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Analysis of Energy Loses In a Converter of Switched Reluctance Machine

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***Abstract* — Switch Reluctance machines gives good progress under variable environment. The SRMS are run only by dc source and proper converter is needed. Therefore, for selection of proper converter it is necessary to determine the losses which occur in it. This research outlines the procedure and computation of the losses. The results are obtained on inclusion of experimental data.**

***Index Terms*— Conduction and Switching loss, Chopping current, Pulse Width Modulation and Energy Loss.**

I. INTRODUCTION

Switch Reluctance machines gives good progress under variable environment they have both variable speed and drives. The SRMs are run only by dc source and proper converter is needed. The motor is developed by quality of attraction of starter pole by the adjusting of rotor pole. SRs has different variety of converter topologies, there are some major points which are consider for choice the motor, like simplicity shows, and must be a reliable as well as choose for the switching sections for converter sections. The SRM used two types of switch operation like switch open or switch close and also has two kinds of losses occur in SRM switches they may be called switch or conduction loss. The good selection of machine based on chooses the proper switches and converters because they reduced the losses in electrical aspect as well as added some energy related to magnet. The switches have must be added by freewheeling diode because they provide the energy path [1] The electrical machine is based on design basically how to reduce the losses concerned on emission, this basically one of Switch Reluctance machine is a kind of stepper motor simply having a high life and runs by reluctance torque. In this torque is produced by the process of magnetic reluctance. The Demand of electric vehicle is too important For Famous cities because they overcome the carbon dioxide emission caused by fuel combustion [2] the performance of electric vehicle established by in terms of low price. They produced high power and having a good resistance. The Switch Reluctance machine is providing best path of permanent magnet motors. Switch Reluctance Machines were established by many long times to produce or make in the subject of power electronics and semiconductors. There are lots of advantages of SRMs are listed below (i) Low price (ii) High temperature (iii) High speed (iv) High reliability.

There are Lots of household and industrial of Switch Reluctance Machine like electric motors, generator starters and turbines so on [3]. The SR motor needs only one direction for different operating modes based on converter topologies involve different switching modes and devices related to current, voltage, capacitor storage and inductor storage through they develop converter circuit [4]. SR motors have a different speed drive which can easily overcome by different loads into stator phase because they have a simple construction to control having long efficiency related to speed range and they endure lots of fault due to this they make machine proper for variable drivers to control energy of different converters and provide a better environment for different magnetic circuit topologies made by according to choose the no of stator and rotor poles for continuous of different topologies by it is easy to make this dimensional mode [5].

The SR motors having a high density torque with a low price as well as high efficiency for selection of this motor they have considerable losses in switches as well as converters well the losses are mostly depends on the different operating modes, converter as well as variable topologies and different conditions of power semiconductors to overcome this losses we must be control the operating mode, rating of different power devices as well as topologies related to converters [6].

II. LITERATURE REVIEW

Ali Rezig et al. He proposed the concept of noise which occur in Switch reluctance Motors to overcome In- wheel by proposed the model of SRM-EV Simulink of commutation method through we can overcome if the voltage is increased randomly [8]. Duy-Minh Nguye et al. He proposed the concept of efficiency which related to global if this increased in SRMs and its converter we can overcome by Intermittent control (INC) and also overcome the stator vibration and its noise. Pedro Lobato et al. He proposed the concept of low speed of SRS based on scale mode application of different renewable energy sources and through to compare between variable magnetic topologies to control the speed range [9]. H. Torkaman et al proposed the concept of Faults which occur inside the SRMs through the numerical analysis, if the fault is so severe then directly affect the power loss more than overcome the power output [10]. Wei Peng et al. He proposed that he controlled the losses occur in switching side by varying the firing angle in concept of overcome the torque ripple as well as copper and losses occur in converter overcome through the MATLAB by Torque Sharing Function [11]. R. Kirshan et al. He proposed the concept of SRMs need only one direction of current for different operating modes by different converter topologies, and design the different shapes of converter used in SRM drive and also developed the circuit of converter through the lab in which experiment is performed to achieve different results of current, voltage and switching frequency [12]. Shubham R Patel et al. He proposed that the relationship between torque and speed with high reliability occurs in electric vehicle or SRMs to require the need of firstly traction motor to design the optimized the SRMs with geometric shape it seems to water cooled IM to control the speed range, high efficiency through this simulation to easy design the machine [13]. Hongha Wang et al. He works on bearing less SRMs in salient pole of rotor with high speed to loss the windage of different methods like computational fluid dynamics with different dimensions they also overcome the windage loss [14]. Nimit.k. Sheth et al. He proposed the calculate the core loss with accurate waveform flux in different section of motor to provide the more exact results of core loss based on triangular flux in stator pole by Finite Elements method to take the results more reliable [15].

