Numerical Calculation of the Dynamic Behavior of Asynchronous Motors with COMSOL Multiphysics

Jan Güdelhöfer[1], Raimund Gottkehaskamp[1], Alexander Hartmann[1]

[1]Department of Electrical Machines and Electromagnetic Field Theory, University of Applied Sciences Düsseldorf, Düsseldorf, Germany

Abstract

The numerical electromagnetic field calculation is an important tool to calculate and design electrical machines. To lay out a design for the magnetic circuit it is sufficient to consider two dimensions, where leakage inductances and resistances, caused by winding overhangs and short-circuit rings of an Induction Motor in the end area, are neglected. However, if the stationary and dynamical operating behavior are to be simulated, magnetic and electric influences have to affect the model simultaneously. In three-dimensional simulations, winding overhangs and short-circuit rings can be represented geometrically and therefore also be considered in calculations, but the solving times for these exact models are unacceptably high. The effects on the operating behavior can be considered very accurately in less time consuming two-dimensional calculations [1][2], by simulating the electromagnetic conditions in the end area of the machine via lumped components coupled to the FEM model (Figure 1). Numerical models of electrical machines are often supplied with impressed current densities. This alternative allows the calculation of the static magnetic circuit. For stationary and dynamical simulations, it has to be considered that the RMS values and the time dependence of the phase currents adapt according to the amount of revolutions per minute, the magnetic saturation, and the applied voltage. However, this is only possible if the stator is also connected to a voltage system. This paper shows how a time-dependent and non-linear simulation of the dynamic operation behavior of an induction machine is executed by means of the "Rotating Machinery" interface from COMSOL Multiphysics 4.2a. The two-dimensional FEM model is connected to electrical circuits by coupling the physics "Rotating Machinery" and "Electrical Circuit" interfaces. These circuits include the lumped electrical components to simulate the electrical effects in the end area as well as the three-phase-voltage system to supply the stator. Simulations are made for constant slip values as well as dynamical start-ups (Figure 2, Figure 3, and Figure 4) with an additionally defined equation of motion as an ordinary differential equation by means of the "Global ODEs and DAEs" interface.

Reference

1. Arkkio, A.: Analysis of Induction Motors Based on the Numerical Solution of the Magnetic Field and Circuit Equations. Acta Polytechnica Scandinavica, Electrical Engineering Series No.59, Helsinki 1987.
2. Gottkehaskamp, R.: Nichtlineare Berechnung von Asynchronmaschinen mit massiveisernem Rotor und zusätzlichem Käfig im stationären und transienten Zustand mittels Finiter Differenzen und Zeitschrittrechnung. VDI-Verlag, Fortschritt-Berichte VDI Series No.131, Dortmund 1993.

Figures used in the abstract

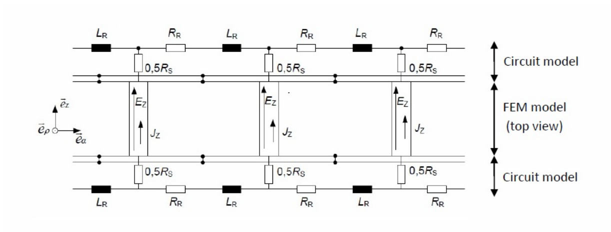

Figure 1: External circuit of the rotor, top view.

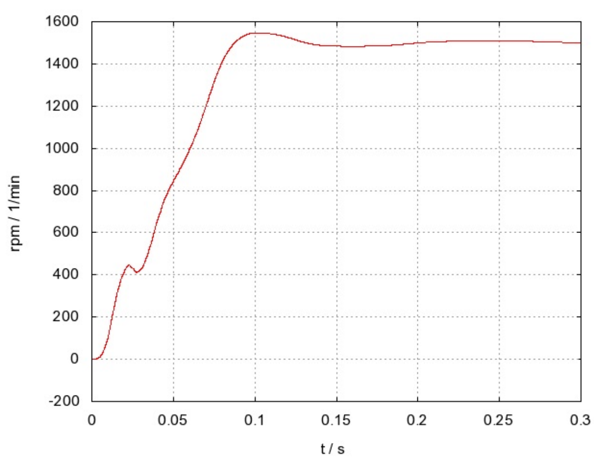

Figure 2: Revolutions per minute during start- up.

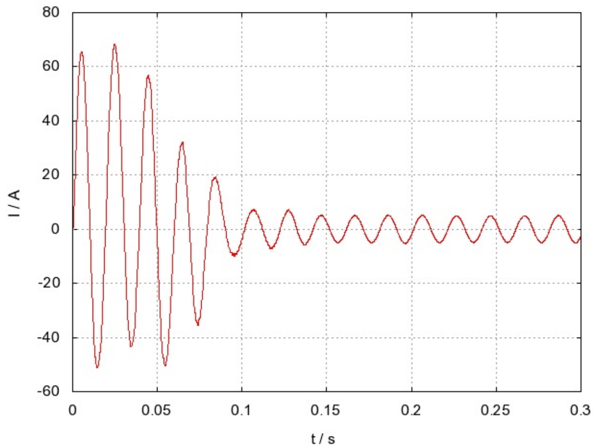

Figure 3: Phase current during start- up.

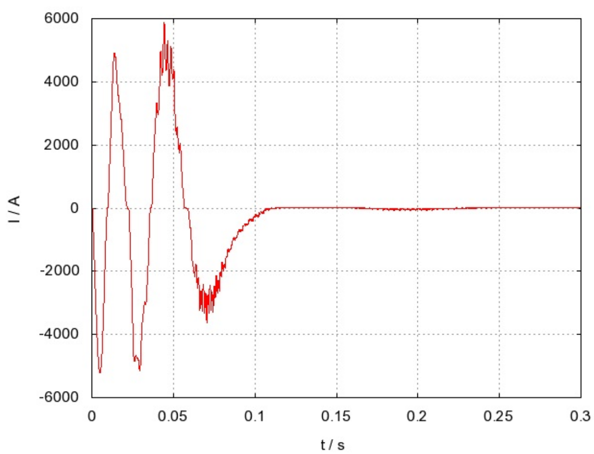

Figure 4: Rotor bar current during start- up.