

Performance Analysis of Induction Motor using Ansys



N.Susmitha, T.Revanth, S.Anvesh Reddy, P.Sobha Rani

Abstract: Squirrel cage Induction motors are useful in constant speed and variable frequency drives applications because they are self starting and have high overload capacity. Though they are self starting, their design limits corresponding to torque should be large to meet the actual load conditions. To get optimum performance of motor, it needs unique design characteristics. Design of machines is a time consuming process. Proper methods are required for designing. ANSYS software is being used in recent times for designing electrical machines. In this paper, RMxpert tool box is used to design induction motor and its performance is analyzed using ANSYS Maxwell. In RMxpert, the induction motor's geometric model is designed and analyzed. In this model the machine rating is of 1100W with a rated speed of 1450 rpm and with rated voltage of 330V. With the help of this design, squirrel cage induction motor performance in terms of torque, power, efficiency, voltage and current can be analyzed for any rating.

Keywords : ANSYS, Induction motor (IM), Performance, Squirrel cage induction motor (SCIM).

I. INTRODUCTION

High efficiency and performance induction motor drives are needed to meet the industrial needs of industries such as paper mills, machine tools, servos and transportation. This is because of their advantages namely easy construction, ruggedness, less maintenance and economy. It has provided one of the biggest advancements in the fields of engineering and technology since electricity was invented. Generally, this motor has been used for constant speed appliances. With development of vector field control methods, it is possible to operate induction motor similar to a separately excited dc motor [1].

ANSYS Maxwell is simulation software which can be used for design and performance analysis of semi conductors, electric machines, transformers and other electromagnetic devices [2].

ANSYS RMxpert is useful to calculate performance of machines. With Maxwell and RMxpert it is possible to create a customized machine design.

ANSYS electrical machine design provides a complete virtual prototype laboratory for the design and development of machine tools. This software provides five tools for electrical machine design: RMxpert, Maxwell 2D/3D, Simplorer, Optimetrics and ANSYS mechanical/CFD. In this paper RMxpert and Maxwell 2D are utilized for machine design.

Figure1 represents the design procedure in ANSYS.

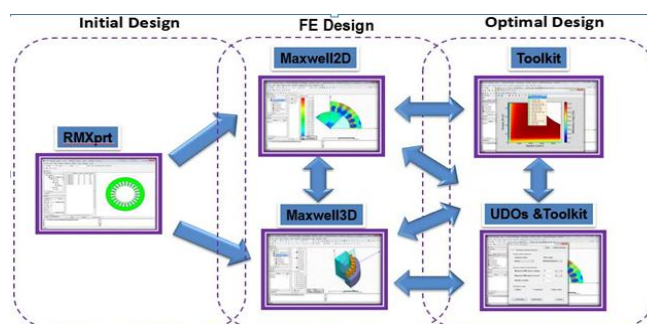


Fig 1: Process of machine design in ANSYS

Magnetic flux density parameters of SCIM were analyzed using finite element method [3]. The electromagnetic phenomena of 3-phase induction motor using Maxwell was discussed in [4]. In this paper both RMxpert and Maxwell are used to analyze the performance of 3-phase SCIM.

II. 3-PHASE INDUCTION MOTOR

SCIMs are mostly used in industries and home applications. The stator of the three-phase IM consists of number of slots to create a 3-phase winding circuit. Once the primary winding or the stator is given a source of 3- phase AC, it creates a spinning magnetic field that rotates at the synchronous velocity. The difference between the stator and rotor velocities is named as slip. The torque of induction motor is proportional to rotor current, stator pole flux and rotor power factor. The torque slip curve for an induction motor provides the details about the torque variance with the slip. The slip variance can be achieved with the speed variation. When speed varies the slip will also vary and the torque corresponding to that speed will differ as well. The performance of SCIM in steady state can be analyzed in terms of starting torque, maximum torque, current, power factor and efficiency. During design process, special attention is required for the induction motors.

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A primary consideration for induction motor designer is the design of motor with high starting torque, better efficiency and power factor. There are many design components like stator core diameter, core length, air gap length, stator and rotor slot shape and many others parameters which are considered during design process to achieve the desired performance.

