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Design of Rotor Holding Arrangement for Measurement of Static Characteristics of Switched Reluctance Motor

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ABSTRACT: This paper describes the development of rotor holding arrangement system for measurement of static characteristics of Switched Reluctance Motor. The rotor position measurement is essential for driving the Switched Reluctance Motor. Improper sensing of rotor position leads to creation of audible noise during the operation of Switched Reluctance Motor. The static and steady state characteristics measurement method such as flux linkage with proper rotor positions is described in this paper. A suitable MATLAB program is developed for plotting the static and steady state characteristics of SR Motor.

KEYWORDS*:* Switched Reluctance Motor, Static Characteristics, Co-energy, Torque, Dynamic Characteristics

I. INTRODUCTION

SWITCHED RELUCTANCE Motor (SRM) gaining popularity due to significant advantages over the classical motors such as Induction Motor, DC Motors etc. The SR Motor runs in a closed loop system and requires special attention on rotor position sensing system. The use of Switched Reluctance Motor is increased because of their simple structure, absence of rotor windings and absence of slip rings making more robust, relatively efficient, low maintenance, capable of running at very high speeds, high torque to mass ratio, high torque to volume ratio, simplicity of power converter, and low cost. More over varied performance can be obtained from these motors by appropriately varying the switching “ON” and “OFF” angle of phase current pulses and supply voltage. The vast control of machine is possible if one has knowledge of magnetisation and static torque characteristics with higher accuracy. These characteristics can be obtained by mechanical blocking of the rotor in appropriate position. The effort has been taken to design and develop a proper rotor holding arrangement at various rotor positions typically from 0^0 to 30^0.

II. LITERATURE SURVEY

The literature [1,2] describes the working, principle of operation of Switched Reluctance Motor. The paper for SRM by Semsudin Masic et.al.[3] , paper gives on overview of the procedures of determination of static characteristics (flux linkage, magnetic co energy and torque), steady state characteristics (current and torque) and dynamic characteristics (speed, current and torque) of switched reluctance motor. Peter N. Materu and R.krishnan in their paper [4] present an approach to the steady-state analysis of the drive including the effects of stator winding resistance, input filter parameters, and snubber circuits, which are often neglected. K.N. Shrinivas and R. Arumugam [5] propose the dynamic characterization by simulation of Switched Reluctance Motor (SRM) systems and the development of a package for the same. The modeling of electromagnetic, control and mechanical concerns is presented in this paper. For measurement of steady state or static characteristics, a special rotor holding arrangement is required hence efforts are directed to develop a procedure with specific design of rotor holding arrangement.

III. DESIGN OF ROTOR HOLDING DISC

The measurement of static characteristics such as flux-linkage, magnetic co-energy and torque is required for

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calculation of performance parameters of Switched Reluctance Motor. This can be achieved by generating a lookup tables for flux linkages, co-energy and torque with specific current *'i'*, and ranges of rotor positions such as from 0^0 to 30^0 for computation of these characteristics. A mechanical rotor locking arrangement is developed for electromagnetic testing of 4 KW Switched Reluctance Motor. For 8/6 SR Motor, a rotor disc is developed with , redial gap length of 28 mm, 120 rotor teeth, and outer diameter of 200 mm. As the torque of the SR motor is about 24 N-m therefore special locking system is developed with two screw fitting arrangement for measurement of electrical parameters. The numbers of stator pole and rotor pole for 4 KW SR Motor is 8 and 6 respectively. The shaft ring outer diameter is 122mm, the thickness of ring is 16 mm, and the radial gap length is 28.75 mm used respectively. The stator pole-pitch can be calculated by SPP = 2π/Ns where Ns is the numbers of stator poles, and total rotation will be 360 degree hence SPP = 360/8 = 45^0. Similarly, rotor pole pitch can be calculated as rotor pole pitch = 2π/Ns and hence 360/6 = 60^0. The Circumference at centre of ring is measured as 378mm. The rotor pole arc is calculated as 27^0. The gap between the poles is 33^0 and stator pole arc is measured as 21^0. The inductance zones calculated for angular repetition period of 60^0, rising inductance zone period of 21^0 and falling inductance zone of 21^0 is considered. The gap between rotor pole arc of 33^0 and gap between stator pole arcs of 24^0 is calculated. The torque of Switched Reluctance Motor is 25 Nm with starting torque of 38 Nm is considered. Therefore numbers of slots required on the disc is 120.

