# COMPARATIVE STUDY OF STATIC TORQUE CHARACTERISTIC OF SWITCHED RELUCTANCE MOTOR USING SPLINE AND LINEAR DATA INTERPOLATION TECHNIQUES

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**ABSTRACT**

**This Paper presents the comparative study of static torque characteristic of switched reluctance motor under spline and linear data interpolation technique. Simulation model for static torque characteristics of switched reluctance motor is presented using spline and linear data interpolation technique to achieve the best cure fit technique. The findings of this study are helpful to achieve the best simulation model, which helps to predict the performance of motor. Due to highly nonlinear curves and big data tables, it is very difficult to predict the performance of switched reluctance motor. Therefore it is always required to choose the suitable curve fit technique. The results obtained in this paper will help in accurate modeling of switched reluctance motor.**

***Keywords:*** *Static Torque Characteristics, MATLAB, Switched Reluctance Machine.*

## 1. INTRODUCTION

Switched reluctance motor has salient type construction i.e. salient poles on rotor and stator. Stator carries the main or field winding whereas rotor does not carries any winding. The semiconductor switches are connected in series with windings of the machine to form a phase. Switched reluctance machine is a multi-phase type machine. SR machine have different number of stator and rotor poles [1].

Due to salient type construction, switched reluctance machine has non-linear nature and magnetic saturation. In switched reluctance motor position dependent switching are key factor, which are achieved by proper electronic control [1]

Appropriate switching and conduction angles are necessary for proper operation of the switched reluctance motor. The switch gate signals with respect to the rotor position are applied at the gate-emitter terminal of the switching devices which are used in the converter of the motor.

The duration of gate signals for which the switching device remains in ON state is known as conduction angle [4].

In switched reluctance machine, rotation is due to magnetic pull of stator poles to rotor poles. Rotor poles rotate from maximum reluctance region to minimum reluctance region where as low region to high region for inductance [2].

Machine is said to be in aligned position when stator and rotor poles are complete overlapped and is said to be unaligned position when rotor and stator poles are not overlapping to each other [3].

Due to highly nonlinear nature of switched reluctance motor, it is very necessary to achieve the best curve fit technique. The literature presented in this paper is mainly concerned with impact of different curve fitting techniques on modeling of switched reluctance motor.

In paper [1] simulation model for sr motor is presented using a suitable curve fit. Polynomial curve fit technique is used for magnetic modelling of machine.

In paper [5] nonlinear behavior of SR motor is discussed. 2D bi cubic spline method is implemented to curve fit. Calculated and experimental results are than compared to measure the degree of accuracy.

Cubic spline curve fitting technique is implemented in paper [6,7]. It is shown that smooth curves are obtained using spline. Paper [8] shows the static torque characteristics of switched reluctance motor using appropriate curve fit. A bi-cubic spline interpolation method is implemented to achieve smooth curves in paper [10]. These curves show that phase flux linkage depends on the phase current at different rotor positions and are obtained experimentally.

Literature presented in [1], [5-10] highlight application of any one curve fitting technique when applied on flux linkage characteristics or static torque characteristics and

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have not applied the comparative study to achieve the best curve fit. This paper mainly focus on spline and linear data interpolation techniques when applied on static torque curve to achieve the best curve fit technique.

## 2. STATIC TORQUE CHARACTERISTICS

Static torque curves are function of rotor position [8]. Fig.[2.1] shows static torque curve from un aligned to aligned rotor position. Stator and rotor pair of poles are completely unaligned at -30 angle, as angle decreases poles starts to be aligned and 0 angle is the position when stator and rotor pair of poles are completely aligned. From Fig.[2.1] it can be seen that, near to -15 angle is the position when maximum torque is achieved and no or zero torque is produced when stator and rotor pair of poles are completely aligned i.e. at 0 angle position

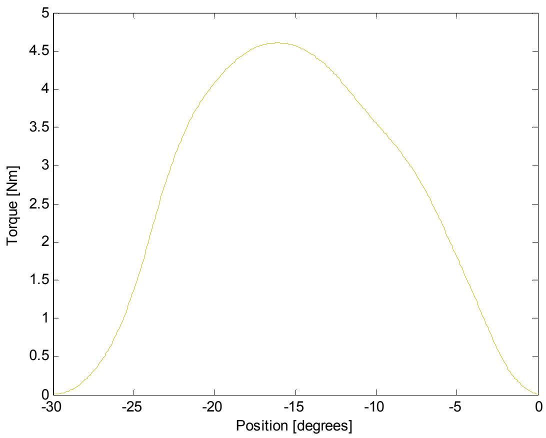


Figure: 2.1 Torque versus rotor position

The data of static torque is calculated once the data of co-energy is known using equation (1)

$$T(\theta, i) = \frac{\delta\omega(\theta, i)}{\delta\theta} \quad (1)$$

Where angle $\theta$ is rotor position and $i$ is current carrying coil. Co-energy is represented by $\omega$ which is the function of rotor position and coil current.