III. INDUCTION MOTOR MACHINE SPECIFICATIONS

The specifications of induction motor are presented in Table I. Table II represents stator specifications of induction motor. Figure 2 represents induction motor stator slot specifications.

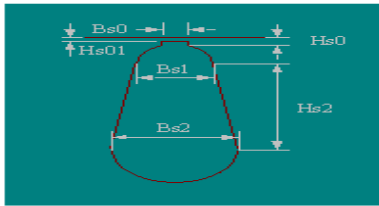


Fig2: induction motor stator slot specifications

Table I: Specifications of Induction motor

NAME	VALUE
Machine type	Three Phase Induction motor
No. of poles	2
Stray Loss Factor	0.01
Frictional Loss	0
Windage Loss	0
Reference Speed(rpm)	1450

Table II: Induction motor stator specifications

NAME	VALUE
Outer diameter(mm)	140
Inner diameter(mm)	78
Length(mm)	250
Stacking Factor	0.95
Steel Type	D21_50
No.of slots	36
Slot type	1
Lamination sectors	3
Press Board Thickness(mm)	0
Skew Width	0

Table III shows rotor specifications of induction motor.

Table III: induction motor rotor specifications

Parameter	VALUE
Stacking Factor	0.95
No.of Slots	28
Slot type	1
Outer Diameter(mm)	76
Inner Diameter(mm)	32
Length(mm)	250
Steel Type	D21_50
Skew Width	1

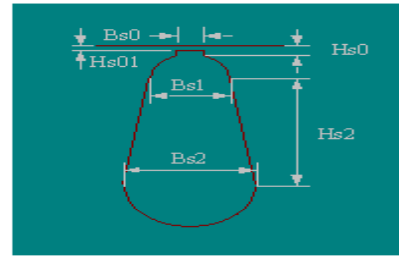


Fig 3: Induction motor rotor slot specifications
TableIV and TableV represents rotor slot and rotor winding specifications respectively.

Table IV: Induction motor rotor slot specifications

Parameter	VALUE(mm)
Hs0	2
Hs01	2
Hs2	8
Bs0	3
Bs1	4
Bs2	5

Table V:Induction motor rotor winding specifications

NAME	VALUE
Bar Conductor Type	Copper
End Length(mm)	5
End Ring Width(mm)	5
End Ring Height(mm)	5
End Ring Conductor Type	Copper

IV. CONSTRUCTION OF MACHINE IN RMXPRT

The following procedure is followed for constructing induction motor in ANSYS RMxpRT:

1. First open the ANSYSlectronics desktop.
2. Go to file select open examples.
3. In open examples select induction motor and rename the file in new project
4. A complete geometrical built in model of induction motor will appear on the screen
5. Then go to project manager window and select stator
6. Assign stator poles as and assign its parameters like stator outer diameter and stator inner diameter. Also assign the material for the stator.

7. Similarly for the rotor assign poles and repeat the same procedure in step above.
8. Assign the boundaries and excitations of the machine in the project manager window.
9. After run the machine and analyze the output waveforms in Rmxprt.

The induction motor machine model is simulated in RMXprt (Rotating Machine Model) and represented in figures 4,5,6 and 7.

