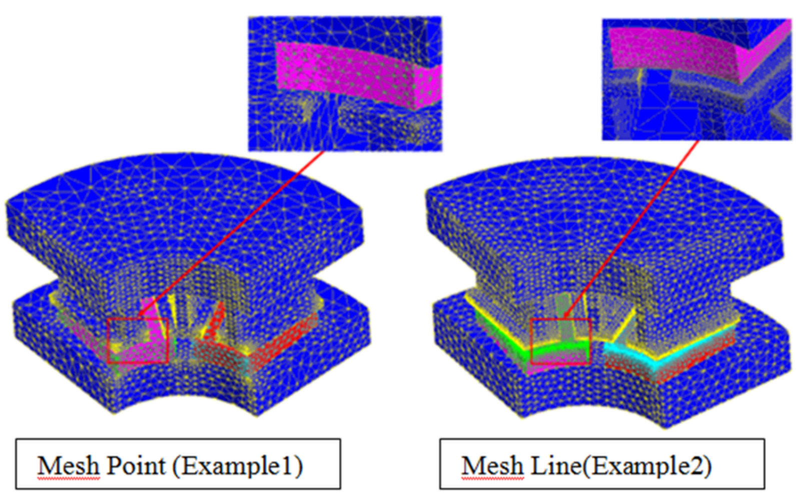
Mesh Line method

This tool has been developed by the Altair Flux development team. They have established that it is necessary to have a thin meshing where the magnetic flux density varies quickly in order to precisely compute magnetic field paths. From this point the meshing method consists in finely mesh edges of volumes next to the airgap.

In order, these are the main steps to use this « Mesh Line » method:

- Use 1st order elements of meshing
- Assign to all the points a dynamic weight, that is to say equal to the length of the shortest line touching a point
- Apply a low relaxation coefficient on all the faces of the geometry
- Apply a high shadow coefficient on all the faces of the geometry
- Use a thin and with no relaxation coefficient mesh line on edges of volumes of the airgap (edges of magnets and of stator teeth touching the airgap)
- Use a thin mesh line coefficient on bows of the sliding cylinder
- Apply a medium relaxation coefficient on faces of magnets and stator teeth side parts

It is possible and recommended to adapt the meshing options according to the need