III. METHODOLOGY

We have used to develop a hardware model of switch Reluctance machine to calculate the energy loss and made the model at MATLAB for calculating the chopping current and pulse width modulation in order to calculate the conduction loss as well as switching loss and finally found the analysis of results. This model because it has maximum voltage rating then MOSFET and it has lower conduction loss and switching loss.
This model is used for the calculation of losses that occurs in switches which is conduction loss and switching loss here we make some programs and coding that is done by easily calculation of this model. And also using some equation to calculate the energy loss, conduction loss and switching loss as well. This is the equation used in model then find out the losses.

$$E_{on} = \int_{t\,on}^{delta\ on} v_{t\,i_t}\, dt \tag{1}$$

$$E_{off} = \int_{ton}^{delta\ off} v_{t\,i_t}\, dt \tag{2}$$

$$P_{con} = q\,\frac{\omega}{\varphi}\int_0^{\frac{\varphi}{\omega}} v_{F\ i}\, dt + q\,\frac{\omega}{\varphi}\int_0^{\frac{\varphi}{\omega}} v_{sat\ i}\, dt \tag{3}$$

$$P_{sw} = q\,\frac{\omega}{\varphi}\left[\sum_1^{N_{on}} E_{on} + \sum_1^{N_{off}} E_{off}\right] \tag{4}$$

IV. SIMULATION MODEL

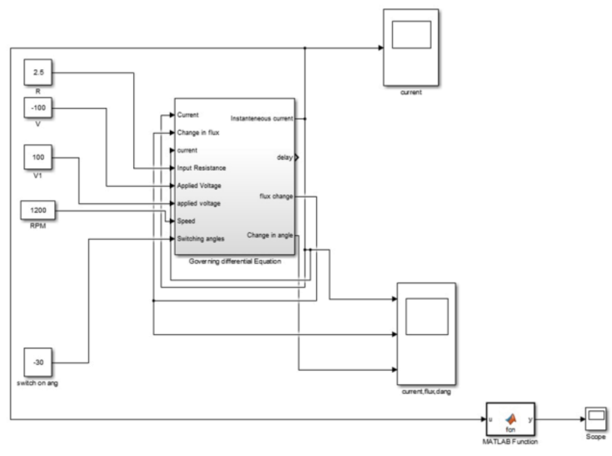

Fig.1 Proposed Simulink Model

Parameters considered in this study are listed below.
- Resistance = 3.0, [Ohms]
- Number of rotor poles = 6
- Number of phases = 4
- Supply voltage = 100 V
- Switch on angle = -30
- Switch off angle = -5
- Speed [rpm] = 1200 rpm
- Upper limit of phase current = 4.2 A
- Lower limit of phase current = 3.8 A

Firstly, we take the experimental data in order to calculate the switch off and switch on time in which condition is the current maximum, voltage maximum and where the power loss occur. In first case, we took the data at switch off condition at 2A in which the current gradually reaches to zero and the voltage occurs at a maximum then multiply both get the power loss shows in fig.2

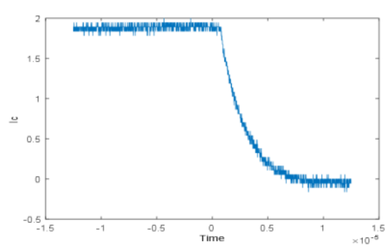

Fig.2.shows the waveform of a current.

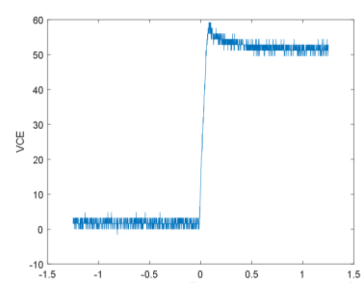

Fig.3.shows the waveform of a voltage.

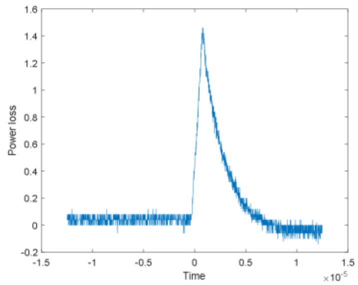

Fig.4.shows the waveform of a power loss.

