A Review of multi physics in machine design

Kay Hameyer

Institute of Electrical Machines (IEM)
RWTH Aachen University

Schinkelstr. 4, D-52056 Aachen, Germany

Abstract: The electromagnetic design of modern electrical machines nowadays requires more particular attention with respect to various parasitic effects or specifications which have to be fulfilled from the drive system. As in the past the electrical machine was considered as a component of a drive train, today's ideas concern an entire system including the individual properties and operation of the components. This inherently means that the development of a drive train clearly means to solve a multidisciplinary task on the system level. A modern drive system consists of the electrical motor, the power electronic converter and the associated controls. Therefore, the multiphysical system for an electrical drive train can be regarded as electromechanical, electric- and control-circuit coupling (Fig. 1).

Next to the interaction of the drive system components itself, they need to be described, respectively modelled in a multi physical way as well. Inside the electromechanical energy converter, e.g. the motor, the magnetic field - electrical circuit coupling have in the most simplest case to be considered. Particular problem classes with e.g. thermal couplings, mechanical forces acting on the energy converter exciting noise and the material models which simulate the ferromagnetic losses inside the device represent a multi physical task as well; this time on the detailed model level of the device (Fig.1).

There are various possibilities to realise the mentioned couplings of the single physical effects. Numerical strong and weal coupled overall models can be derived and used to simulate either on the system level or on the detailed component level.

The evaluation of multi physics solutions can be a troublesome task. The complicated interactions of the single problem types requires next to the algorithmic aspects of the solution process for the physical aspects novel approaches to evaluate the solution. The way of representing and post-processing solutions in diagram form or coloured schemes is not sufficient to evaluate the increased number of parameters influencing the overall solution of the problem. A novel way to perform such an evaluation can be to employ techniques out of the field of virtual reality (Fig. 2). This approach enables not only to evaluate multi parameter models but as well is suited to interactively influence the design procedure for the device under study.

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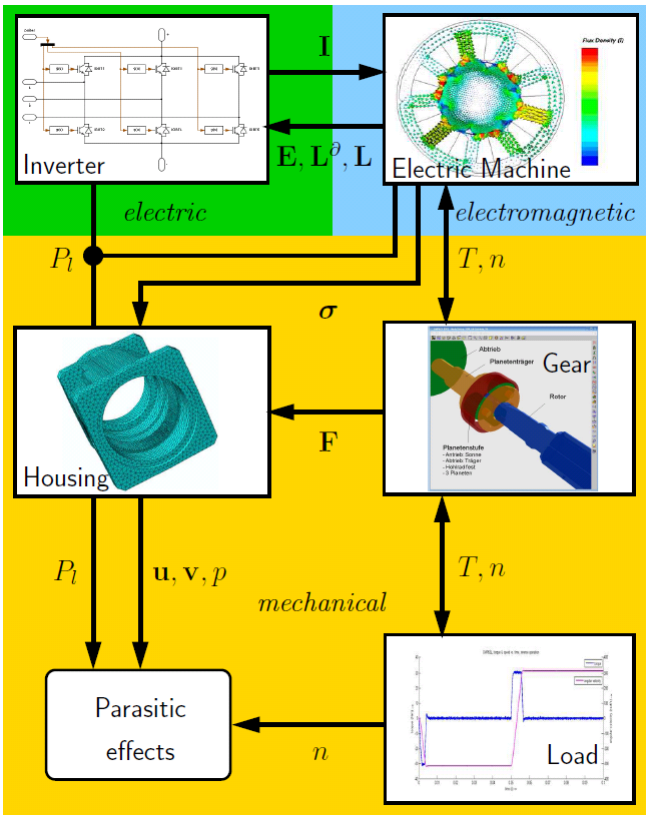

Fig. 1. Multi physics model environment involving magnetic field interaction with electric circuits of a power electronic circuit, mechanical transmission devices such a s a gear, structure dynamic effects excited by magnetic forces, forces introduced by mechanical forces and other parasitic effects such as magnetic and electric losses (Multi physics environment IEM RWTH Aachen University, www.iem.rwth-aachen.de).

Fig. 2. Virtual reality (VR) environment. Electromechanical device presented in a VR-cave.