PERFORMANCE ANALYSIS OF SWITCHED RELUCTANCE MOTOR WITH DIFFERENT CORE MATERIALS

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Abstract:

This paper presents 6/4 Switched Reluctance Motor output study with varying core materials. The stator and rotor structure is studied with M-15 and Mega perm material with Ansys software. Power output, efficiency is analyzed using Rotating Magnetic Expert of Maxwell tools. In terms of torque, rotational speed and efficiency characteristics, the performance of the two types of 6/4pole SRM having dimensions same but core is made of different material is compared.

IndexTerms **- M15; Megaperm; motor; performance.**

I. INTRODUCTION

In every industry, there are processes that need electric motor adjustment for their normal operation or optimum output. For drive with variable speed, motors such as the DC machine, SM and IM are connected to load directly or sometimes indirectly. The switched reluctance motor (SRM) is unique compared to other machines of electric type. The SRM drives for industrial applications are of recent origin. SRM has certain unique features even though of synchronous in nature. In various domain applications like residential, industry and transportation - electric motor usage has been in demand for many years. Thereby continuous improvements in terms of size, volume and weight, fault tolerance capability, high torque characteristics, high efficiency, manufacturing cost on low side thereby switched reluctance motors are recommended. It works in a way that is somewhat analogous with a stepper motor.

Nowadays SRM are employed in electric vehicle based drive system compared to Permanent magnet and Induction Motor drive. However noise is still a main challenge for SRM for their normal operation or for optimum performance.

FEM analysis of magnetic flux is done on core part with different materials in [1]. Latest SRM with Dual Stator-rotor is suggested for the high power density Permanent Brushless DC Motor (PM-BLDC) in [2]. Segmental rotor SRMs have been shown to generate higher torque over tooth rotor motor, since each coil can bind more magnetic flux in [3]. A non linear distributed parameter equivalent circuit framework is designed for the calculation of the core losses for belt-driven starter generators of a 16 stator with 10 rotor segmented reluctance motor in [4]. [5] Presents A unique dual-stator mounted reluctance motor with E-core stators and high-torque segmental rotor. The structure having magnetic circuit model is used and illustration of working is done using 2-D finite element analysis. [6] Analyzes the increased performance of an SSRM with 16 stator and 10 rotor pole combination, analyzing important parameters to obtain the optimum values. The results obtained are suggested to demonstrate the SSRM improvement after optimization, and the enhanced fault finding characteristic is described using fem. [7] Presents the Finite element modeling and simulation of the unique a double-stator magnetic induction SRM is performed and the relation is obtained seen between motor's structural parameters and the motor torque and levitation force. [8] Presents the design and analysis of a SRM with pre-fabricated SMC blanks low mass density to replace existing dishwasher pump for a fast and low cost approach. Finite element analysis study has been conducted to accurately determine key motor parameters, and the experimental output are checked by valid performance predictions. [9] Discusses the development of Soft magnetic composite materials in recent years.[10] describes the efficiency of SRM for Toyota Prius with the same power rating with the same surface area and Size. The implemented motor consists essentially with only cores laminated with ferromagnetic material and dense windings on the stator. A system configuration of a SRM with efficient torque performance and also with reference to IPMSM in an electric hybrid vehicle is examined in [11]. [12] Experimentally verifies the SRM core of permendur material – This alloy does have an exceptionally more flux density with reduced core loss, alloy formed with 49 percent cobalt material along iron mixture. In terms of torque, rotational speed and output, two types of 12/8-pole SRM with the similar size but various core combination material are compared to the traditional.

This paper analysis’s the performance of 0.55KW, 6/4, SRM using Mega Perm, China steel and M-15- non-oriented silicon steel for stator core using FEA software Tool of Ansys- Maxwell Software package. Two types of 6/4pole SRM with the same dimensions but different core material are compared with the standard non-oriented Si steel parameters like torque, rotational speed and motor efficiency characteristics and the other one is M15, are made on a trial basis for comparison. The SRM made of M-15 demonstrates the better performance as a result of experimentation.

