Multi-physics modeling of asynchronous electrical machines in non-stationary conditions with eccentric rotor

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Abstract

The large demands of electrical machines in various industrial fields has driven an intensified attention to their conception design and dynamic behavior analysis especially for NVH purposes in the automotive industry. One of the main reasons of the electrical machine vibration is the electromagnetic vibration caused by the uneven air-gap [9]. The air-gap eccentricity is often generated by the misaligned of the rotor rotation axis and the stator axis, which can be caused by either installation parallel deviation, bearing wear or mass unbalance. All these mechanical defects lead to the presence of the unbalanced magnetic pull (UMP) in the motors. This electromagnetic radial force drives the rotor to move along with the direction to the minimum of the air-gap and continues to worse the eccentricity problem. Meanwhile the variations of the parameters in magnetic field generate the new magnetic force to change the mechanic behavior of the motor. Therefore, a multi-physics modelling including the strong electromechanical coupling of the electrical machines is of great importance. In this paper, a multi-physics model combining the electromagnetic part based on Permeance Network Method and the mechanic part based on Timoshenko beam theory is proposed to describe both the mechanic and electromagnetic performance of the asynchronous cage induction motors. With a three-phase supply voltage as an input data, all the simulation results like the currents in the stator, the currents in the rotor and the displacement and velocity of each element of the rotor are obtained. The electromagnetic torque and the radial motor eccentric force are calculated by using virtual work method. Simulation results of the generated torque and stator's current are verified by comparing with some results offered by an integrated software on a realistic electrical machine from our industrial partner. Moreover, the influence of different values and configurations of dynamic and static eccentricities have been drawn and discussed in the analysis section of the paper. Some comparisons with existing references will also be presented in the same part. Also by applying an angular approach on this multi-physics description, this model is capable to simulate the dynamic behavior of the motor in non-stationary operating conditions in speed or load without any assumptions on the speed and the rotational degree of freedom of the rotor

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is preserved as a state variable. The motor's nonlinear dynamic behavior with the variation of the rotation speed are simulated and according to the simulation results, the influence of the varied rotor speed to the whole system response is reported in this contribution.