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Analyzing Effects of Varying Circuit Parameter of an Asynchronous Motor on its Dynamic Characteristics using MATLAB-SIMULINK

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***Abstract* - A poly-phase Asynchronous Machine – for instance Induction Motor, finds application in several areas due to its reliability. Around 90 per cent of the electrical motors used in industry and domestic appliances are either three-phase induction motors or single-phase induction motors. This Paper addresses the impact of stator and rotor parameters of an Three-Phase Induction motor on its dynamic characteristics using a MATLAB / SIMULINK based model. During start-up and other severe transient operations induction motor draws large currents, produces voltage dips, oscillatory torques and can even generate harmonics in the power systems. A Comparison is done taking different measures i.e. low level, medium level, high level of Parameters, this analysis helps in determining the stator and rotor circuit resistance and inductances to reduce steady state time and minimize jerks during starting of the motor.**

Keywords – Asynchronous Motor, MATLAB, Modeling, SIMULINK, Speed- Torque Characteristics

I. INTRODUCTION

Induction machines undergo transients when voltage, current, and (or) speed undergo changes. Turning on or off the power grid may also lead to transients in induction motors. Reconnecting an induction machine after a short-lived power fault (zero current) is yet another transient. Bus switching for large power induction machines feeding urgent loads also qualifies as large deviation transients. Sudden short-circuits, at the terminals of large induction motors, leads to very large peak currents and torques. On the other hand, more and more induction motors are used in variable speed drives with fast electromagnetic and mechanical transients. Among these, the parameters such as Rotor Resistance, Rotor Inductance, Stator Inductance, Stator resistance of an asynchronous machine also plays a vital role there value may lead the motor fall out of the system.

Computer based modeling and simulation of the Induction machine has opened new horizons for the performance analysis. A good mathematical model can help in predicting the behavior of an induction machine under different operating conditions and in selecting the appropriate machine for specific applications. The Work carried by [3] depicted the rotor and stator current, speed, electromagnetic torque and torque speed characteristics of the motor taking different values of rotor and stator resistance and impedances. Their work has been further carried out in detail. The Objective of the Present Work is to compare the different levels divided in three sections i.e. low level, medium level, high level of Parameters such as stator resistance , stator inductance, rotor resistance, rotor inductance. This analysis helps in determining the approximate value of stator and rotor circuit resistance and inductances to reduce steady state time and minimize jerks during starting of the motor, as during start-up and other severe transient operations. For the proposed aim a Three Phase Test system has been Developed Using MATLAB/ SIMULINK and a conclusion has been drawn by comparing graphical characteristics of varying parameters of rotor and stator circuit resistance and Inductances.

II. OBSERVATIONS

A. Stator Inductance: Observations made at Three different Levels

At low stator Inductance it was observed that the transient lasted for a short period and a constant steady state torque, speed, current were achieved quickly whereas in analysis of medium level oscillations were observed the transient lasted for longer period. Also the time span for the steady state torque, speed, current were found to be increased. At Higher level of stator Inductance the transient lasted for much longer period, the start was a bit jerky. The Oscillations were found to be multiplied as compared to the medium level. Observation also showed that the current drawn from the supply was excessively high. The machine took long period to achieve steady state torque, current and speed.

B. Stator Resistance: Observation made at Three different Levels

When the stator resistance was assigned a low level value the Torque –speed characterictic showed a initial oscillations but the steady state was found to be achieved in a very short time, as the assigned value of the stator resistance was increased but maintained at medium level the machine started with

initial oscillations that had high intensity as compared to the one observed at low level of stator resistance. The transient lasted for a long period as the time to achieve steady state increased. At higher value of stator resistance it was observerd from the torque speed characteristic that the machine started with jerks as there was a increase in initial oscillations. This type of level may harm the Induction motor and the transient took very long time period to settle.

C. Rotor Inductance: Observation made at Three different Levels

A low level of Rotor Inductance gave transient that lasted for a short period Transient lasted for a short period and the steady state torque, speed, current were achieved quickly whereas on analysis of medium level, initial oscillations were observed . The transient for the medium level of Inductance lasted for a long period also the time span for the steady state torque, speed, current were found to be increased. At Higher level of stator Inductance the Transient lasted for a very long period. The machine took long period to achieve steady state torque, current and speed. The start was a bit jerky, initial Oscillations were found to be multiplied as compared to the medium level. Observation also showed that the current drawn from the supply was excessively high.

D. Rotor Resistance: Observations made at Three different Levels

In this the observation showed that a small variation of rotor resistance at low level had a little impact on its dynamic performance. Although it was noticed as the Rotor resistance level increased i.e. from medium to higher level it was observed that the initial oscillations of the motor reduced in numbers hence the motor started with lesser jerks.

