The Finite Element Method For Parametric Identification Of A Three-Phase Induction Machine With Genetic Algorithms

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1. Introduction.

In this paper a three-phase magnetic induction motor squirrel-cage is analyzed with the Finite Element Method (FEM). Five variations of the rotor geometry designs are analysed. The analysis has been made with simulations of static configurations. For each geometry an identification of the parametric model has been obtained. To the optimization of the parameters, genetic algorithms (GA) have been used as a robust optimization method. An induction machine with a moving rotor can be modeled using a relatively simple circuit model (Fig. 1). The dynamic behavior of the machine has been deduced through simulations of mechanically static configurations. The purpose of the analysis is to identify the parameters in the circuital model. The circuit model can then be used in a wide variety of conditions, including the simulation of transient conditions [1]. Although circuit parameters can often be approximated by closed-form expressions in explicit terms, the identification of these parameters via FEM analysis will validate the approximations and simplifications that inevitably have to be made in the derivation of analytical design formulas [2]. The purpose of this paper is the parametric identification with FEM of five rotor geometry designs and the optimal adjustments of them using GA [3].

Keywords: Finite Element Method, Parametric Identification, Genetic Algorithms, Induction Machine.

2. Induction Machine Model

The circuit model (Fig. 1) represents a phase of the machine at steady state with a constant electrical frequency and a constant mechanical speed. In this model, the entire leakage is lumped on the stator side in the inductance L_l [1],[3]. The dependency of the inductance on the slip frequency provides a way to identify motor parameters. These results, the circuital model and the FEM analysis, will provide a profile of the parametric induction machine. A frequency analysis is applied, allowing identification of a circuital model and continuous model (FEM) using different static configurations at different frequencies. The result is the flux per phase evolution and electromagnetic torque at different slip frequencies identifying the parameters M, mutual inductance, L_l leakage inductance and τ the rotor time constant of the induction motor [2].

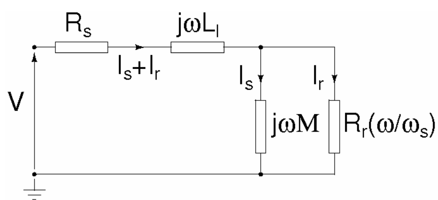

Fig. 1. Simple steady state per phase circuit model.

The adjustment and optimization for these parameters (M, L_l and τ), has been made with genetic evolutionary algorithms applied to obtain optimal values within a compromise that minimizes the objective function [3]. The objective function is the real part and imaginary part of inductance as a sliding frequency dependent function, that is closely related to the parameters M, L_l and τ .

3. Results.

The operator values used in GA correspond to: 50 population size, 200 number of generations, 0.01 mutation probability, and 0.6 the crossover probability. Table 1, show the adjustment between the analytical results of the parametric model and those results obtained by the FEM for different types of rotor geometries analyzed. Results for the rotor geometry type 2 of an induction machine adjusted by GA are shown in Fig. 2a. and Fig. 2b.

4. Conclusions.

The parametric model of the five rotor geometries have been adjusted with the FEM continuous model. The curves torque-speed of the different types of geometry analyzed have been compared and classified with NEMA (*National Electrical Manufacturers Association*)/IEF (*International Electrotechnical Commission*) standard.

	τ (s)	M(H)	L_l(H)
Type 0	0,1635770	0,313115	0,01556420
Type 1	0,0703136	0,164614	0,00682070
Type 2	0,0619364	0,140215	0,00938430
Type 3	0,2384990	0,139849	0,00677501
Type 4	0,0944839	0,164065	0,00888070

Table. 1. Optimal results of the adjustment by GA for all geometries.

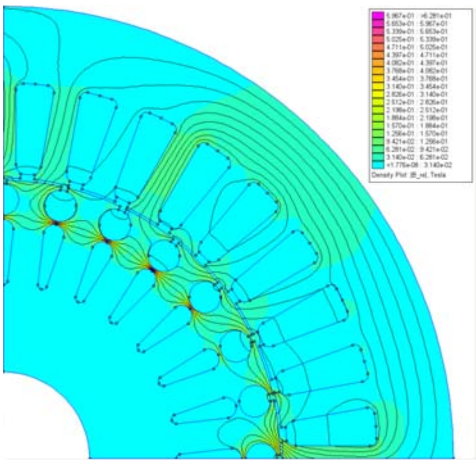

Fig. 2a. Type 2 rotor geometry analized by FEMM.

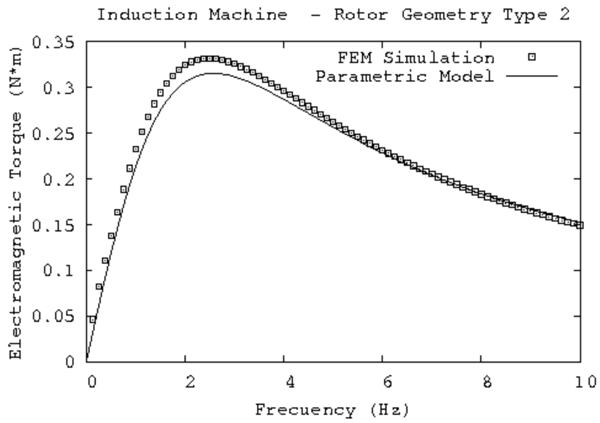

Fig. 2b. Adjustment with GA between the parametric model and FEM continuous model.

References

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