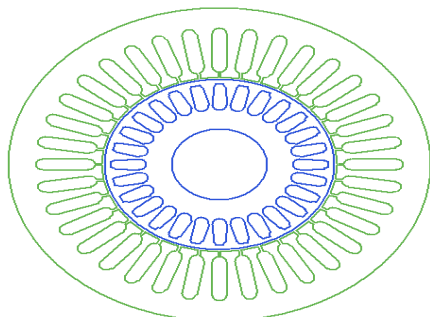


Fig 4: Induction motor design in Rmxprt

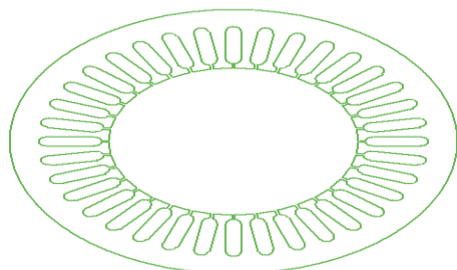


Fig 5: Stator of induction motor

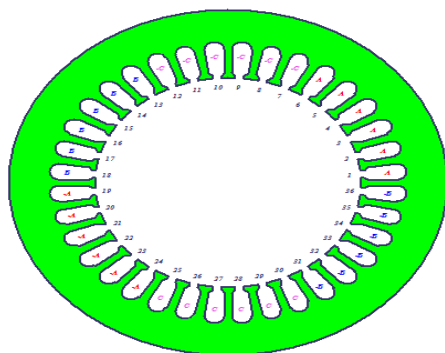


Fig 6: windings of stator

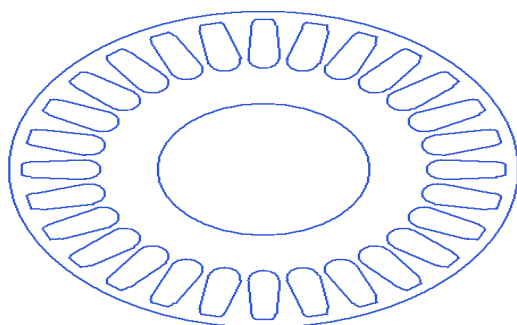


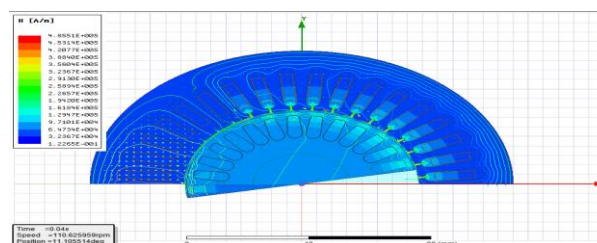
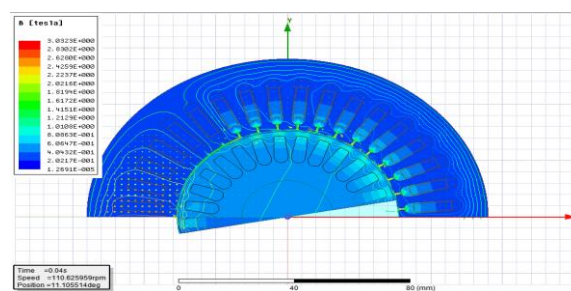
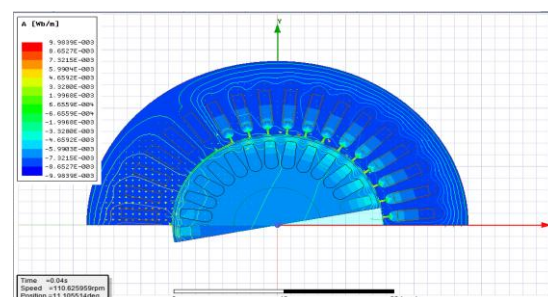
Fig 7: Construction of rotor