III. SIMULINK OUTPUTS

The Simulink test comprised of Twelve stages :

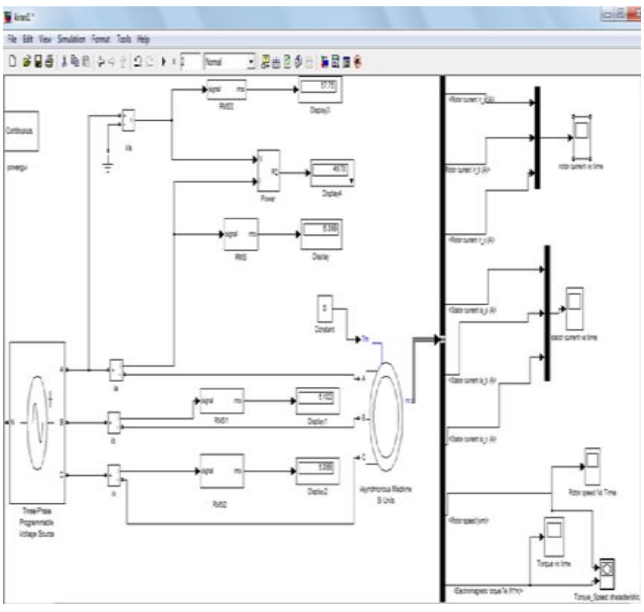

Fig 1 Asynchronous Motor Test System

1. *Result of simulation- Low Stator Inductane(`~ 0.5mH)*

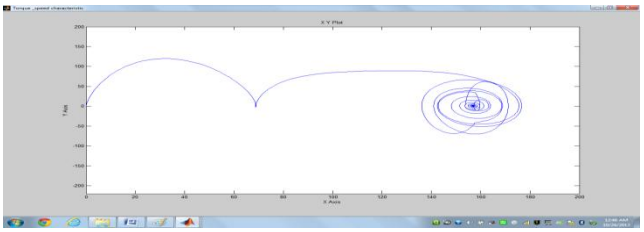

Figure 1.1: Torque Speed characteristic for low stator Inductance

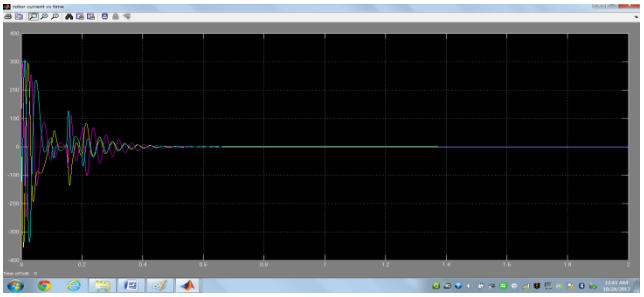

Figure 1.2: Rotor Current Vs Time graph for low stator inductance

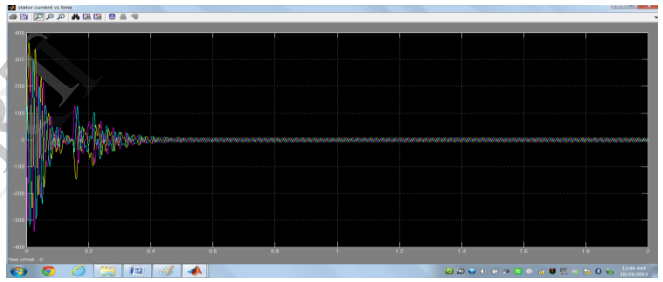

Figure 1.3: Stator Current Vs time graph for low stator Inductance

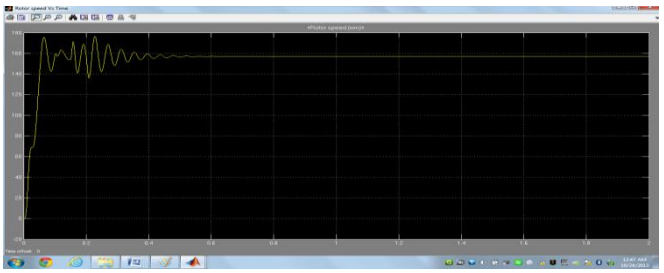

Figure 1.4: Rotor Speed Vs Time graph for low stator Inductance

2. *Result of Simulation – Medium Stator Inductance (~ 0.7mH)*

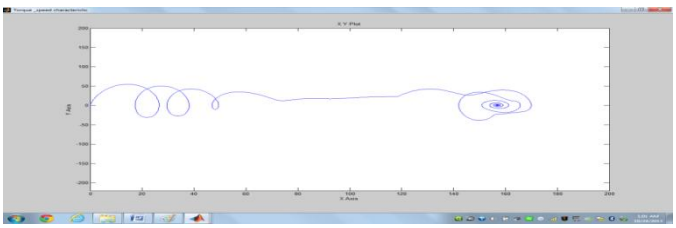

Figure 2.1: Torque Speed Characteristic for Medium Stator Inductance

