II-7. COMPARISON OF STATOR- AND ROTOR-FORCE EXCITATION FOR THE ACOUSTIC SIMULATION OF AN INDUCTION MACHINE WITH SQUIRREL-CAGE ROTOR

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Abstract. In this paper the structure- and air-borne noise of an induction machine with squirrel-cage rotor are estimated. For these, different types of surface-force excitations and rotational directions are regarded for the first time. The comparison of the different excitations shows, that it is necessary to take the rotor excitation into account, and that the direction of the rotation has a significant effect on the noise generation.

Introduction

The drivers of passenger cars nowadays make great demands on the acoustics of the technical equipment such as the electrical power steering. Therefore, it is of high interest to estimate the audible noise radiation of these components. The induction machine with squirrel-cage rotor used as power-steering drive is computed in three steps: coupled to the casing caps by the bearings. For this, the rotor excitation has to be taken into account as well for comparison reasons.

1. electromagnetic simulation,
2. structural-dynamic computation, and
3. acoustic estimation.

The theory is briefly described in [1] and therefore not repeated. In the case of an induction machine with skewed squirrel-cage rotor the location of the maximum force excitation of the stator teeth depends on the rotational direction. So far, only stator-teeth excitation has been regarded in literature [2–4]. Further on the impact of the force exciting the rotor is taken into account. Therefore, four different cases of electromagnetic surface-force excitation are compared and discussed in this paper as listed in Table 1.

Since the rotor of the induction machine is skewed (skewing angle $= 10^\circ$) the stator teeth are excited very asymmetrically. The location of the maximal tooth excitation depends on the direction of rotation. In case of right-hand rotation the highest excitation

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Table 1. Cases for different force excitations

Type of excitation	Rotational direction
Stator-teeth	Left-hand
Rotor-teeth	Right-hand
Stator-teeth	Right-hand
Rotor- and stator-teeth	Right-hand

values are positioned on the side of the mounting-plate. Left-hand rotation results in maximal excitation locations on the opposite side of the machine. For this, both directions are computed and the audible acoustic-noise radiation is compared. Fig. 1 defines the rotational direction.

Usually it is sufficient to simply take the force excitation of the stator in to consideration to make good predictions of the radiated noise. The stator of the regarded machine is weakly coupled to the casing mechanically spoken by hard rubber rings around the casing caps and steel-spring pins in the notches of the stator and casing. The rotor on the other hand is strongly coupled to the casing caps by the bearings. For this, the rotor excitation has to be taken into account as well for comparison reasons.

Electromagnetic simulation

The first step of the computational process is the electromagnetic simulation. The induction machine is simulated with a three-dimensional magnetostatic model, which uses stator and rotor currents as excitations. Due to computational timesaving reasons the rotor-bar currents are derived from a two-dimensional, transient computation [5]. The 2D model consists of 6,882 first order triangular elements and the computation of one time step in 2D takes

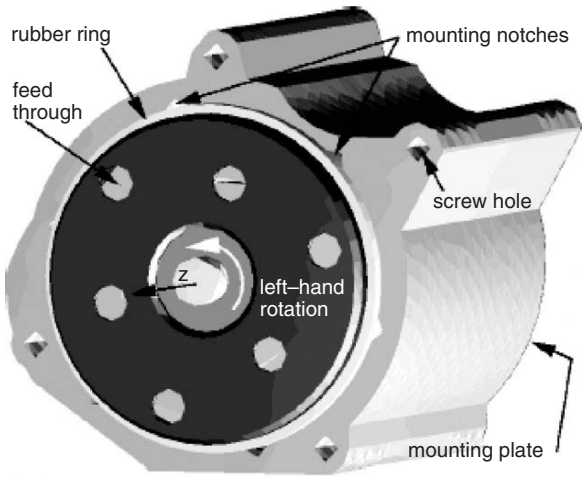

Figure 1. Definition of rotational direction; location of the mounting plate, the mounting notches, the screw holes, and the rubber rings.