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

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Introduction: If the stationary and dynamical operating behavior of an induction machine are to be simulated, magnetic and electric influences have to affect the model simultaneously. The effects on the operating behavior can be considered accurately in two-dimensional calculations, by simulating the electromagnetic conditions in the end area of the machine via lumped components coupled to the FEM model.

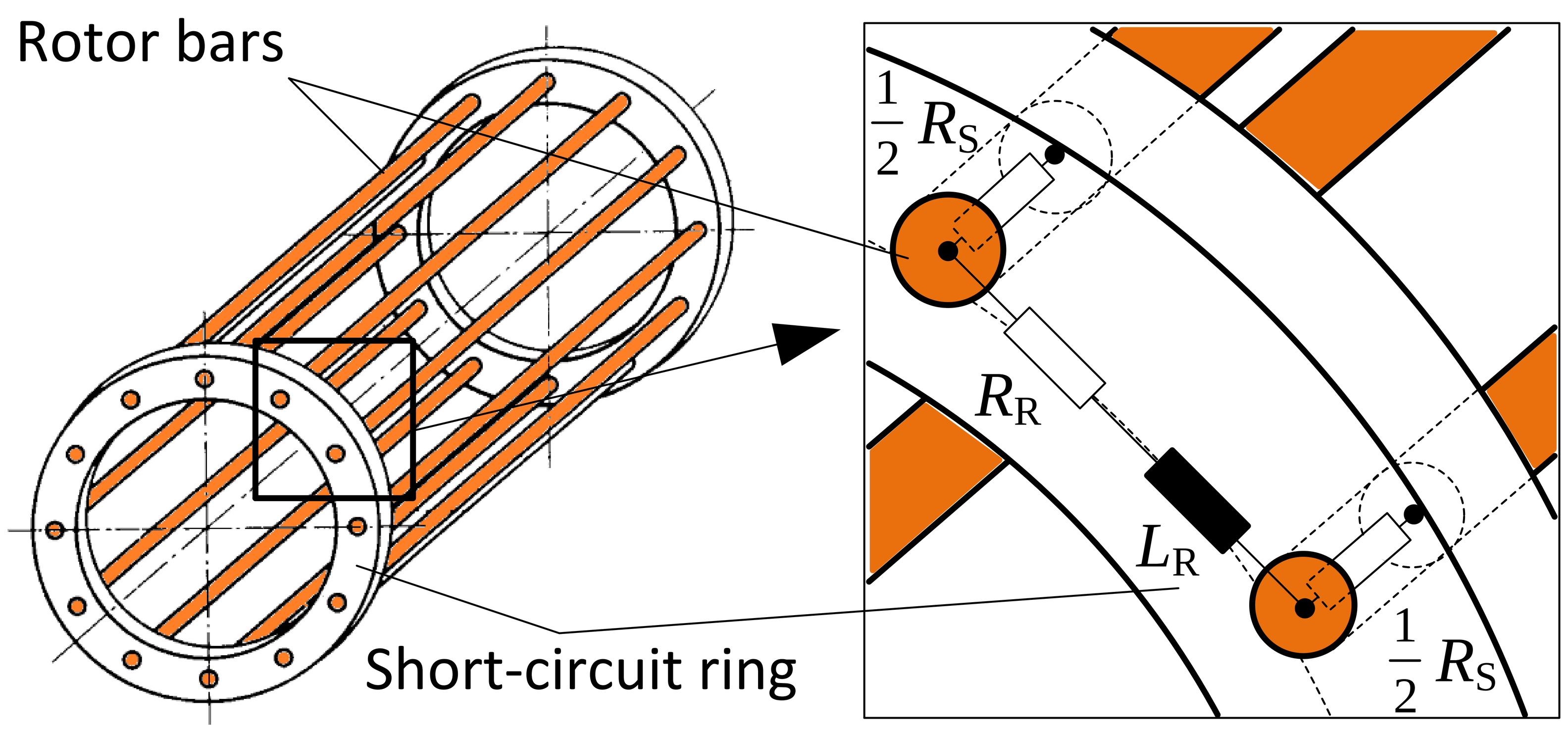

Figure 1. The rotor geometry in the end region of the induction machine is replaced by lumped components.

Computational Methods: The FEM model is built within the Rotating Machinery physic interface and the electrical model consists of a stator circuit and a rotor circuit.