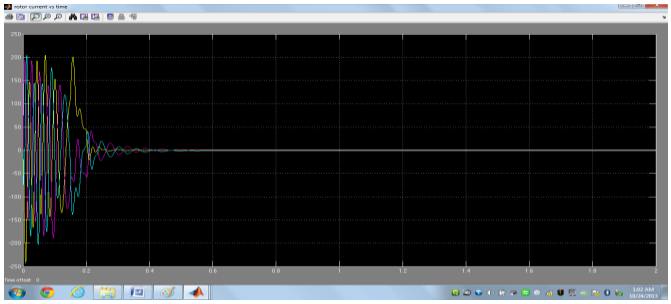

Figure 2.2: rotor current vs Time graph for Medium stator Inductance

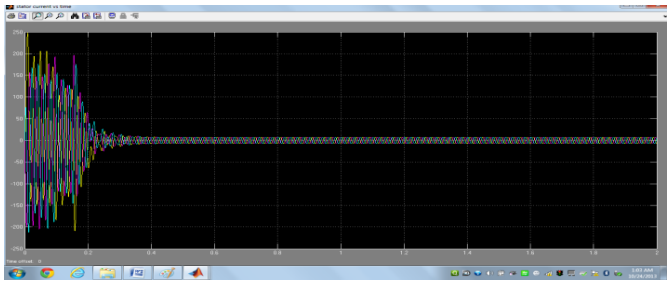

Figure 2.3 : Stator current Vs time graph for Medium Stator Inductanc

Figure 2.4: Rotor Speed vs time graph for medium stator Inductance

3 *Result of Simulation – High Stator Inductance (~ 2mH)*

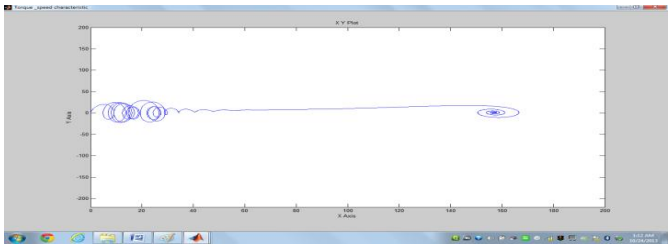

Figure 3.1 : Torque Speed characteristic for High stator Inductance

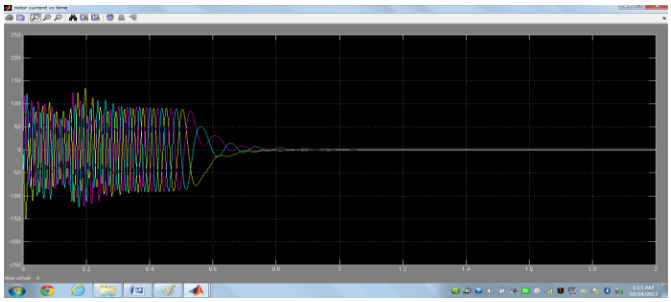

Figure 3.2: Rotor current vs time graph for High Stator Inductance

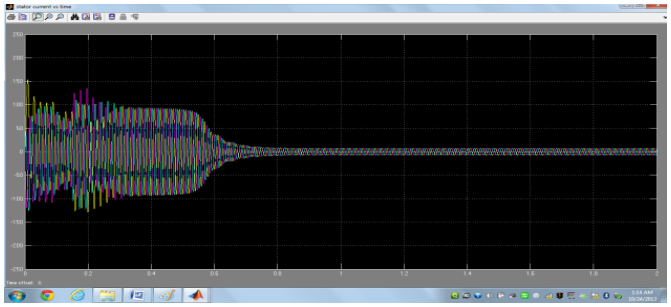

Figure 3.3 : Stator current Vs Time graph for High Stator Inductance

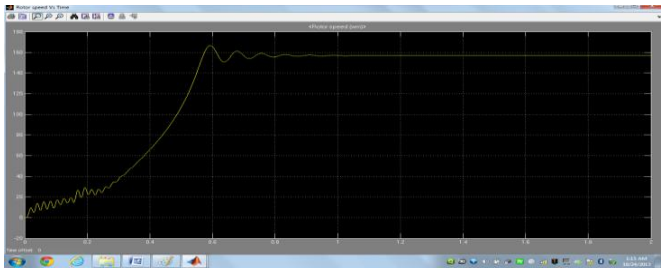

Figure 3.4: Rotor Speed Vs time graph for High Stator Inductance

4.Result of Simulation - Low Stator Resistance (~ 0.09 ohms)

