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A COMPARITIVE STUDY OF 10/8 AND 10/6 SWITCHED RELUCTANCE MOTORS IN ANSYS MAXWELL

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Abstract: Switched Reluctance Motors are finding enormous application in various fields. This is due to the advancement of power electronics in recent years. The winding free rotor and magnet free nature of a Switched Reluctance Motor are major attractions. Both the above-mentioned factors are indirectly or directly a burden for human. In the case of magnetic materials their extraction process is harmful for humans so it is a burden for human beings. Since power electronics has advanced a lot we can impose these burdens which is presently on humans to power electronics. The accompanied use of these power electronics along with the Special Electrical Machine such as Switched Reluctance Motor, its applications can be increased where conventional AC and DC machines are playing splendid roles. Torque and Speed are prime concerns for various applications such as vehicles. In this paper a study is done on two types of Switched Reluctance Motor with different rotor poles. Comparison of Torque Vs Speed characteristic of two Switched Reluctance motor is done in this paper. A 2D design of the above mentioned Switched Reluctance Motors in Ansys Maxwell is also presented in this paper.

Keywords: Switched Reluctance Motors, Torque, Speed

I. INTRODUCTION

Motors which has variation in air gap and reluctance with respect to the rotor position are Variable Reluctance Motors. They have concentrated coils on the stator and a rotor with neither brushes nor windings in them. Because of the requirement of a power electronic circuit to act as a drive for the motor they are called Switched Reluctance Motors. This Switched Reluctance Motor they are one of the simplest electric motors.

Switched Reluctance Motors are very much suitable for applications which require high speed and high power. The stator phases which are independent to each other are excited by means of a DC supply separately. This excitation produces a variable reluctance for the rotor part, which results in the production of a variable torque. This developed torque provokes the rotor to rotate thereby bringing the rotor in alignment with the excited stator phase. Alignment of the rotor pole to the excited stator pole maximizes the inductance of the excited coil. Since torque is directly proportional to the square of the current, torque production is not dependent on the direction of the current. If the phases are sequentially excited, we can produce a continuously rotating torque.

Switched Reluctance motors have many advantages over conventional electric motors. A few of these are minimized copper loss due to the absence of windings in rotor, easy construction, efficiency compared to the motors in the same power ratings, very high speed application, high torque inertia ratio, faults in phases are tolerable, etc. they also have some disadvantages as requirement of rotor position sensors, torque ripples acoustic noise etc.

A 10/8 SRM and 10/6 SRM are commonly used combination (according to the stator and rotor poles). Here 10 denotes the number of stator poles and 8, 6 denotes the number of rotor poles. In this paper both SRM are designed in Ansys Maxwell and a comparative study is done on torque speed characteristics of the motors.

II. DESIGN OF SRM

The prime factors required for the design of an SRM are the power demanded for application and frame size. Determining the dimensions and variation in inductance due to rotor position are the prior steps in the design. Stator pole angle (βs) and rotor pole angle ((βr) for an efficient output [1 2] are the other important quantities to be determined.

The design steps of a SRM are as follows:

• Motor specs: n - speed in rpm, maximum permissible current I (A) and AC Supply Voltage (V)

• Output Torque: the shaft torque of an SSRM can be calculated using the power output and speed as follows:

$$Tshaft = Pout \frac{2\pi n}{60} [Nm] \text{------}(1)$$

• Dimensions: Outer radius of stator (Dso) is determined as follows

$$Dso = (Ld - 3)\times 2 [mm] \text{-------}(2)$$

L_d - Stack length (already defined in IEC Standards)

• Pole numbers: Number of Stator (Ns) and rotor pole (Nr) should be decided by the designer. They have various combinations.

Stator pole angle (βs) and Rotor pole angles (βr): Determination of stator and rotor pole angles should follow several constraints which are as follows:

Stator pole angle < Rotor pole angle.

The angle between adjacent rotor poles should be bigger than stator pole angle.

Effective torque region should be smaller than

Stator pole angle but bigger than the firing angle(ε).

• Air gap length (g): The most effective energy conversion can be achieved with the smallest air gap possible.

• The ratio of stack length (L_d) to Rotor outer radius (D_{ro}) should lie between 0.4-3.0.

• The ratio of Rotor outer radius (D_{ro}) to Stator outer radius (D_{so}) should be approximately around 0.5-0.55.