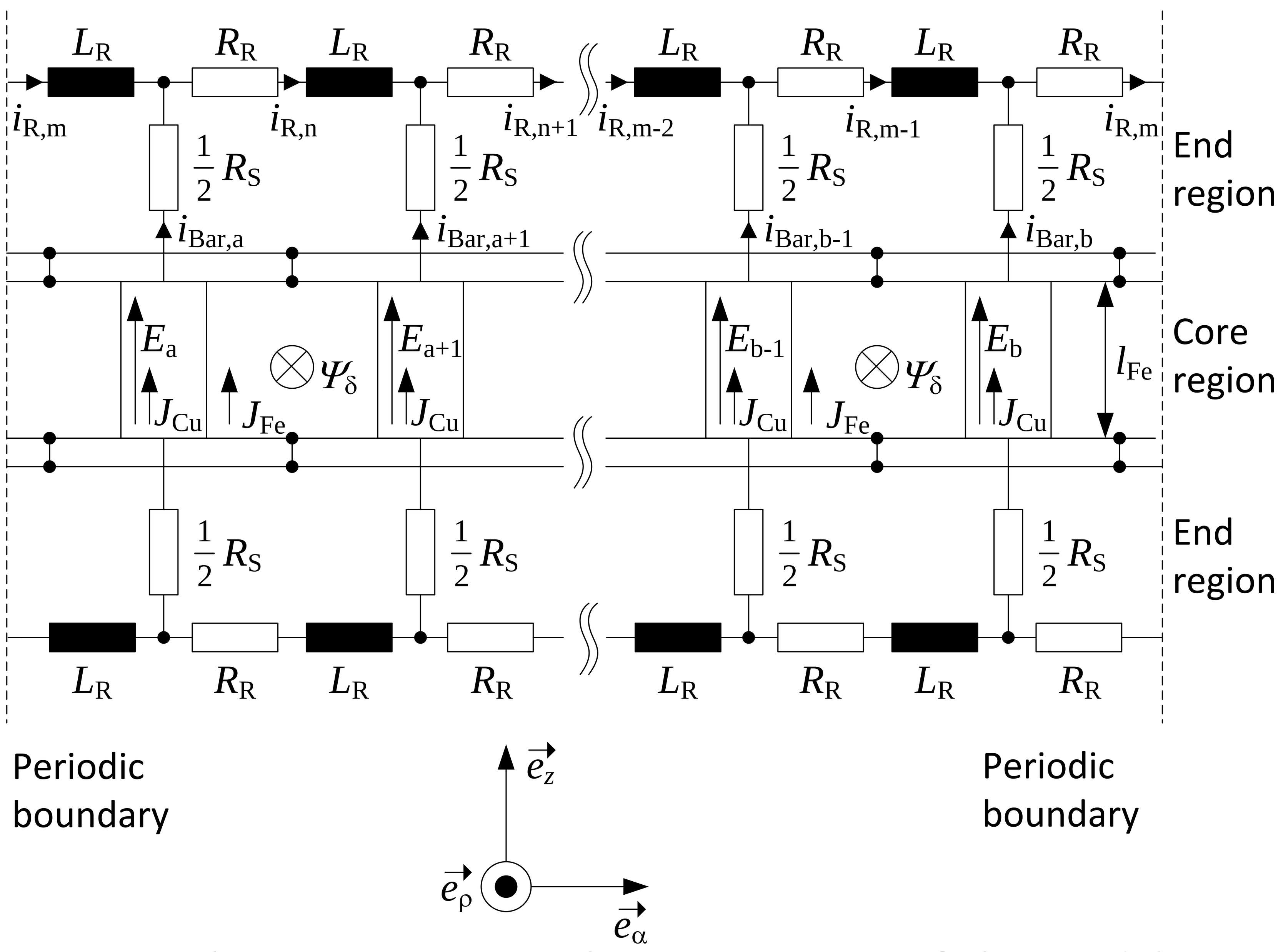

Figure 2. The rotor circuit is the continuation of the model in Figure 1.

The stator circuit contains, among others, voltage sources to supply the 2D-FEM geometry with a three-phase-voltage-system. The coupling between the rotor equations in Figure 2

$$2\,L_{\mathrm{R}}\frac{\mathrm{d}\,i_{\mathrm{R,n}}}{\mathrm{d}\,t} = -l_{\mathrm{z}}\left[E_{\mathrm{a}} - E_{\mathrm{a+1}}\right] - R_{\mathrm{s}}\left[2\,i_{\mathrm{R,n}} - i_{\mathrm{R,n-1}} - i_{\mathrm{R,n+1}}\right] - 2\,R_{\mathrm{R}}\,i_{\mathrm{R,n}}$$

and the rotor bar domains in the FEM model is made with

$$\vec{J} = \kappa\left[-\frac{\partial\vec{A}}{\partial t} + \vec{E}\right]$$

Results: The outcomes of the calculations are time dependent values of magnetic, electric and mechanical variables such as phase currents, rotor bar currents and revolutions per minute.