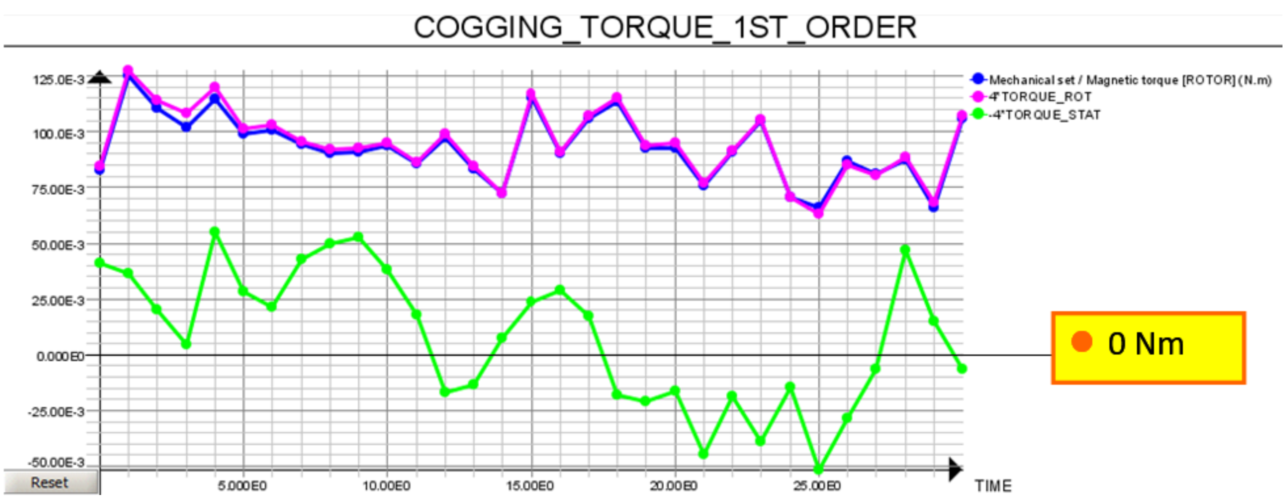


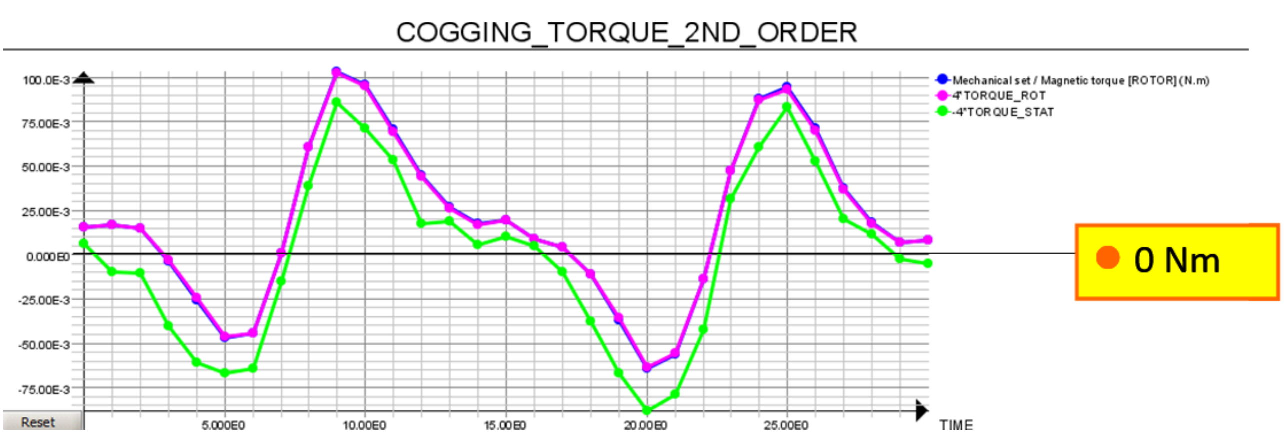
Results

Comparative table

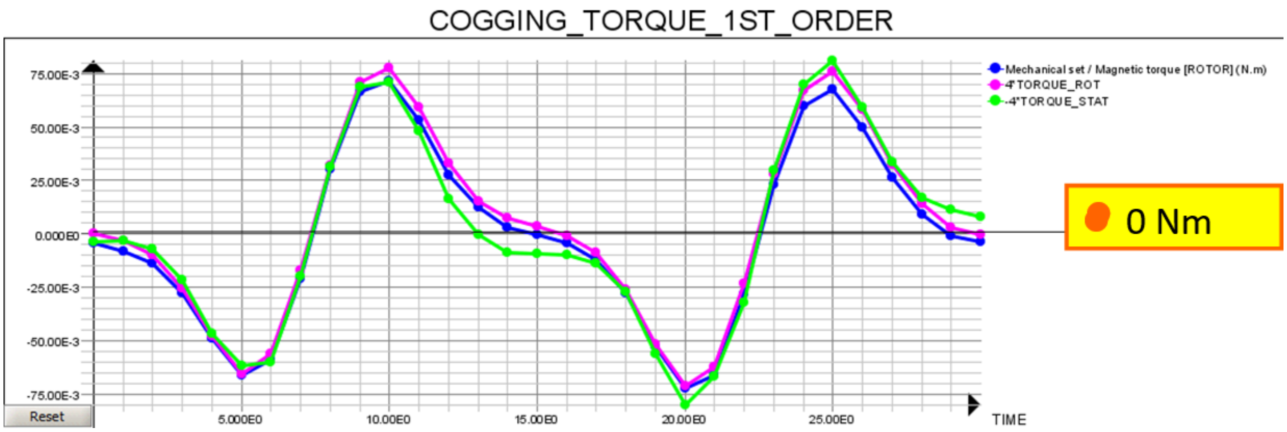
Method	Order	Number of nodes	Number of volume elements	Computation time
Classical Mesh Point (Example 1)	1st	8685	38270	**2’**
	2nd	59556	38270	**10’**
Mesh Line (Example 2)	1st	36444	174982	**8’**
	2nd	**258699**	**174982**	**72’**

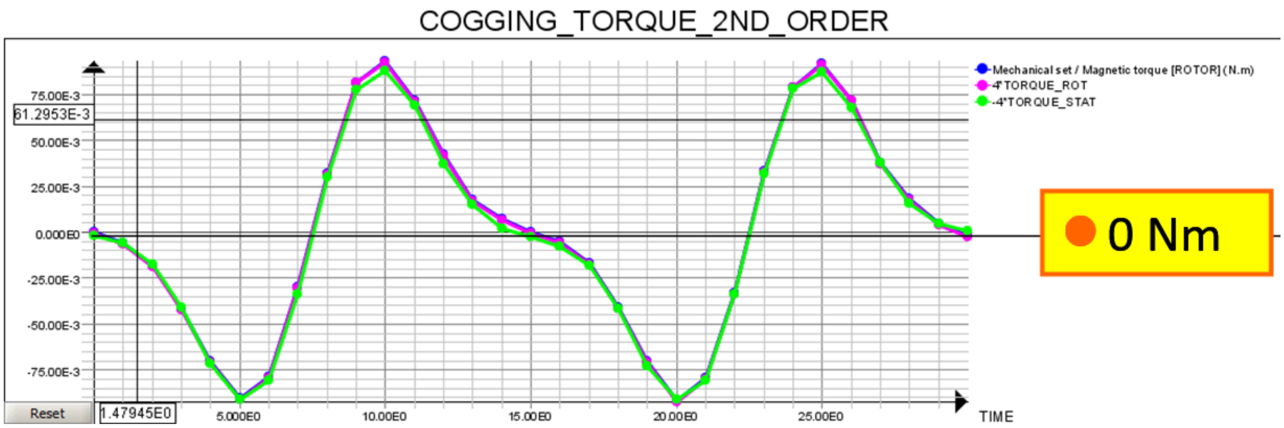
Results with mesh point for the 1st and the 2nd order





Results with mesh lines for the 1st and the 2nd order





The use of a 1st order mesh line leads to obtain better results than the use of a 2nd order mesh point. Plus we have a 20% decrease of the computation time.

Conclusions

Modelling electric motors in 3D has always been un complex work. Nowadays, the 3D solver combined with the Altair experience in this domain lead to make this work easier.

In this document we have reviewed a method to efficiently mesh our device to quickly get a reliable estimation of the cogging torque.