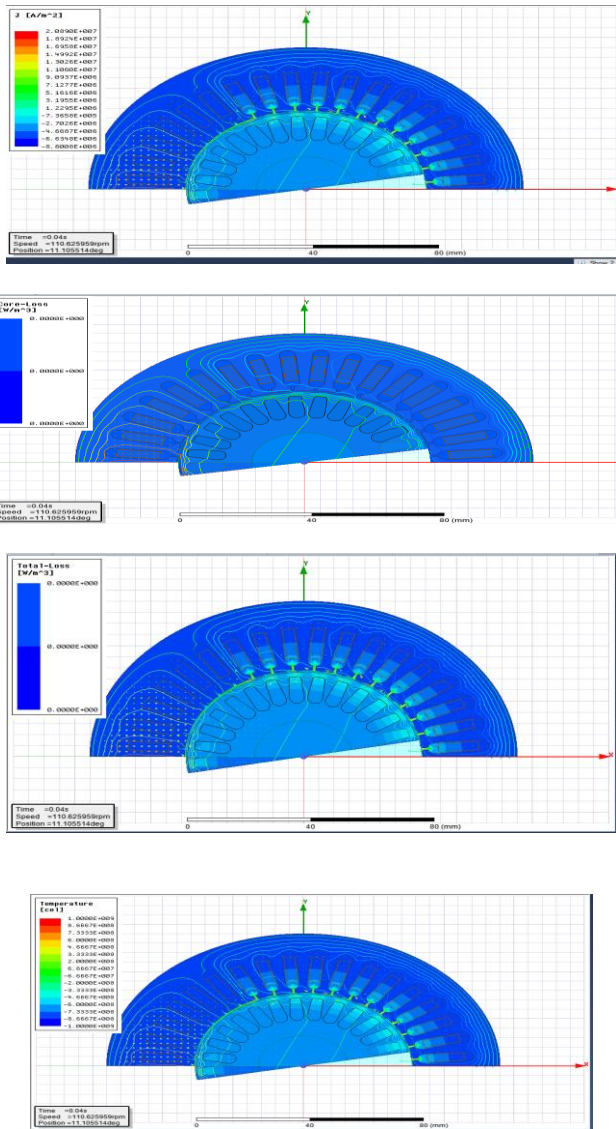
V. MESH OPERATION

A. ANSYS Maxwell is used to create accurate geometric representation of induction motor and perform all mesh operations. The following procedure is followed for designing motor in Maxwell-2D

1. After constructing the geometrical model in RMXprt go to the analyse in the project manager window.
2. Right click on the set up and select export option.
3. After export option select the model as 2d
4. Then the 2d model of induction motor will appear on the screen. Again the boundaries and excitations in the machine.
5. Click on Analyze all option in the project manager window and observe the waveforms.

After designing the machine, identification of material , applying boundary conditions, defining parameters in RMXprt, the simulator generates meshes and solutions are made in these meshes as represented in following figure. In this analysis, the error rate is 1% for this model.





B. PERFORMANCE CHARACTERISTICS OF INDUCTION MOTOR

The following performance characteristics presented in figures 8 -17 are obtained using ANSYS Maxwell.