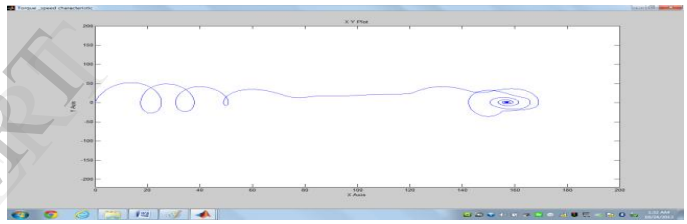

Figure 4.1 : Torque Speed characteristic for low stator Resisitanc

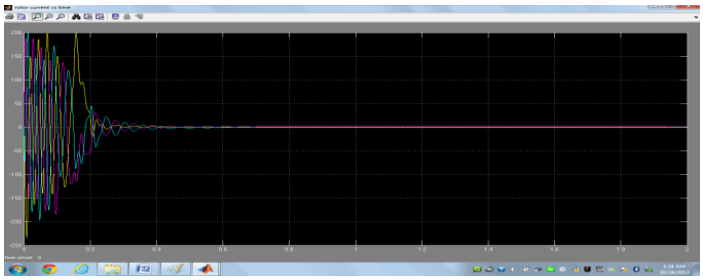

Figure 4.2 : Rotor Current Vs Time graph for low stator Resistance

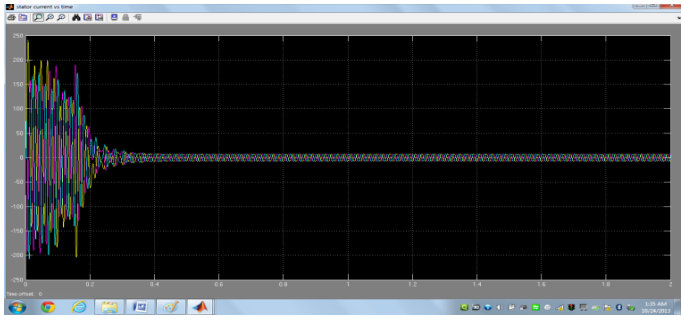

Figure 4.3 : Stator Current Vs Time graph for low stator resistance

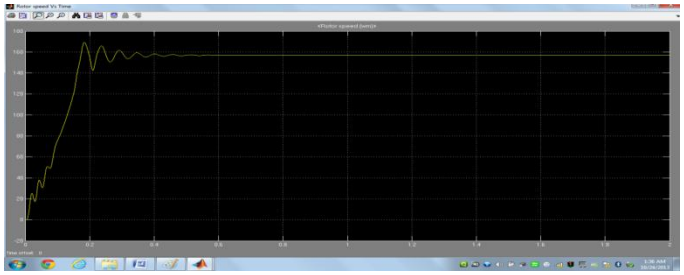

Figure 4.4 : Rotor Speed Vs Time graph for low stator resistance

5. Result of Simulation – Medium Stator Resistance (~ 0.16 ohms)

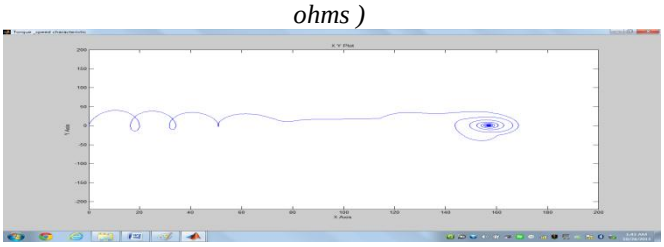

Figure 5.1 : Torque Speed Characteristic for medium stator Resistance

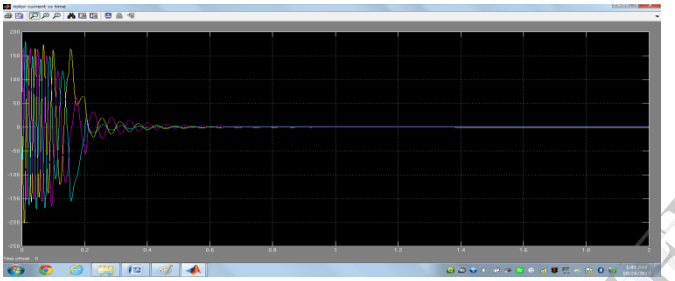

Figure 5.2 : Rotor Current Vs Time graph for medium stator Resistance

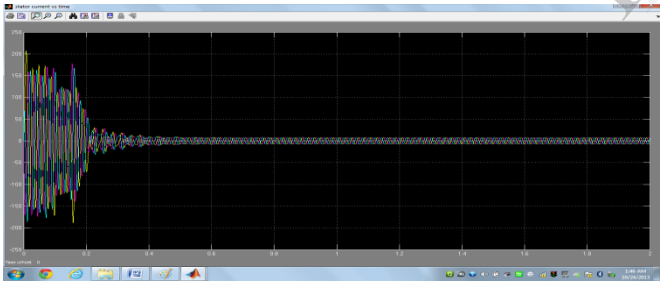

Figure 5.3: Stator Current Vs time graph for Medium stator Resistance

