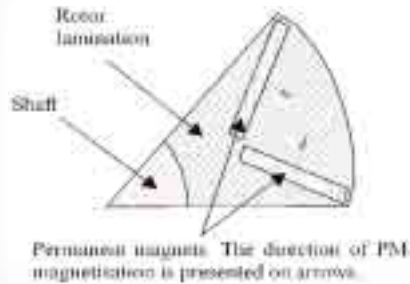


Cogging Torque in Radial Field PM Machines.

A. Parviainen, Lappeenranta University of Technology, Finland.

Radial field PM machines are under great interest in direct drive industrial applications due to their excellent performance in low-speed applications. A possibility to remove a gearbox, which is often required with induction machines, is also a considerable advantage reducing the maintenance costs of the drive system and improving its reliability. Lappeenranta University of Technology (LUT) has developed in co-operation with ABB such low-speed PM machines. During the design, finite element analysis is an important tool to verify the performance of machines before building up actual prototypes. As a user of FLUX 2D and 3D applications FE-programs, LUT developed in-house training material related to the 3D FEM modelling of radial field PM machines by using FLUX 3D FE-program. This material is now available on CEDRAT as a form of technical document and it may be used to training purposes. The presented FE-model of the machine is based on an actual PM machine prototype (45 kW, 600 rpm) designed and constructed by the LUT. The machine geometry is illustrated in figure 1.



In most cases 2D FEM analysis is good enough to predict the machine performance with practical accuracy. However, if one has to study in more details phenomena, such as leakage fluxes in rotor ends or leakage inductances in end-windings, a 3D FEM analysis is required. The created technical document illustrates how to use FLUX 3D in such purposes as well as in more conventional computations. The technical document defines also how to create the required machine geometry, how to mesh it successfully, how to define the physical properties of the model and how to perform the computations. The presented computations include the computation of cogging torque, the computation of torque under load condition by using a current driven model as well as some computations of leakage fluxes. The results of the computations are reported in a technical document.

From the point of view of computation time, the number of elements is typically more critical in 3D FEM than in 2D FEM.

3D FEM analysis may be very time consuming to perform even with present-day computers equipped with GHz processors. Thus, it is necessary to reduce the amount of elements to be as small as possible. In order to analyse whether the mesh pattern, described in the technical document, is good enough to give correct results, the cogging torque was computed by using three different meshes. The 1st of them is based on 1st order elements. The second computation based on the same mesh but 2nd order elements were introduced. The 3rd computation was performed by introducing an essentially denser mesh into the region of air-gap and by using 2nd order elements. The results are reported in figure 2. It can be seen that the result given by the 1st order elements include a remarkable amount of numeric noise. If the same mesh pattern is used but 2nd order elements are introduced the numeric noise reduces essentially and the curvature follows the computation result, which is obtained by using an essentially denser mesh in the air gap region. Thereby, the described mesh pattern with 2nd order elements can be considered to be practically good enough.

As a conclusion FLUX 3D is a powerful tool to analyse the actual 3D electromagnetic state of electrical machines. The technical document is developed in order to give guidance for FLUX 3D users how to use FLUX efficiently in modelling of permanent magnet machines.

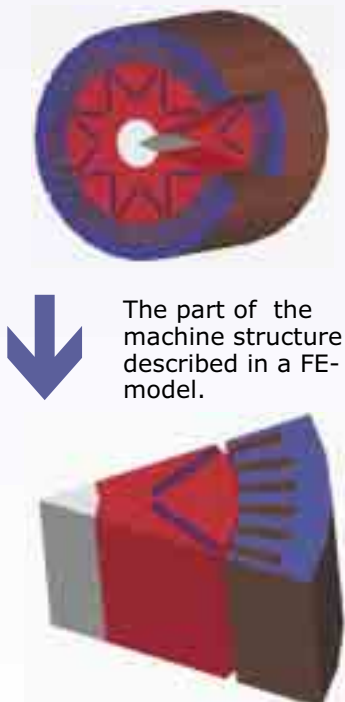


Figure 1. The structure of the modelled radial field PM machine.

Figure 2. Waveforms of cogging torque as a function of rotor angular position computed with different meshes.