III. MATHEMATICAL MODEL

The equivalent circuit [3,4] of a switched reluctance motor is as shown below.
R_s – Phase winding resistance
L – Phase winding self-inductance

Phase voltage equation can be written as;

$$V(t) = Rs.i(t) + \frac{d\lambda(t)}{dt} \quad (3)$$

$$V(t) = Rs.i(t) + L(t).\frac{di(t)}{dt} \quad (4)$$

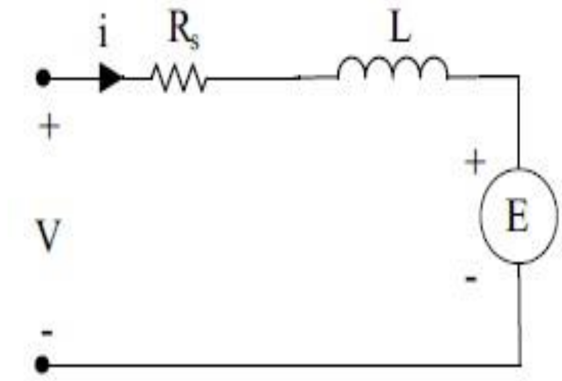

Fig. 1. Equivalent circuit of an SRM

IV. METHODOLOGY

The geometrical parameters of the motor are determined and applied to the Ansys Maxwell Software. The motor will have 10/8 Pole numbers, 3 phase, 0.5 mm aligned position airgap, 120 mm stator outer radius and 74 mm rotor outer radius, 30° stator pole angle. Also with the same dimensions a 12/8 Pole numbers are also designed in Ansys Maxwell. The basic 10/8 and 10/6 SRM is shown in Fig.2. and Fig.3.

The assignment of materials for each part is an important step in Ansys Maxwell. The stator and rotor are given steel1008 as material which is a standard material for the project in the software.The 2D model of the Switched reluctance motor with the above designed parameters are modelled in Ansys Maxwell.the machine was simuated and results obtained are furnished in the next section.

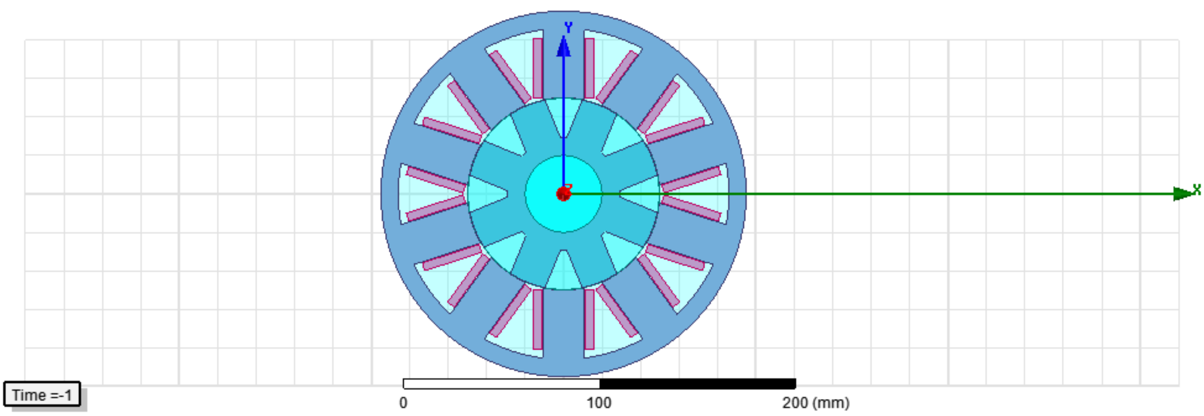

Fig.2. 10/8 pole SRM 2D model in Ansys Maxwell

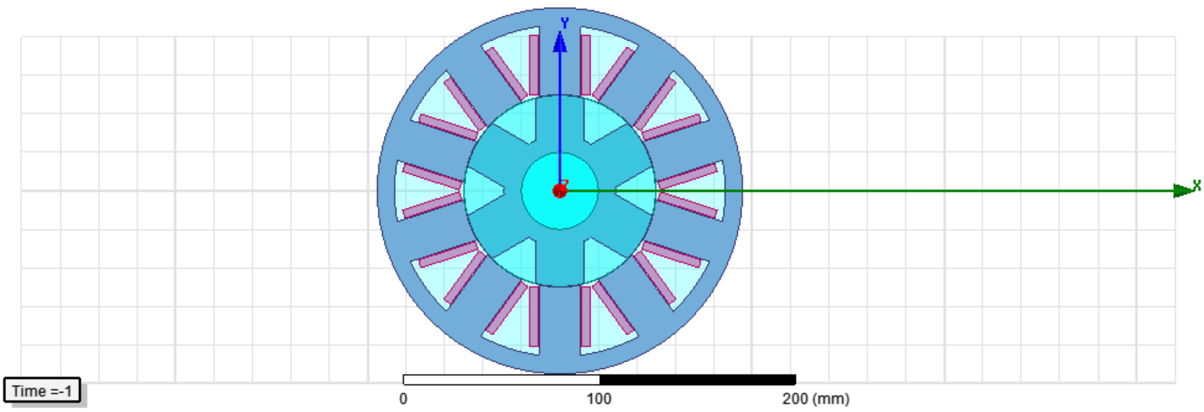

Fig. 3. 10/6 pole SRM 2D in Ansys Maxwell

V. SIMULATION AND RESULT

The modelled machine was simulated and results were obtained. The figure shown below is the result obtained for the 10/8 and 10/6 poles machine modelled in Maxwell.

