PERFORMANCE PREDICTION OF SWITCHED RELUCTANCE MOTOR USING MULTILEVEL SIMULATION

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ABSTRACT:

A multilevel modeling approach was developed for effective prediction for performance parameters of Switched Reluctance Machine. In this approach each system is described by its most efficient model. This paper addresses the problem of multilevel modeling applied to Switched Reluctance Machine (SRM). Using field analysis magnetic characteristics and inductance profile of the SRM are obtained. The characteristics obtained were used in the evaluation of system parameters. SRM is modeled using FEA based CAD package MagNet 6.13.The inductance per phase is calculated depending upon rotor position. The inductance value is used to perform simulation in MATLAB/ Simulink to evaluate Torque, Phase current characteristics of the machine. Using this tool optimum design among various geometries can be obtained.

KEY WORDS: Switched Reluctance Machine Multilevel Modeling , System Simulation , MagNet , MATLAB.

1.INTRODUCTION:

Switched reluctance motor (SRM) are attractive for industrial applications because of their structural simplicity, low cost, ruggedness and reliability in harsh environments[8]. The increasing popularity of SRM has been triggered mainly due to the fact that its speed torque characteristics can be tailored to suit the desired application. This has given rise to the need for exploiting simulation tools that can be used to obtain the characteristics of SRM even before it is manufactured[2].

The Modeling and simulation of motion control system is gaining more attention. The main problem in modeling and simulation of motion control systems are the different models for the various components in motion control system. The main purpose of this simulation is to model the Switched reluctance machine (SRM) to investigate the performance characteristics .In this paper, the static parameters are calculated using finite element analysis.The parameter is implemented in a model which is simulated in system simulation

Using Finite Element Analysis package MagNet6.13 inductance profile of SRM is obtained.Then,using inductance characteristics, an analysis model of SRM was constructed using Matlab/Simulink. By varying the air gap the performance of the machine is analyzed using this simulation.

2. INDUCTANCE ESTIMATION USING FINITE ELEMENT ANALYSIS:

The schematic diagram of 8/6 Switched Reluctance Machine is shown in figure 1.The motor operates due to the inherent nature of the rotor poles getting aligned with the axis of the excited stator poles ,thereby taking the minimum reluctance position(aligned position). When the position of rotor is such that a stator pole is directly opposite the midpoint between the rotor poles ,the position of maximum reluctance(unaligned position).The inductance L of the excited stator winding thus varies with the varying reluctance of the air gap, reaching a maximum of "Lmax" at the aligned position and a minimum of "Lmin" at the unaligned position.

The complicated structure of motor makes magnetic field analysis very difficult through analytical methods .The finite element analysis offers the best approach to determine the flux pattern and inductance profile. The results of FEA are shown below.

