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Design of an axial claw pole motor using a scalar magnetic potential formulation fine tuned thanks to a vector potential one

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Abstract—Designing an electric motor using an optimization process with a finite element model requires a high number of simulations. To avoid a huge CPU time, the finite element model has to be as fast as possible with a satisfactory accuracy. That is why the scalar magnetic potential formulation, faster than the vector magnetic potential formulation one, is often used for 3D calculations. A compromise between speed and accuracy has to be found. In this work, the authors proposed a method to find this compromise by comparing results from both scalar and vector potentials formulations in order to evaluate the accuracy of the model versus the CPU time.

Index Terms—Claw pole motor, Finite Element Method, Weak formulation.

I. INTRODUCTION

In literature, many techniques are used to reduce the CPU time in 3D FEM problems: techniques based on hybrid model with permeance network and 3D finite element [1] or on quasi-3D FEM model [2]. Unfortunately, those methods are difficult to apply on an axial claw pole motor (ACPM), represented in Fig. 1, which has a very thin airgap and a complex geometry. The CPU time can be reduced by expanding the mesh size. The scalar potential formulation will be used in the optimization because its CPU time is faster than with the vector potential. The aim is to choose the model with scalar potential with the largest mesh size while maintaining good accuracy. To evaluate the accuracy of the model depending on the mesh size, the authors proposed to compare the two formulations. The mesh size will be chosen to have a small deviation between the results from both formulations. Then, the scalar potential formulation will be used in the optimization and only the final motor will be validated by an other comparison with vector potential formulation.

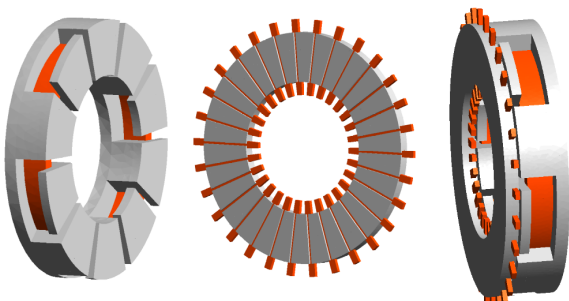


Fig. 1. Synchronous axial claw pole motor

II. PROBLEM

The aim of the method is to find the suitable mesh to apply in a model with the scalar formulation to use in an optimization

process in order to design the ACPM. To evaluate the accuracy of the model, results from both formulations are compared for different meshes. Torque and magnetic flux are calculated with a periodic model. Calculations are made with different mesh range from very fine mesh ($1390 \cdot 10^3$ Dofs for vector potential, $232 \cdot 10^3$ Dofs for scalar potential) to large mesh ($185 \cdot 10^3$ Dofs for vector potential, $32 \cdot 10^3$ Dofs for scalar potential). The periodic model and its mesh will be detailed in the full paper. An easy way to well calculate the magnetic flux from scalar potential will be developed in the full paper.

III. RESULTS

A spectral analysis on time-dependent torque and magnetic flux is made using FFT. Differences between both formulations and the evolutions of these quantities depending on the mesh size are investigated. It is considered that a model has a good accuracy when the deviation between the two formulations is small with a value stabilized versus the Dofs number. The deviation between the two formulations decreases with the Dofs number as seen in Fig. 2 for the magnetic flux. A compromise can be found for the mesh with 65 000 dofs for which the deviation between the two formulations below 10%. This study has to be made on the mean value of torque and on the torque ripple to choose the suitable model.

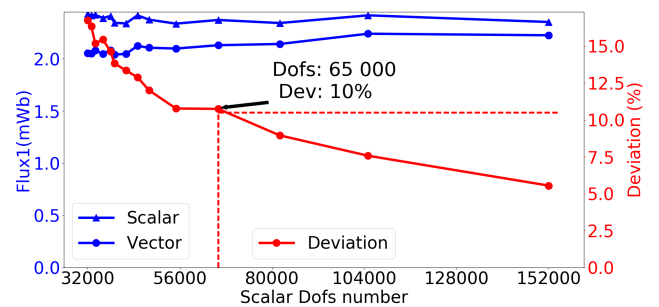


Fig. 2. Fundamental of magnetic flux

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