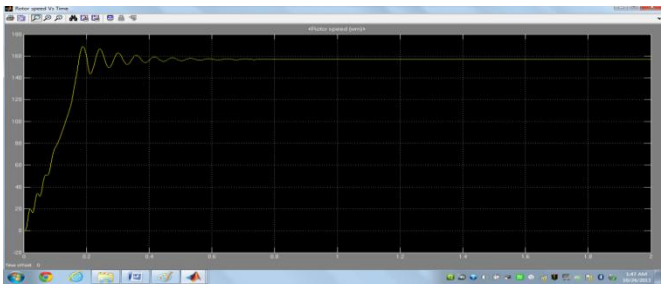

Figure 5.4: Rotor speed Vs Time graph for medium stator Resista

6 Result of Simulation – High Stator Resistance (~ 0.8 Ohms)

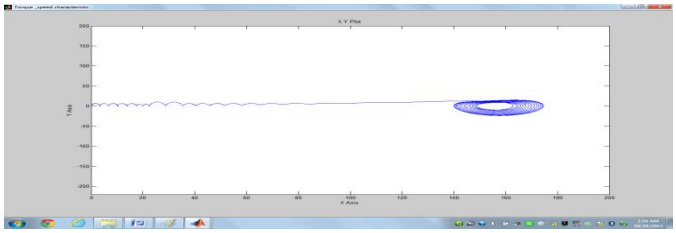

Figure 6.1: Torque Speed characteristic for High stator Resistance

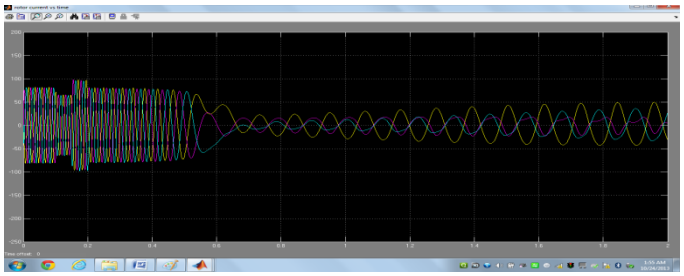

Figure 6.2: Rotor Current Vs Time graph for High Stator resistance

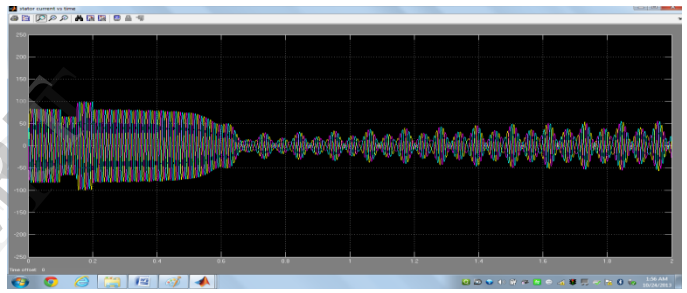

Figure 6.3: Stator Current Vs Time graph for High Stator Resistance

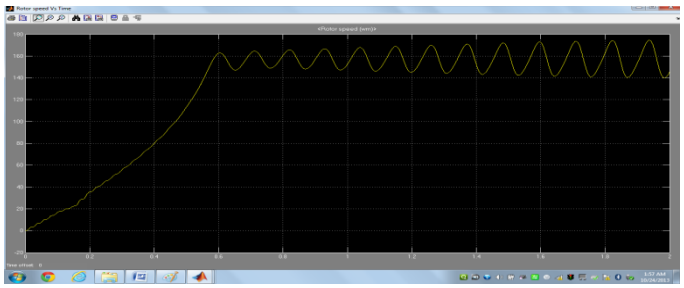

Figure 6.4: Rotor Speed Vs Time graph for High stator Resistance

7 Result of Simulation – Low Rotor Inductance (~ 0.07mH)

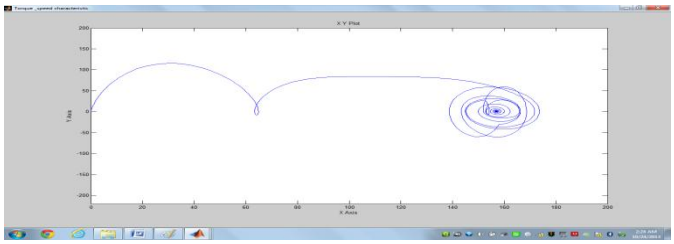

Figure 7.1 : Torque Vs Speed Characteristic for low rotor Inductance

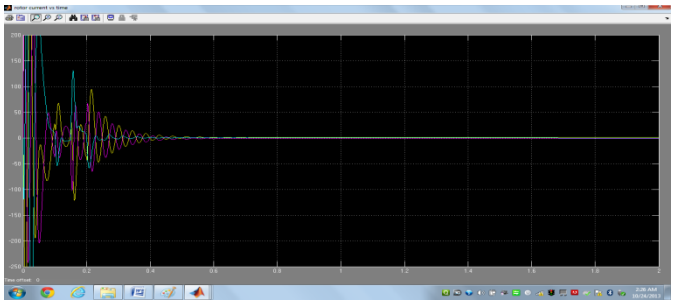