Comparing the results shows that or the same value of input the torque produced by the 10/8 SRM is found to be more than the 10/6 pole SRM. The starting torque for the 10/8 SRM was found to be around 28Nm and that of the 10/6 SRM was found to be only near 12Nm for the same operating conditions. The speed of the same SRM i.e. 10/8 pole SRM was also found to be more than the 10/6 pole SRM. The full load operating speed of the 10/8 pole SRM was found to be around 1386 rpm and that of 10/6 pole SRM was found to be only around700rpm.

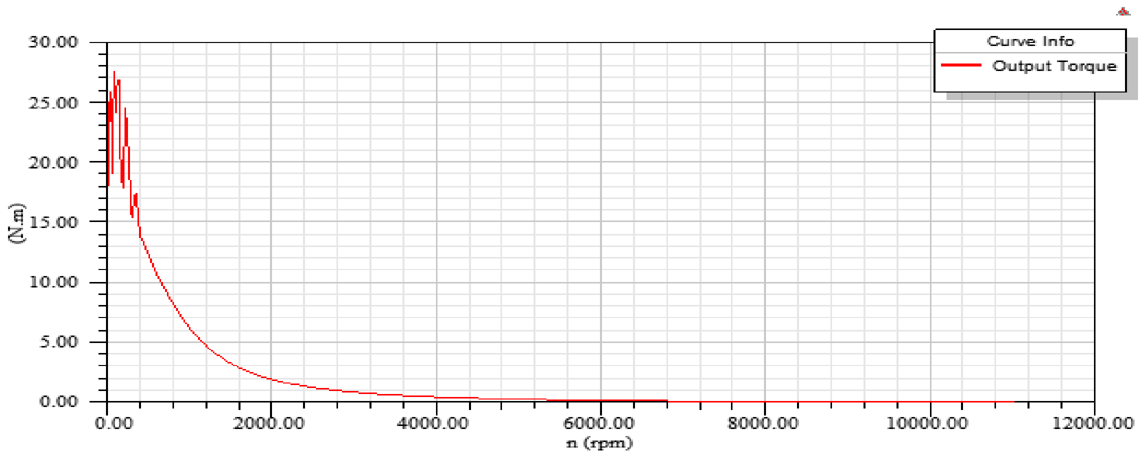

Fig. 1. Torque Vs Speed characteristics of 10/8 SRM

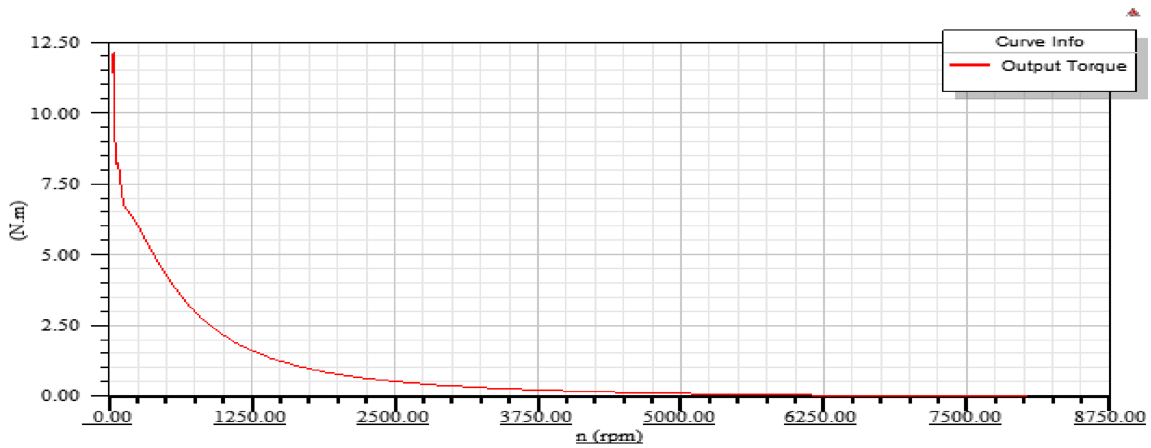

Fig. 2. Torque Vs Speed characteristics of 10/6 SRM

VI. CONCLUSION

The paper showed how speed variation can be obtained without the use of a variable speed drive for an SRM. Here speed and torque variation was attained by changing the number of rotor poles keeping the stator poles same. The variation in speed and torque for the designed motor was studied and results obtained is shown in this paper.

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