Coupled Simulations in the Design of Electrical Machines

Dirk van Riesen, François Henrotte, Christoph Schlensok, Kay Hameyer
Institute of Electrical Machines
RWTH Aachen University, Schinkelstr. 4, D-52062 Aachen, Germany
e-mail: Kay.Hameyer@iem.rwth-aachen.de

ABSTRACT

The design of electrical machines is an iterative process. To reduce costs and development times, prototyping is being replaced by simulations. Single domain Finite Element techniques have reached a high level of precision. However, to fully replace prototyping and measurements, all physical effects have to be regarded accurately. This requires an appropriate model, which can sometimes be huge and therefore computationally expensive.

This contribution will illustrate the need for coupled simulations in the field of electrical machines. For instance, the objectives of the design of an electrical motor concern non-magnetic properties (i.e. thermal, mechanical and acoustic specifications), whereas the design parameters (i.e. geometry, winding types, magnets, ...) are related to the electromagnetic characteristics of the motor.

Coupling the electric and magnetic fields allows for the simulation of eddy currents. These generate losses and therefore temperature rise. A mechanical movement (of the rotor, or in an electromagnetic brake system) also interacts with these eddy currents. The overall forces and torques produced by the magnetic field relate to the macroscopic movement, while local forces generate vibrations in a structural-dynamic model. These, when coupled to the fluid medium air, will result in acoustic noise.

We will give an overview over the physical quantities to be regarded, focusing on the coupling procedures and resulting simulation methods. These methods are applied to technically relevant industrial applications, such as the acoustic simulation of an induction machine [2] and of an induction furnace (Fig. 1). Also a coupling to electrical and mechanical systems is regarded [1].

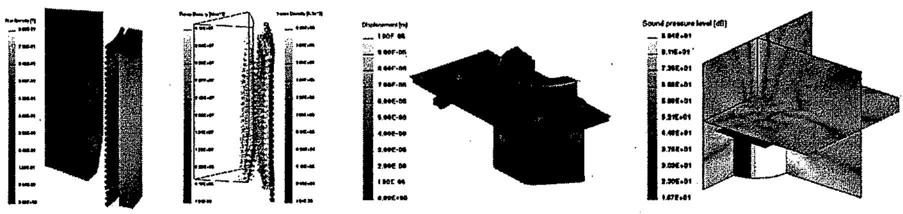

Fig. 1: Flux Density (a), Lorentz Force (b), Deformation (c) and Acoustic Noise (d) of an Induction Furnace.

REFERENCES

[1] F. Henrotte, I. Podoleanu, K. Hameyer. *Staged modelling: a methodology for developing real-life electrical systems applied to the transient behaviour of a permanent magnet servo motor,* Compel, Vol. 22, No. 4, 2003.

[1] C. Schlensok, D. van Riesen, T. Küest, G. Henneberger. *Acoustic Simulation of an Induction Machine with Squirrel-Cage Rotor,* Proc. of the International Conference on Electrical Machines, Cracow, Poland, September 5-8, 2004.

Coupled Simulations in the Design of Electrical Machines

Dirk van Riesen, François Henrotte, Christoph Schlensok, Kay Hameyer
Institute of Electrical Machines
RWTH Aachen University, Schinkelstr. 4, D-52062 Aachen, Germany
e-mail: Kay.Hameyer@iem.rwth-aachen.de

ABSTRACT

The design of electrical machines is an iterative process. To reduce costs and development times, prototyping is being replaced by simulations. Single domain Finite Element techniques have reached a high level of precision. However, to fully replace prototyping and measurements, all physical effects have to be regarded accurately. This requires an appropriate model, which can sometimes be huge and therefore computationally expensive.

This contribution will illustrate the need for coupled simulations in the field of electrical machines. For instance, the objectives of the design of an electrical motor concern non-magnetic properties (i.e. thermal, mechanical and acoustic specifications), whereas the design parameters (i.e. geometry, winding types, magnets, ...) are related to the electromagnetic characteristics of the motor.

Coupling the electric and magnetic fields allows for the simulation of eddy currents. These generate losses and therefore temperature rise. A mechanical movement (of the rotor, or in an electromagnetic brake system) also interacts with these eddy currents. The overall forces and torques produced by the magnetic field relate to the macroscopic movement, while local forces generate vibrations in a structural-dynamic model. These, when coupled to the fluid medium air, will result in acoustic noise.

We will give an overview over the physical quantities to be regarded, focusing on the coupling procedures and resulting simulation methods. These methods are applied to technically relevant industrial applications, such as the acoustic simulation of an induction machine [2] and of an induction furnace (Fig. 1). Also a coupling to electrical and mechanical systems is regarded [1].

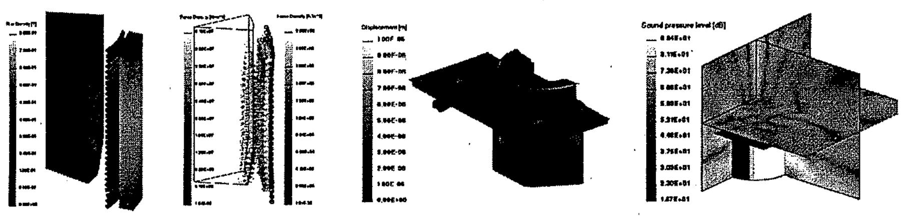

Fig. 1: Flux Density (a), Lorentz Force (b), Deformation (c) and Acoustic Noise (d) of an Induction Furnace.

REFERENCES

[1] F. Henrotte, I. Podoleanu, K. Hameyer. *Staged modelling: a methodology for developing real-life electrical systems applied to the transient behaviour of a permanent magnet servo motor,* Compel, Vol. 22, No. 4, 2003.

[1] C. Schlensok, D. van Riesen, T. Küest, G. Henneberger. *Acoustic Simulation of an Induction Machine with Squirrel-Cage Rotor,* Proc. of the International Conference on Electrical Machines, Cracow, Poland, September 5-8, 2004.