II. SIMULATION

Maxwell toolset from ANSYS is the electromagnetic field simulation tool for designing and analyzing electric motors, actuators, sensors and transformers for studying devices' electromagnetic and electromechanical behavior. With Maxwell toolset, the time - varying, transient movement of electromechanical components and their impacts on the design of the drive and control system can be precisely characterized. Figure 1 shows the flowchart used for design flow analysis in the Ansys Software Tool. Table 1 shows the rating of 550W ,6/4 pole SRM under study with Constant Speed and Constant Power in Ansys Maxwell FEA Tool using RM Expert with two types of Steel: MEGAPERM_40L_0.10MM and M-15 for stator core.

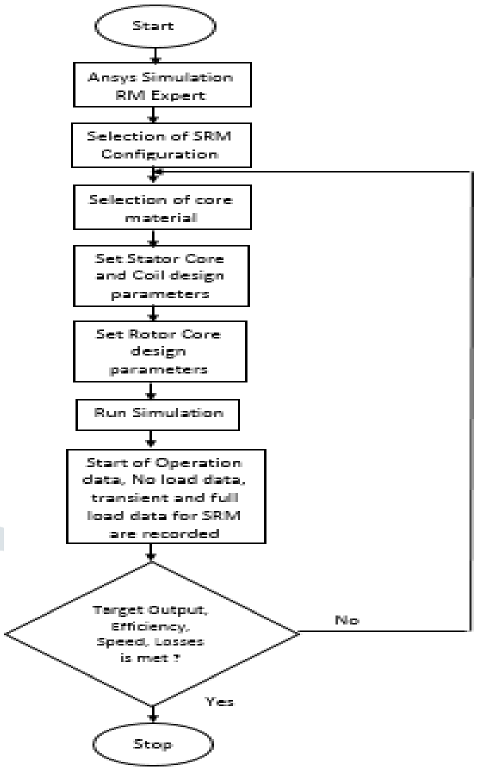

Figure 1 showing the flowchart used for design flow analysis in the Ansys Software.

Table 1 550W, 6/4 pole SRM Specification under study

Type of Steel	Megaperm _40l_0.10mm	M15_26g
Stator Poles in Numbers	6.0	6.0
Stator Outer Diameter in (mm)	120.0	120.0
Stator Inner Diameter in (mm)	75.0	75.0
Thickness of yoke (mm)	9.0	9.0
Pole Embrace	0.5	0.5
Stator Core length (mm)	65.0	65.0
Stator Core having Stacking Factor:	0.95	0.95

SRM are singly excited, double salient electrical machine, torque is produced by rotor, by exciting the stator phase winding sequencely thus minizing reluctance. SRM simpler geometry as evidenced by a 6/4 SRM model of the two-dimensional computer aided design shown in Figure 2.

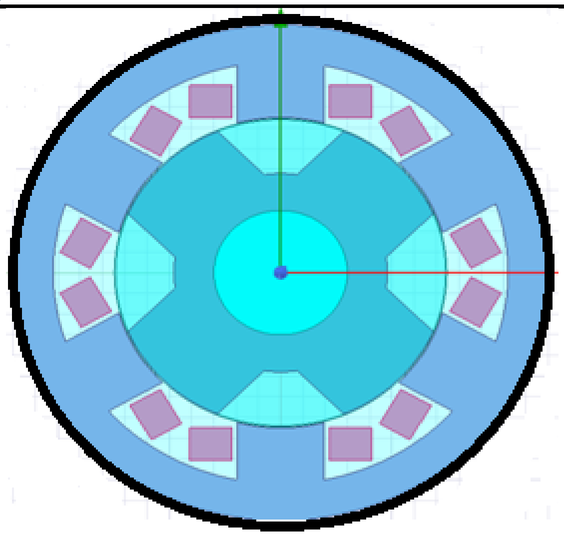

Figure2. Two-dimensional computer aided model of 6/4 SRM

Stator poles of SRM are having concentric winding mounted on it. Stator and rotor core materials are silicon steel laminated. Figure 3 shows the electromagnetic analysis with Finite Element Analysis (FEA) model of 6/4, three phase, SRM at different angular position.