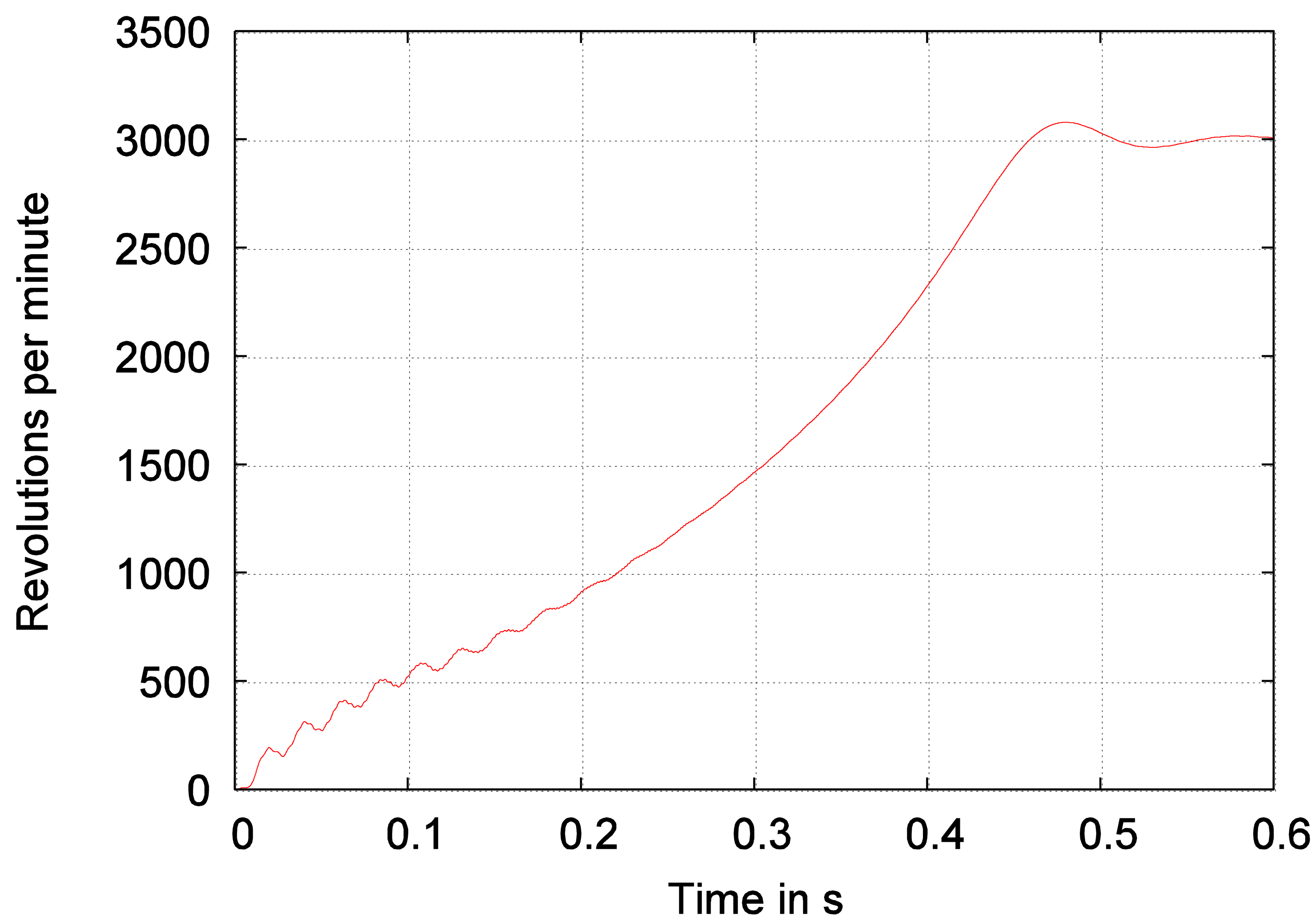

Figure 3. Revolutions per minute with respect to time of an induction machine (2 poles) during start-up.

Conclusions: The results show that coupling different kind of physic interfaces like Electric Circuit and Rotating Machinery within the COMSOL model allowed to reduce the three dimensional model to two dimensions without neglecting electrical effects, which are relevant for the dynamical behavior.

References:

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