Figure 7.2 : Rotor current Vs Time graph for low rotor Inductance

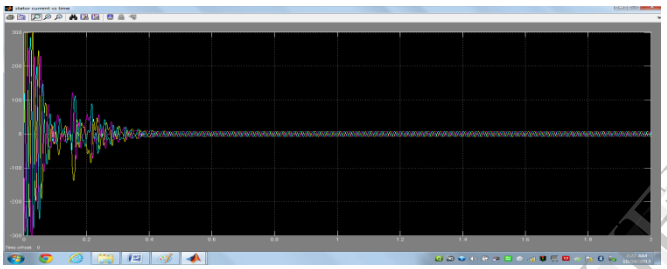

Figure 7.3 : Stator current vs time Graph for low rotor Inductance

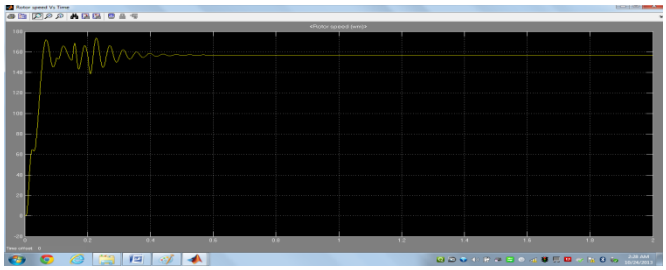

Figure 7.4 : Rotor Speed Vs Time graph for low rotor Resistance

8 Result of Simulation – Medium Rotor Inductance (~0.5 mH)

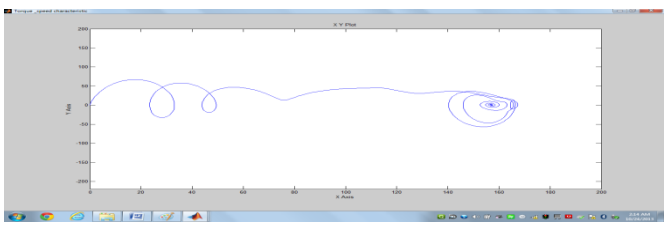

Figure 8.1 : Torque Vs Speed Characteristic for Medium rotor Inductance

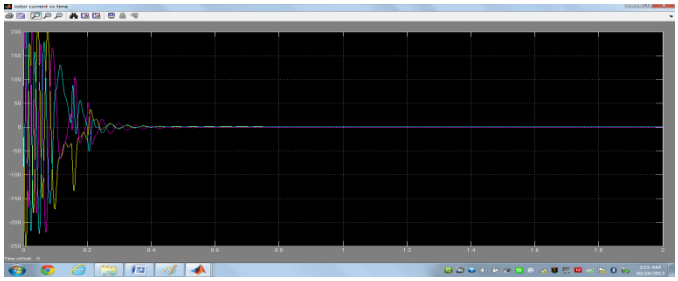

Figure 8.2: Rotor Current Vs Time graph for Medium rotor Inductance

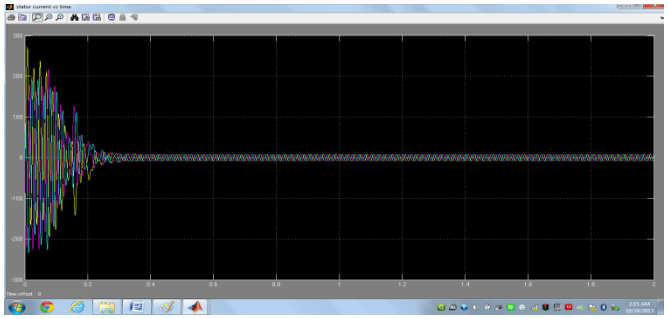

Figure 8.3 : stator Current Vs Time graph for Medium Rotor Inducatance

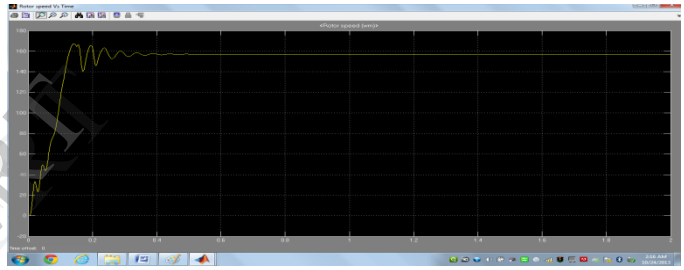

Figure 8.4 : Rotor Speed Vs time graph for medium rotor Inductance