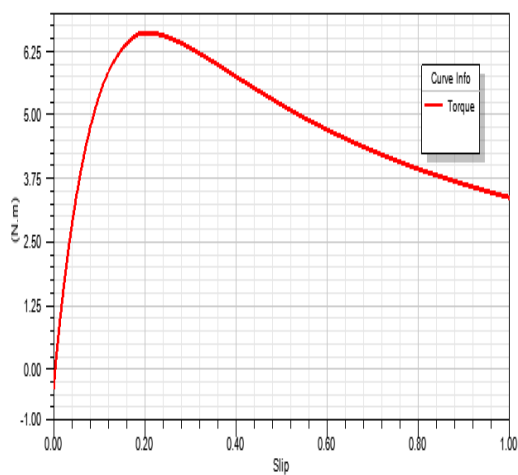


Fig 8: Torque-Slip characteristics

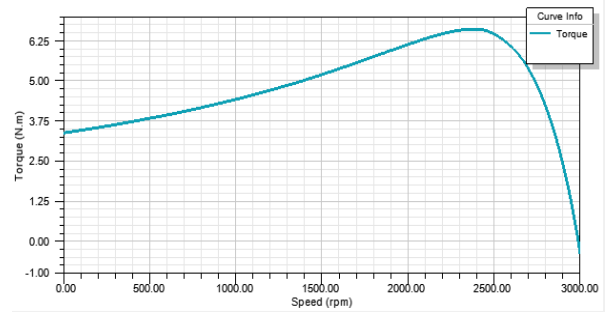


Fig 9: Torque Speed characteristics

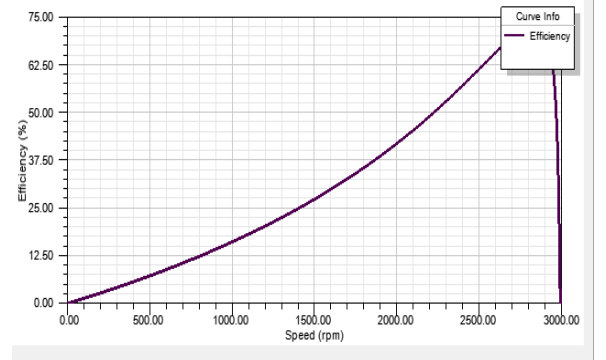


Fig 10: Efficiency vs Speed characteristics

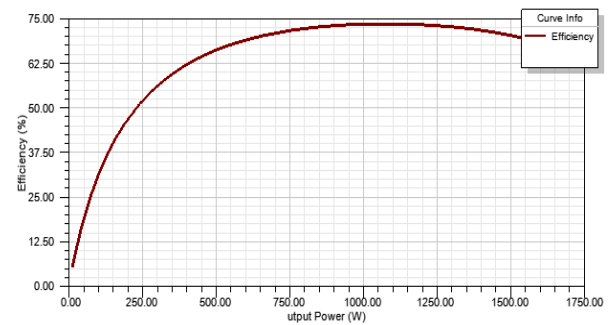


Fig 11: Efficiency vs Output power characteristics

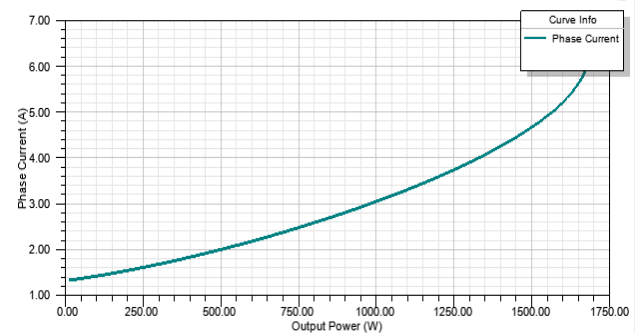


Fig 12: Phase current vs Output power characteristics

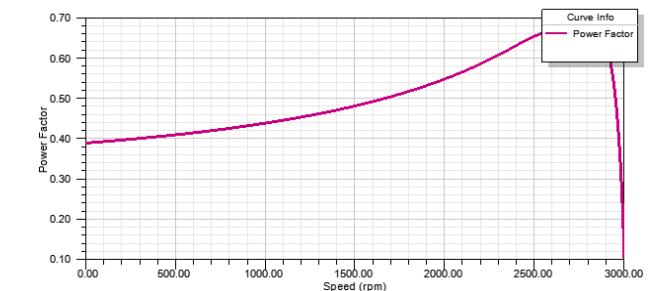


Fig 13: Power factor vs Speed characteristics

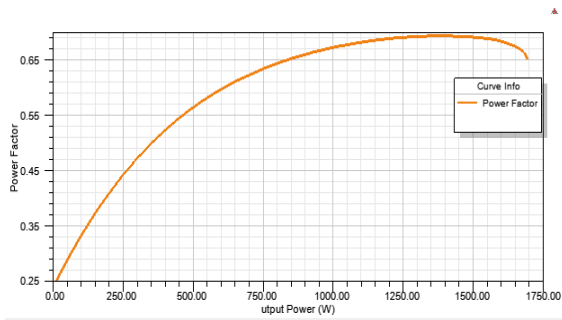


Fig 14: Power factor vs Output power