## 3. SIMULATION MODEL AND COMPARISION

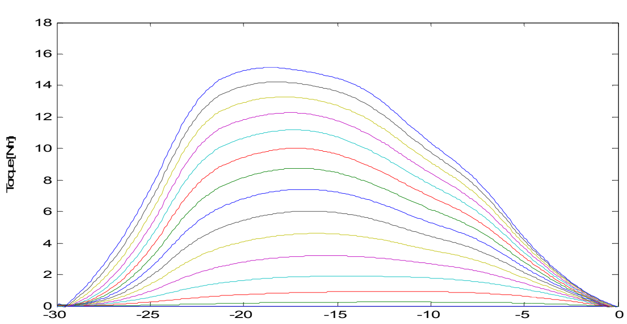


Figure 3.1 Torque versus rotor position [under spline]

Fig.[3.1] shows static torque characteristics which are function of rotor position. Curves are obtained under spline data interpolation technique. From above figure it can be seen that smooth curves are achieved under spline curve fit.

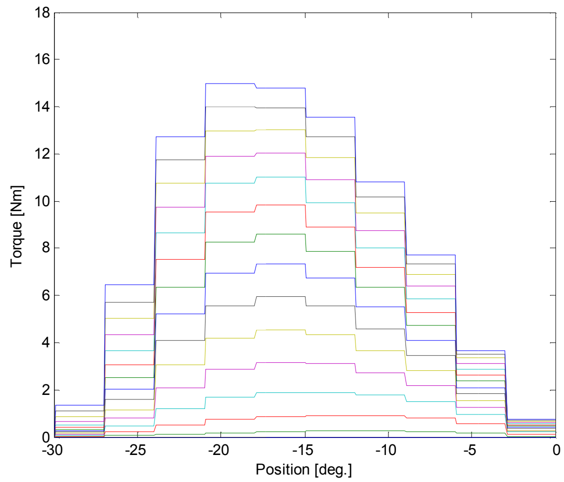


Figure 3.2 Torque versus rotor position [under linear]

Fig.[3.2] shows static torque curves under linear data interpolation technique. Fig.[3.2] has zero bulges and lot of errors. From fig.[3.1] and fig.[3.2] it is shown that static torque curves obtained under spline curve fit are smooth and has no errors whereas as the curves produce under linear are not smooth and has errors.

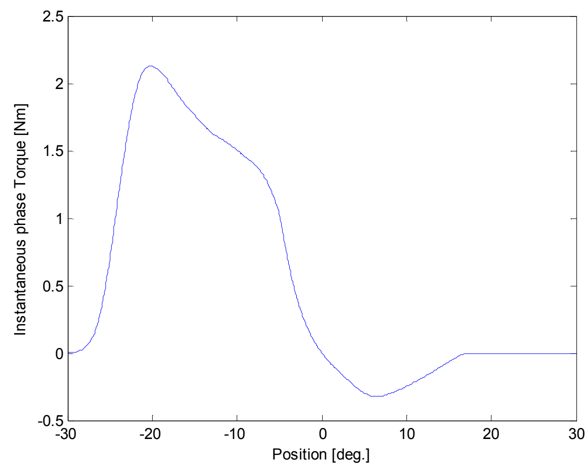


Figure 3.3 Instantaneous Phase Torque versus rotor position [under spline]

Fig 3.3 shows the instantaneous phase torque versus rotor position curve using cubic spline curve fit. From above fig it seems that as the rotor pair of poles changes its position from unaligned to aligned (-30 deg to 0 deg) the instantaneous value of torque increases sharply from -30 deg to -20 deg and starts decreasing from -20 deg to 0 deg. The curve is seems to be ok

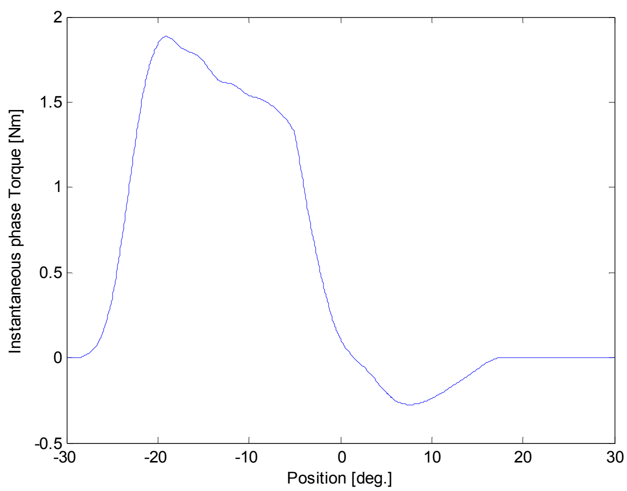


Figure 3.4 Instantaneous Phase Torque versus rotor position [under linear]

When comparing the Fig 3.4 (under spline) with the Fig 3.3 (under linear) it seems that the curve under linear interpolation has some distortion between -20° to -5° deg. From above fig it seems that as the rotor pair of poles changes its position from unaligned to aligned (-30 deg to 0 deg) the instantaneous value of torque increases sharply from -30 deg to -20 deg and starts decreasing from -20 deg to 0 deg. At -5 degree the switch turns off but torque does not decrease instantly because of current, which does not falls rapidly due to R L circuit.

## 4. CONCLUSION

Static torque characteristic that is the highly nonlinear function of torque and rotor position is achieved using curve fit techniques. Cubic spline data interpolation and linear data interpolation techniques are employed and compared to achieve the best curve fit. From above results it is concluded that smooth and regular curve is achieved using spline curve fit technique while the linear has errors. Results are helpful in performance prediction of machine.

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