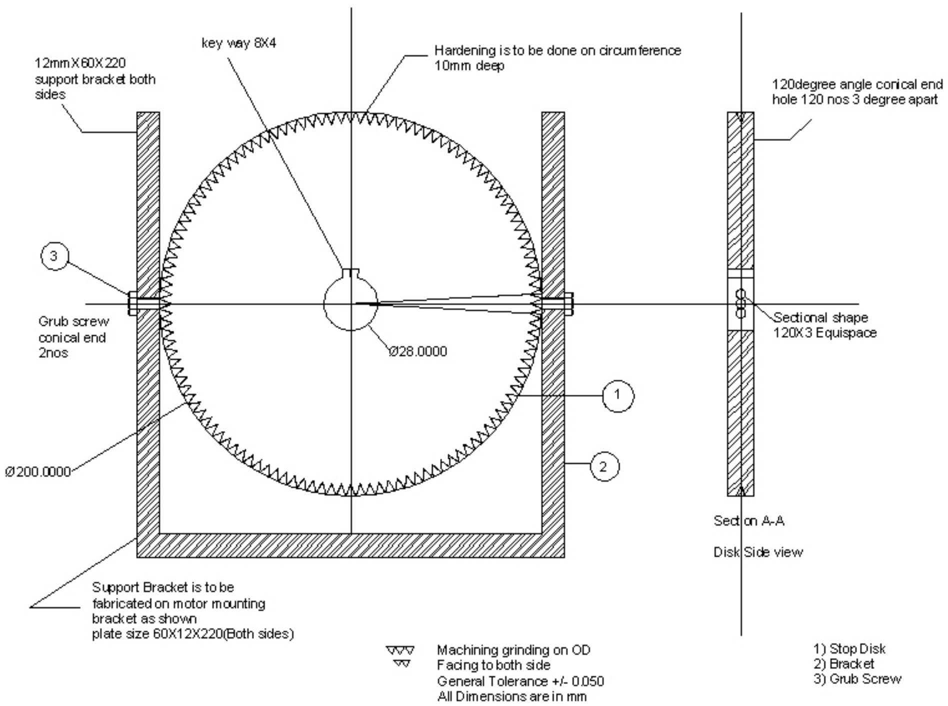

Fig. 1 Rotor Holding Disc

IV. TESTING WITH SR MOTOR

The shaft of the SR Motor is locked using specially developed locking arrangement. The instrumentation card is connected to terminals of SR Motor. The hall sensor is connected to current carrying winding. The IGBT Chopper module is connected in series with winding. Battery of 24 volts is connected to chopper module. The microcontroller card's output is connected to gate driver of IGBT. After switch is ON, the voltage and current readings are captured. The captured reading is then transferred to PC for processing. Matlab program developed for the same is initialized. The iterative readings are processed by the Matlab (using Simpson's 1/3 rule) which calculates the flux linkage. The readings are repeated for every 30 (From 00 to 300).

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V. EXPERIMENTAL RESULT

A simple but yet useful hardware and software is developed and effectively implemented for measurement and data recording. In the experimentation, the similar circuit is used for analysis of SRM performance characteristics. The power modules are developed for one phase of Switched Reluctance Motor. The instantaneous waveform of flux linkage is shown in figure (2)