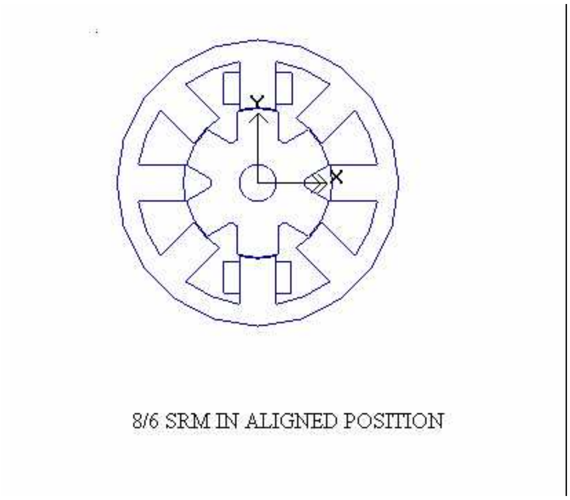

Fig 1.8/6 SRM in aligned position

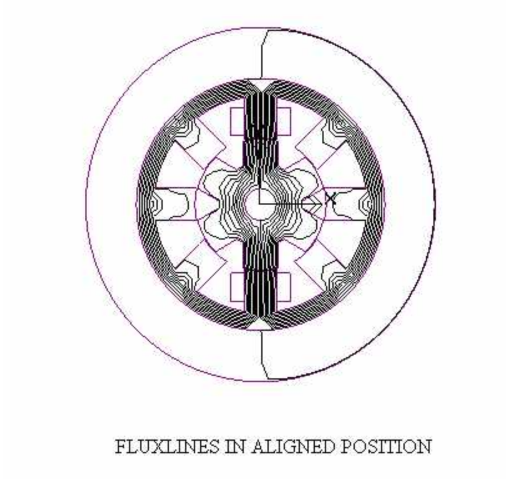

Fig.2 Flux Linkage at Aligned Position

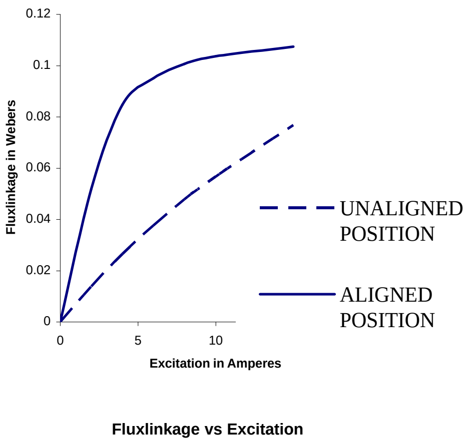

Fig.3 χ-i characteristics of SRM

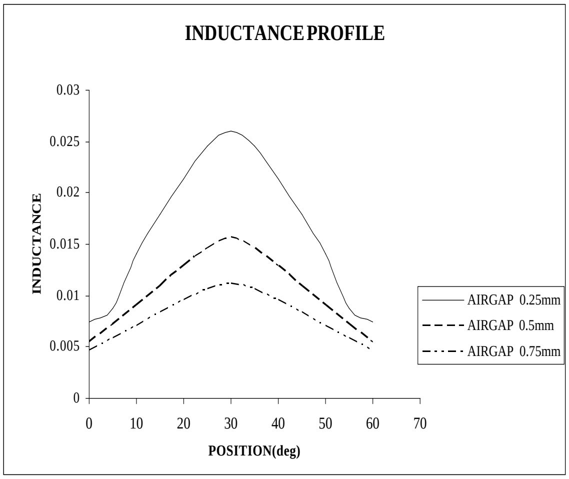

Fig. 4 INDUCTANCE PROFILE

3.MATLAB MODEL OF SRM:

On the basis of inductance profile , mathematical model of SRM using Matlab/Simulink is obtained. The Electrical model for SRM developed in Matlab/Simulink is described briefly in figure 5 for one phase. When all phase models are included, the electromagnetic torque of the motor can be found. Finally, a mechanical model of the motor is linked to the electrical model, so the rotor speed and rotor position can be obtained. A Combination of FEA and MATLAB model is used for performance analysis.The modeling equations used to evaluate the performance are,

1.ROTOR POSITION EVALUATION

The rotor position is calculated using the formula

$$\theta=\int\omega \, dt$$

2.INDUCTANCE EVALUATION

The inductance profile obtained from the FEA is used for phase current evaluation.

3.PHASE CURRENT EVALUATION

For the phase current evaluation the value of the flux linkage is calculated using,