9. Result of Simulation – High Rotor Inductance (~2 mH)

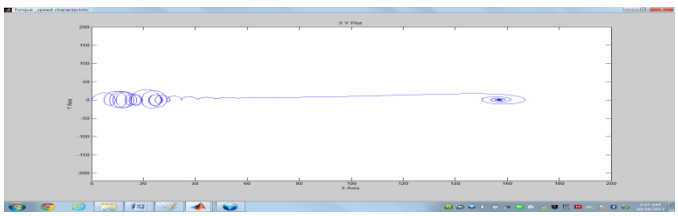

Figure 9.1: Torque Vs Speed Characteristic for High rotor Inductance

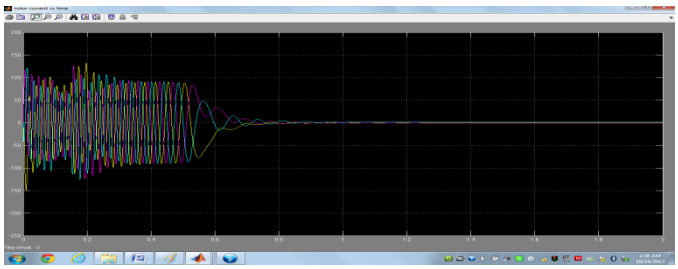

Figure 9.2 : Rotor current Vs Time graph for High rotor Inductance

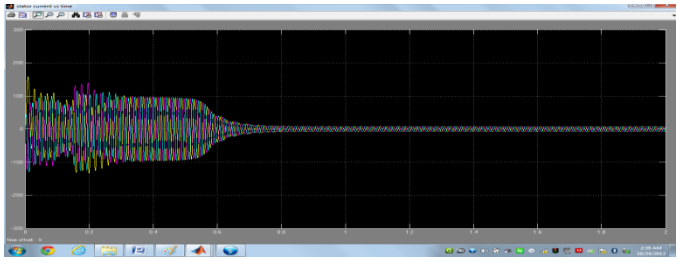

Figure 9.3: Stator current Vs Time graph for high rotor Inductance

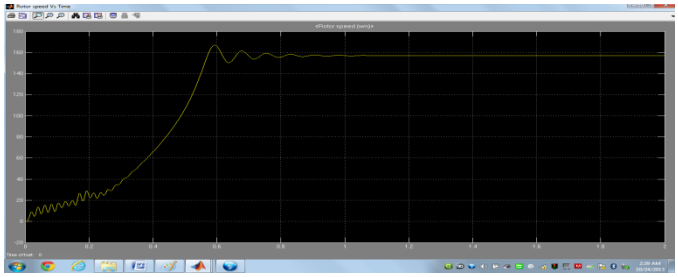

Figure 9.4: Rotor Speed Vs Time graph for high Rotor Inductanc

10 Result of Simulation – Low Rotor Resistance (0.1 ohms)

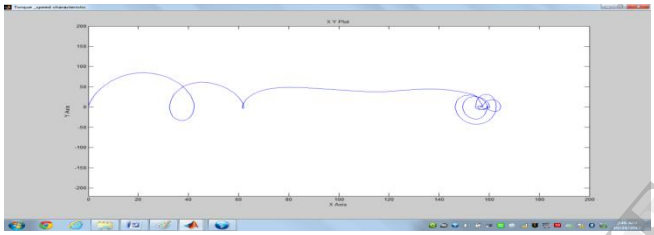

Figure 10.1 : Torque Vs Speed characteristic for Low Rotor Resistance

Figure 10.2: Rotor Current Vs Time graph for low Rotor Resistance

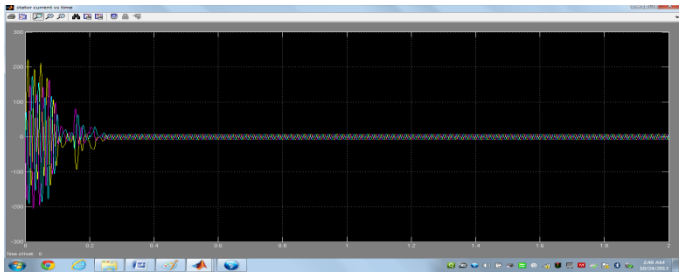

Figure 10.3: Stator current Vs Time graph for low Rotor Resistance.