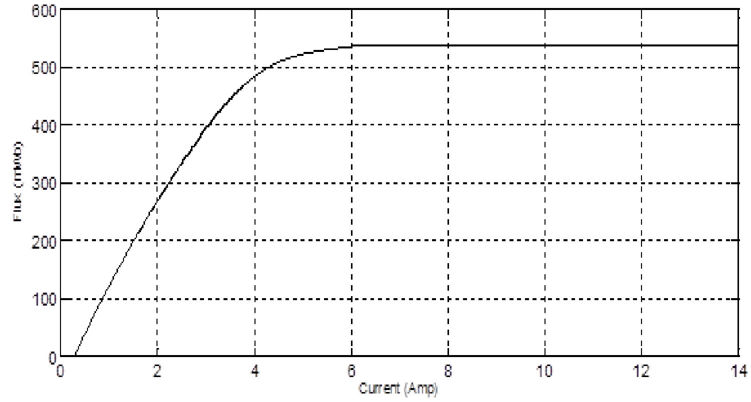

Fig.2 Flux-Linkage Characteristics of 4KW SR Motor at 0^0

The rotor is hold at 0^0 positions and a current is passed through the phase winding of Switched Reluctance Motor. The difference of voltage at terminals of phase is measured and integrated numerically using Simpson's 1/3 rule. MATLAB software is used for the same.

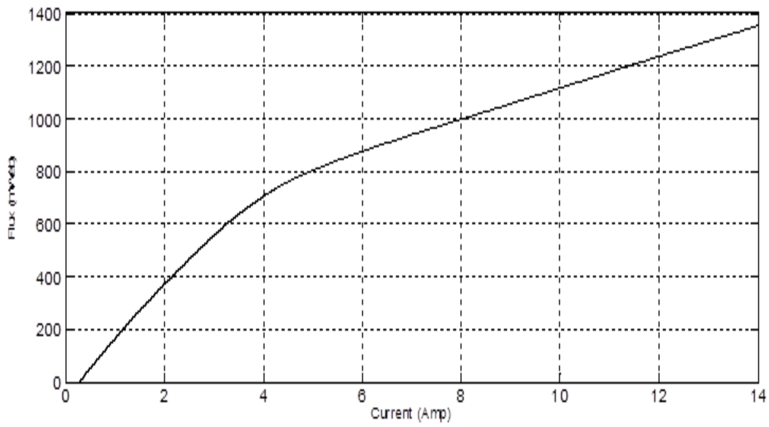

Fig. 3 Flux-Linkage Characteristics of 4KW SR Motor at 15^0

Further the rotor is fixed at 3^0 and corresponding readings are taken for plotting the flux linkages. The figure 3 shows the flux linkages characteristic at 15^0. At this position, the rotor and stator poles are partially overlap and at same time voltages difference readings are taken for plotting the flux linkages characteristic.

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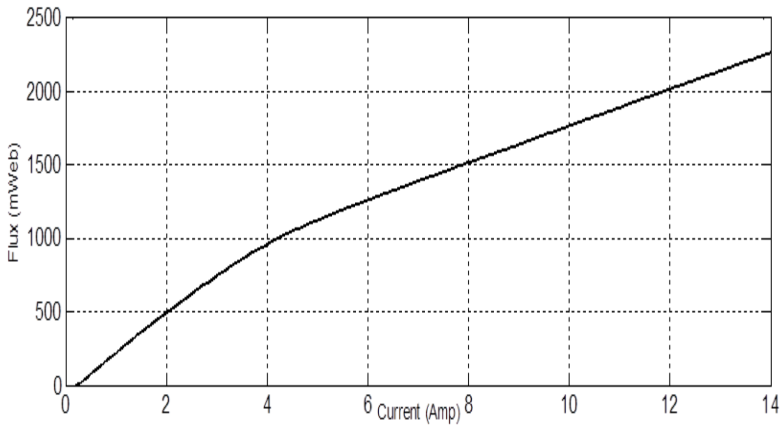

Fig. 4 Flux-Linkage Characteristics of 4KW SR Motor at 30^0

The figure (4) shows the flux linkages characteristic at 30^0. The rotor of Switched Reluctance Motor is fixed at 30^0 positions and the difference of voltage at phase of SR Motor is recorded. The same procedure is adopted to calculate flux linkages characteristic at 30^0 position of rotor. The stator and rotor are fully overlapped at this position and the inductance of the winding at one phase becomes maximum in its value.

V. CONCLUSION

A suitable rotor position holding arrangement is developed for plotting the steady state characteristics of Switched Reluctance Motor. A rotor holding mechanism for 30 Nm rated torque for 6/8 Switched Reluctance Motor is used and a software program using MATLAB is developed for analysis of static and steady state characteristics of Switched Reluctance Motor. The flux linkage and steady state torque measurement method is developed for SR Motor.

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