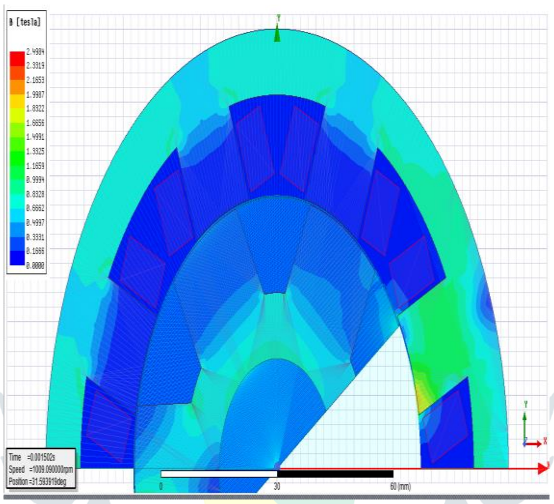

Figure 3.Finite Element Analysis of SRM

III. SIMUATION RESULTS

Finite element analysis study has been conducted to accurately determine key motor parameters, and validation is done on prototype model for analysis of performance. Magnetic characteristics for proposed motor is as shown below , motor output of flux lines in material, flux linkage and torque are resulted for the two stator core materials as in following figures.

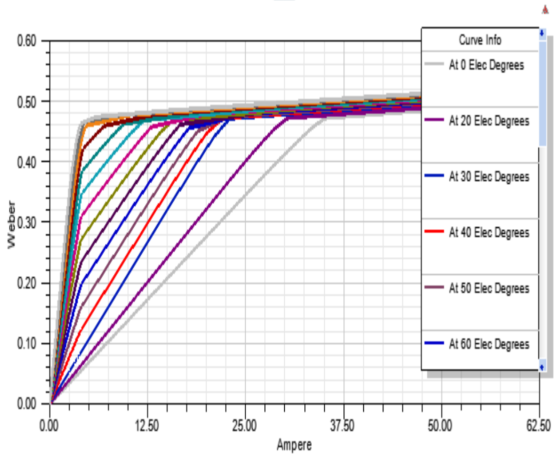

Figure 4a: Flux linkage for motor design using Mega Perm core steel materials.

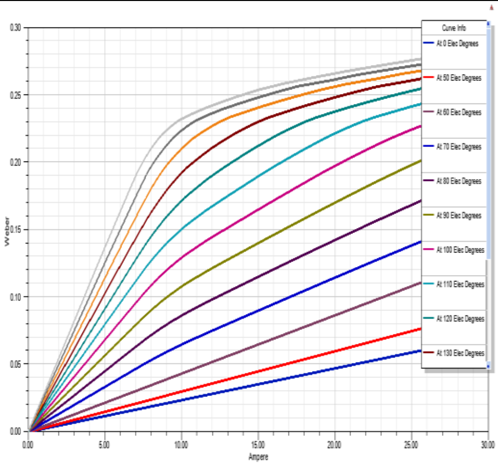

Figure 4b: Flux linkage for motor design using M15 cores steel materials.

The flux linking with different phase current/positions from 0˚ to 180˚ for the two cores steel materials indicate that the flux linkage is low for lower electrical degrees and flux linkage is increased with gradual loading, drawing more current. The flux linkage data for 6/4 SRM and having 0.3874Wb for Mega Perm core steel and 0.04Wb for M-15 core steel material.

Figure 5 shows the Magnetic flux density (B) and field intensity (H) for M15 core having better B-H characteristics compared to Mega Perm core steel material.