In Second case, we took the data at switch on condition at 3A in which the current gradually reaches to maximum and the voltage occurs at minimum then multiply both get the power loss.

V. Simulation Results and Discussion

We took the data and find out the energy loss at different level of voltage on switch on and switch off condition then through coding in MATLAB get the three- dimensions of energy loss shows in Fig.5:

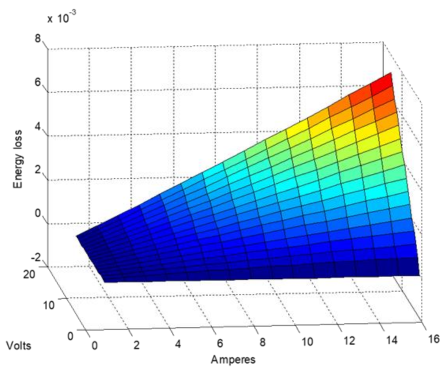

Fig.5.shows Energy waveform at switch-off condition

Through the MATLAB model, we calculate the current and voltage on chopping and pulse width modulation. In current chopping is a control technique tell us about how many times the current is being chopped. Basically, we don't know the frequency in this case but we select the upper and lower limit in which we want to current flow through this limit then if we put the small value of these limit then the losses occur more shown in Fig.6. The conduction loss and switching loss through this data and formula.

P_{scon} = 11.5990 W

P_{sw} = 1.7189 W

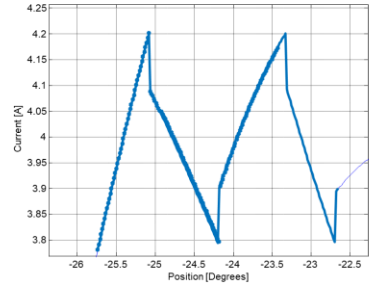

Fig.6.shows the upper and lower limit of a current waveform.

Here is a second case if we put large value then the losses will be minimum through this data and figure.

Resistance = 3.0, [Ohms]

Number of rotor poles = 6

Number of phases = 4

Supply voltage = 100 V

Switch on angle = -30

Switch off angle = -5

Speed = 1200 rpm

Upper limit of phase current = 4.0 A

Lower Limit of phase current=3.0 A

Pscon = 9.9530 W

Psw = 0.9943 W

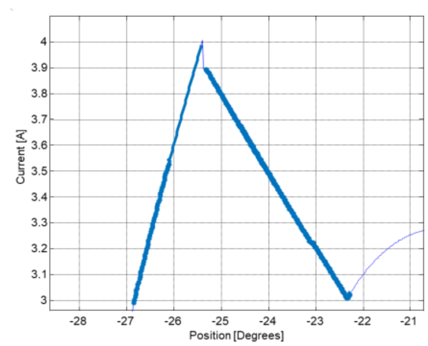

Fig.7.shows the upper and lower limit of a current waveform.

In pulse width modulation is a control technique through which the power is delivered by an electrical signal effectively chopped into discrete part. The main advantage of PWM is that lower power loss occurs at switches. It is depending upon the duty cycle and frequency. Through this method we can easily find out the conduction and switching losses occurs in switch. If we increase the duty cycle then the losses will be more. If we decrease the duty cycle the losses will be less.

Frequency = 1000 Hz

Duty cycle = 0.25

P_{sccon} = 6.8055

P_{sw} = 1.4259 W

Duty Cycle = 0.3

P_{scon} = 6.8957 W

P_{sw} = 1.4836 W

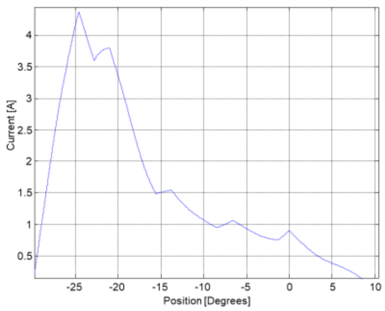

Fig.8.shows the waveform of a PWM

VI. CONCLUSION

This is verified from analysis of results that conduction losses of switches (IGBT) are increased due to increase in duty cycle (Conduction angle [switch on minus switch off]. Whereas, due to increase in frequency switch losses increase. We can easily find out the current chopping and pulse width modulation to calculate the losses and also know the energy losses at switch on and switch off condition.

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