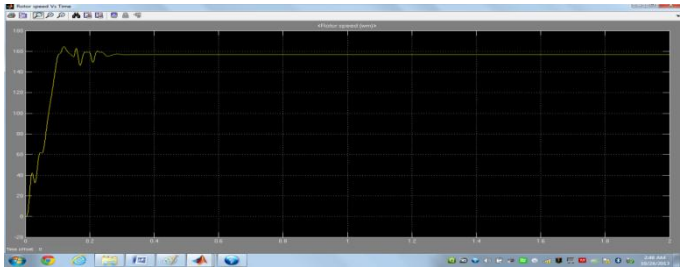

Figure 10.4 : Rotor Speed vs Time Graph for low Rotor resistance

11 Result of Simulation – Medium Rotor Resistance (~0.3 Ohms)

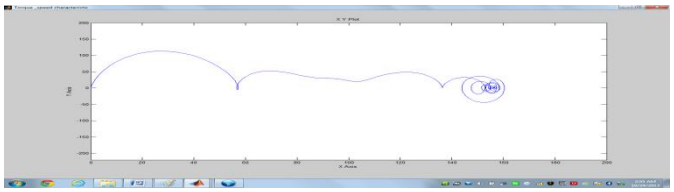

Figure 11.1: Torque Speed Characteristic for Medium Rotor Resistance

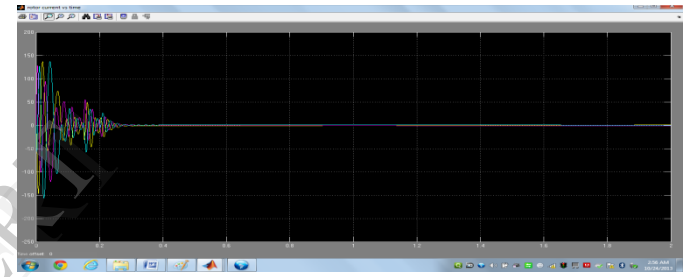

Figure 11.2: Rotor current Vs Time graph for Medium Rotor Resistance

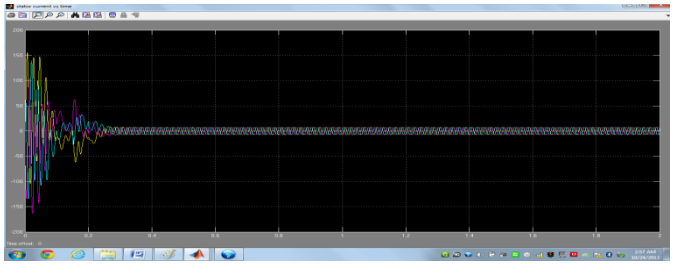

Figure 11.3: Stator current Vs Time graph for Medium Rotor Resistance

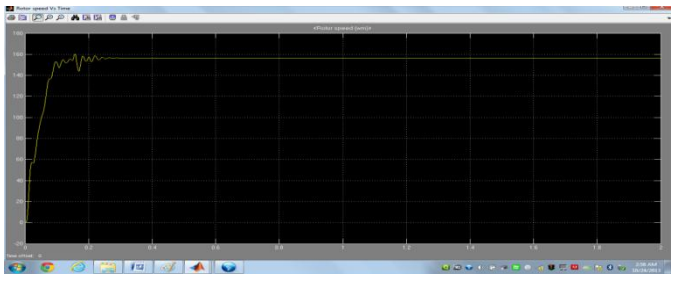

Figure 11.4: rotor speed Vs Time Graph for Medium rotor Resistance

12 Result of Simulation – High Rotor Resistance (~0.5 ohms)

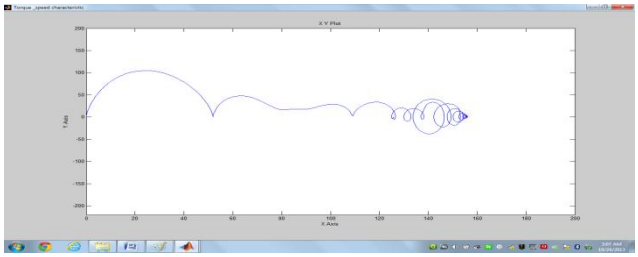

Figure 12.1 : Torque Vs Speed characteristic for High Rotor Resistance

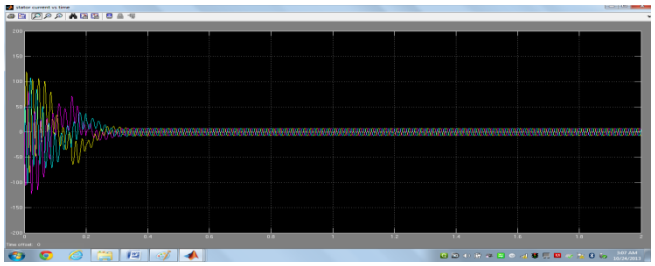

Figure 12.2 : Rotor current Vs Time graph for High Rotor Resistance

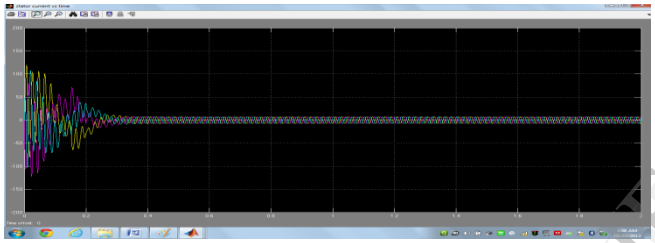

Figure 12.3 : Stator Current Vs Time graph for High Rotor Resistance

Figure 12.4 : Rotor Speed Vs Time graph for High rotor resistance

IV. CONCLUSION

A Comparison was done taking different measures i.e. low level, medium level, high level of Parameters such as Stator Inductance, Stator Resistance, Rotor Inductance, Rotor Resistance the results showed that on increasing the motor inductance (either rotor or stator), the transients lasted for longer period the machine took longer time to achieve its steady state speed, current and torque. So it is adviced that the Inductance value (Stator as well as Rotor) should be maintained low. On the other hand increasing the rotor resistance, had no effect on the steady state time on the machine, it was observed the fluctuations in the transient period were reduced. Also the maximum torque occurred at lower speed. Hence it can be concluded that by increasing the rotor resistance showed a little impact on the dynamic characteristic of the Asynchronous motor. Like wise on increasing the stator resistance, the steady state time increased as well as the machine started with more jerks. Thus it is advised that the stator resistance must be kept as low as possible.

V. FUTURE SCOPE

The following test were performed regarding the Rotor Reference frame, the similar can be tested for the Stationary Reference frame and the Synchronous Reference Frame.
The Practical aspects of the give test can be Compared with those of the theoretical results to check the feasibility of the given concept.

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