Analysis and Design Program for Switched Reluctance Motor using an Analytical Method*

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Abstract – This paper describes an interactive design and analysis tool for switched reluctance motors consisting of a scooping module and a CAD program. The methodology follows conventional algorithms in which the flux linkages, inductances and torque are calculated numerically with voltage and current control. Two SRMs were designed and simulated. The simulation is compared with test results.

INTRODUCTION

A switched reluctance motor (SRM) design and simulation program is implemented with an interactive front end using *LabVIEW*. The program follows a five-step approach: Steps 1 through 3 input data defining the motor. Step 4 sizes the motor and Step 5 provides a more detailed analysis based on waveforms. Figure 1 shows half of the cross-section of the 12 kW SRM described in this study. The motor has six rotor poles and eight stator poles.

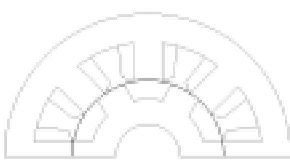

Fig. 1. Schematic of the 8/6-pole 12 kW SRM.

ANALYTICAL FORMULATION

The calculation of magnetic flux linkages as a function of stator current and rotor position is fundamental to the method. The main flux contribution to the total flux linked by a phase is[1]

$$\lambda(\theta, I_{ph}) = n_{ser}\; N_{tp}\; L_{stk}\; k_{stf}\; R(\theta)\;\; B_m\,, \qquad (1)$$

where $R(\theta)$ is a function of rotor position, n_{ser} is the number of pole windings in series, N_{tp} is number of turns per pole, L_{stk} is the motor stack length, k_{stf} is the lamination stacking factor, and $\boldsymbol{B}_m$ is the main flux density in airgap.

The SRM terminal voltage equation is solved by an iterative Runge-Kutta method. The inductance is calculated by using the flux-linkage and phase current, and the torque is calculated by

$$T_{static}(\theta, i_{ph}) = \left[\frac{\partial W_{co}(\theta, i_{ph})}{\partial \theta}\right]_{i_{ph}}\,, \qquad (2)$$

where W_{co} is a co-energy calculated using the flux-linkage vs. current.

RESULTS

To validate the models, experimental values provided by an third party industrial partner were compared with theoretical values calculated by the program for two motors: an 8/6 pole, 12 kW SRM, and a 24/16 pole, 35 kW SRM. Figure 2 shows the flux-linkage-current curves and an energy conversion loop of the 8/6 poles 12 kW test model under condition of 220V, 210A at 6000 rpm. Figure 3 compares calculated and measured torque curves for the base speed of 500 rpm, V_s =300 V, and current limit of 170 A. The simulated and measured results are in good agreement.

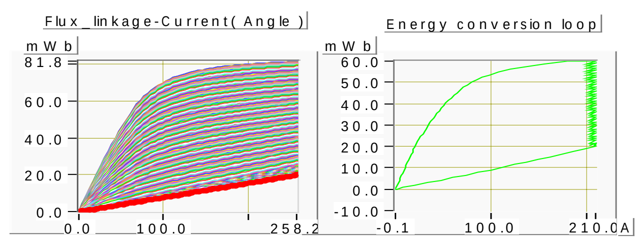

Fig. 2. Flux-linkage-current curves and an energy conversion loop at the rated condition of the 8/6 poles 12 kW SRM.

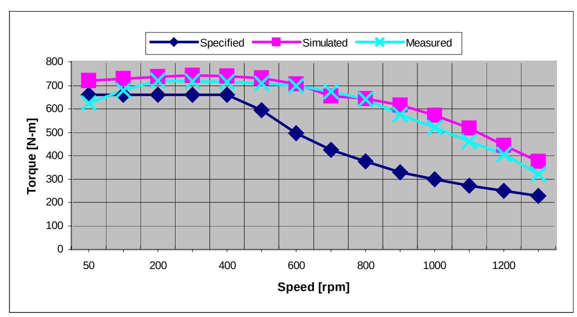

Fig. 3. Waveforms of input voltage, phase current and torque lines of the 8/6 12 kW SRM as a function of rotor position.

ACKNOWLEDGMENT: This work is supported by DOE's Office of Transportation Technology and the Korea Research Foundation (KRF-2000-EA0044).

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