$$\psi = \int (V-I*R)dt$$

From the flux linkage, current is calculated using

$$\psi= L(\theta)\, i$$

4.TORQUE EVALUATION

The torque is evaluated using the torque equation

$$T = 1/2\, i^2\, dl/d\theta$$

5.SPEED EVALUATION

The speed is evaluated using the equation

$$\omega= \int (T-f\omega)/J$$

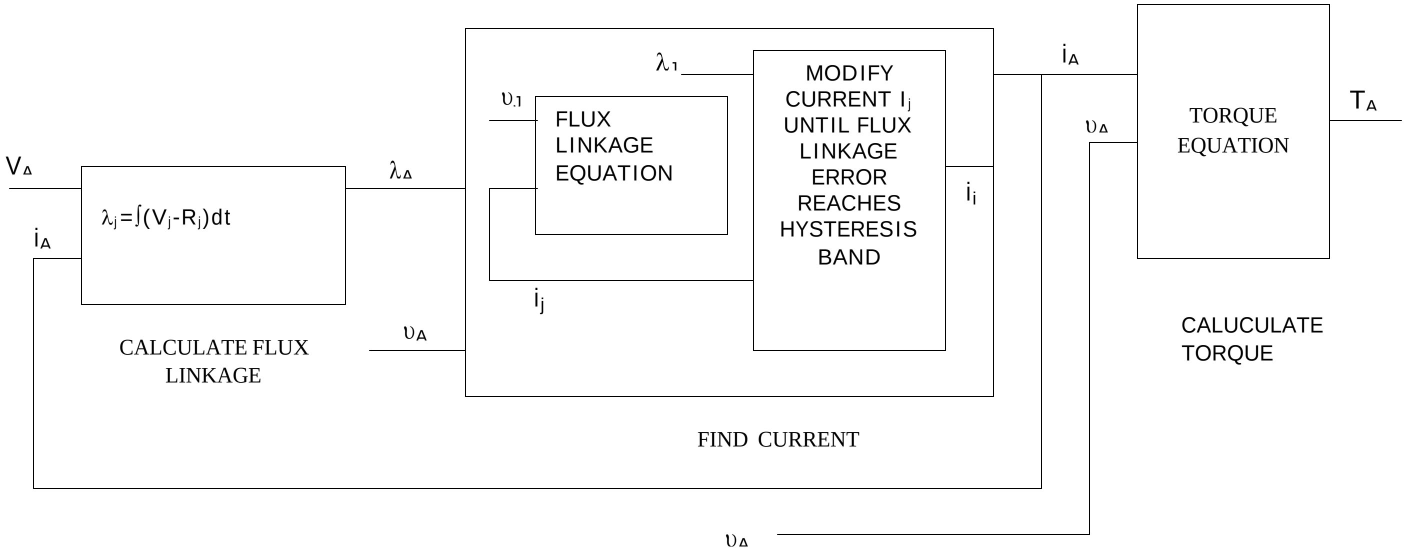

FIG5.SINGLE PHASE MODEL OF SRM

4.RESULTS OBTAINED FROM MATLAB/SIMULINK:

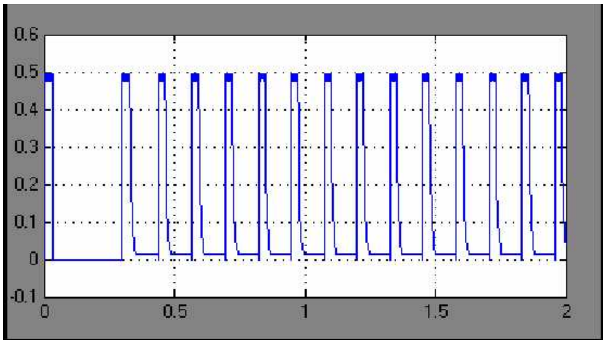

FIG6.TORQUE FOR 0.25mm AIRGAP

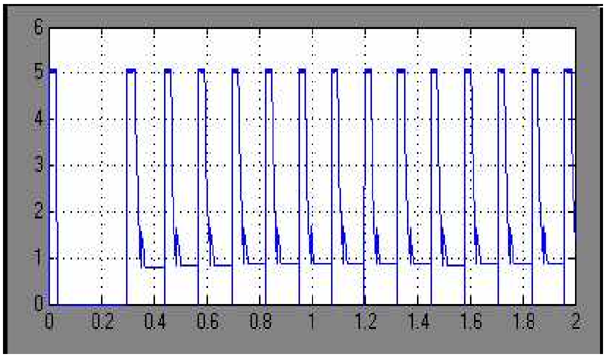

FIG7. PHASE CURRENT

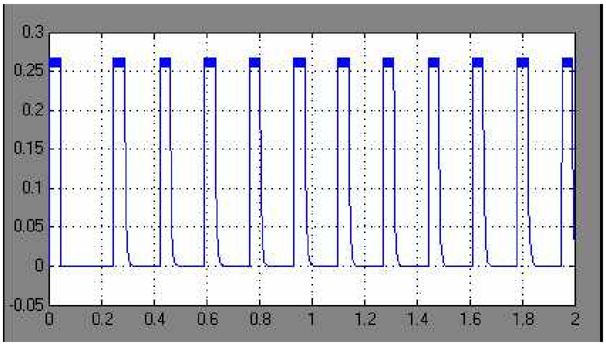

FIG8. TORQUE FOR 0.5mm AIRGAP

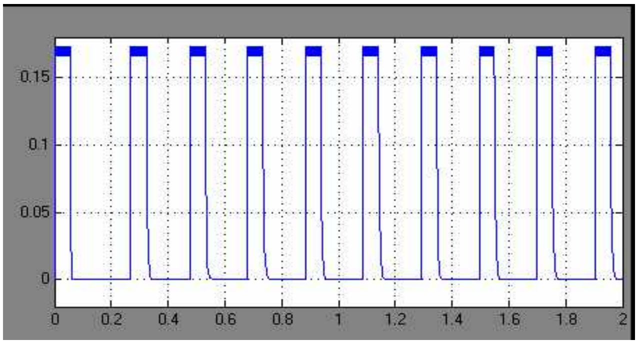

FIG9. TORQUE FOR 0.75mm AIRGAP

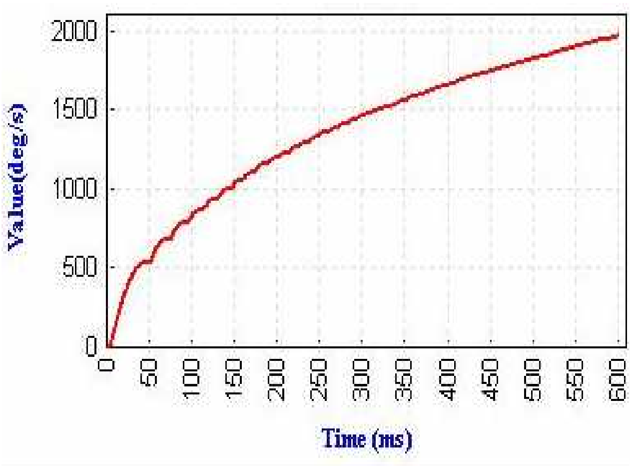

FIG10.SPEED

5.CONCLUSION:

A multilevel modeling is a useful simulation method to analyze the performance characteristics of SRM. By using finite element analysis inductance profile is obtained by varying the air gap. Using the inductance values, the mathematical model is designed using MATLAB / SIMULINK to obtain the performance characteristics. From the analysis, the performance of the machine with smaller air gap is found to be optimum. Various design optimization can be done using this simulation. This simulation tool serves the purpose of modeling SRM and analyzing the performance characteristics before manufacturing the machine.

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APPENDIX:

The Geometry of Standard 8/6 SRM used for FEA Modeling is given below.

R_{SH} = 4.6mm

R_0 = 11.88mm

R_1 = 18.50mm

R_2= 30.50mm

R_3 = 35.54mm

N_S = 8

N_R = 6

$\beta_S = 28^0$

$\beta_R = 32^0$

Stack length : 50.8mm

Material used for modeling the SRM in MagNet 6.1:

Stator: Cold Rolled Steel.

Rotor: M43USS24 cage

Shaft: Steel

Winding: Cu $5.77e^7$ Simens/m