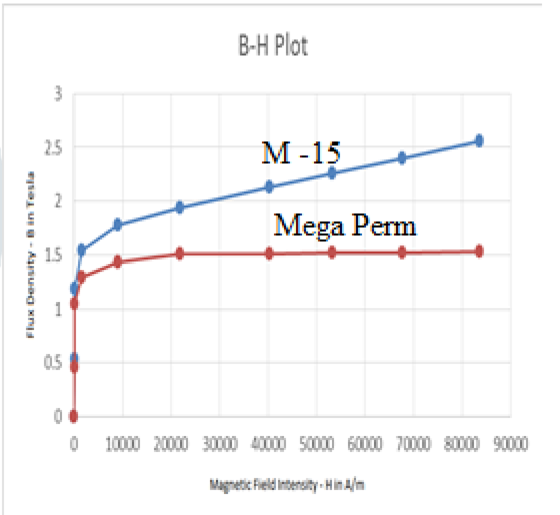

Figure 5: B-H Features of M-15, Mega Perm Stator core steel material.

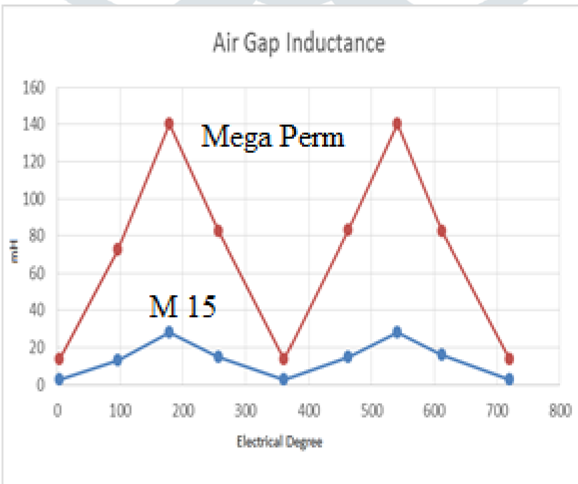

Figure 6: Air gap inductance details of M-15, Mega Perm Stator core steel material.

Figure 6 show the inductance air gap for two core materials. The flux linkage has reduced compared to both the machines.

Figure 7 describes the plot of efficiency versus speed for two types of core materials namely Mega Perm with 0.1mm and M15 material which is an non oriented silicon steel type, producing much higher efficiency compared to other. The efficiency gradually increases at lower speed and reaches maximum and remains constant for high speed operation of motor, where as Mega

Perm material it is vice-versa, the efficiency increased for low speed and reaches maximum for rated speed of motor, and gradually falls for higher speed operation of motor.

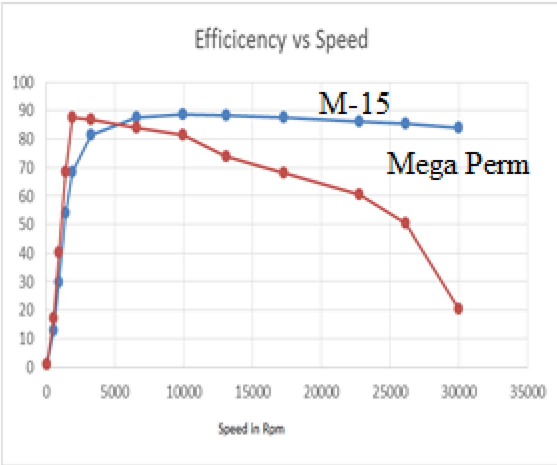

Figure 7: Plot of Efficiency versus Speed for the two tator core materials under study

Finite element analysis conducted for two different core materials M15 - core materials of type Non-oriented silicon steel for stator and rotor, total net loss were reduced from 180W to 73W and Efficiency of the machine is increased to 88% from 73% that of Mega perm magnetic core material.

IV. CONCLUSION

In terms of torque, rotational speed and performance, two types of 6/4pole SRM having the similar dimensions for different stator and rotor material are compared with the traditional one. One is M-15 silicon steel of non-oriented type and second is Mega perm, are used for comparison of study. Simulation result says, M-15 materials motor results are better with Mega perm. core materials in SRM are investigated. FEA tool is used to accurately determine key motor parameters, and performance predictions are simulated in ANSYS software, results of the prototype model are presented. Magnetic characteristics and simulation results are worked on in finding flux lines and its linkages, inductance, efficiency and speed are presented

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