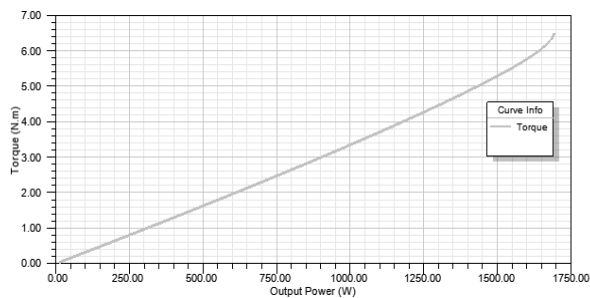


Fig 15: Torque vs Output power

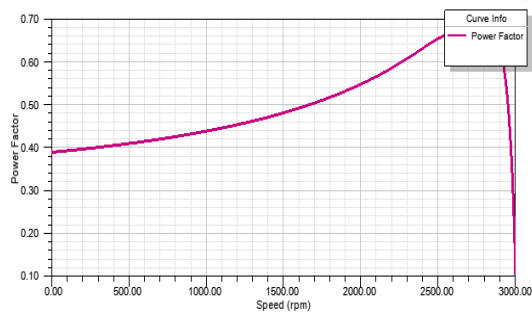


Fig 16: Power factor vs Speed

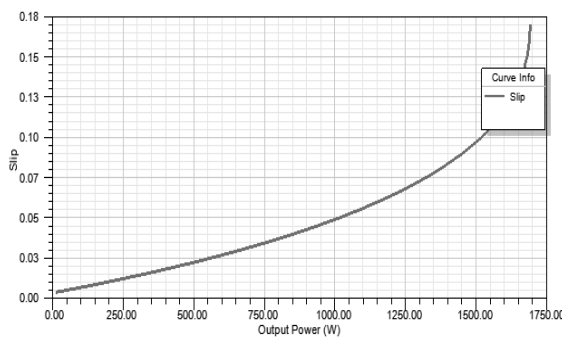


Fig 17 : Slip vs Output power

The following figure 18 shows the 2D model of Induction motor by using ANSYS Maxwell 2D

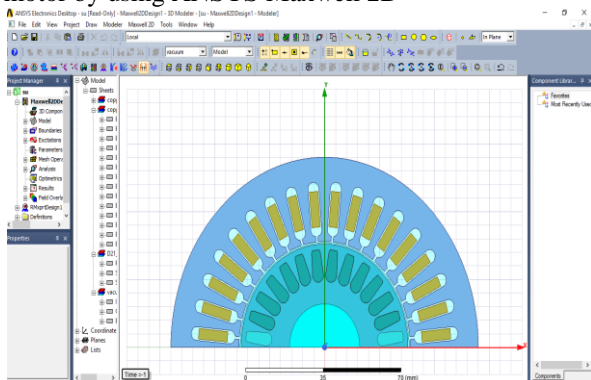


Fig 18: 2D model of Induction motor

C.OUTPUT CURVES

The output curves are represented in figures 19-23.

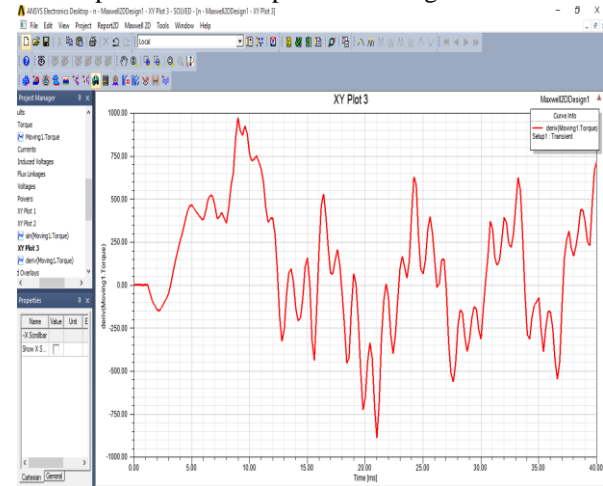


Fig 19: Torque vs time graph

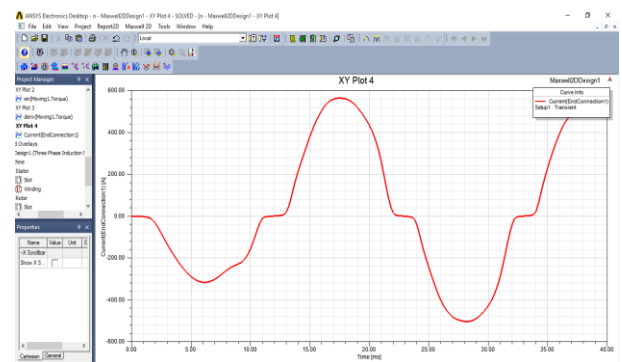


Fig 20: current end connection vs time graph

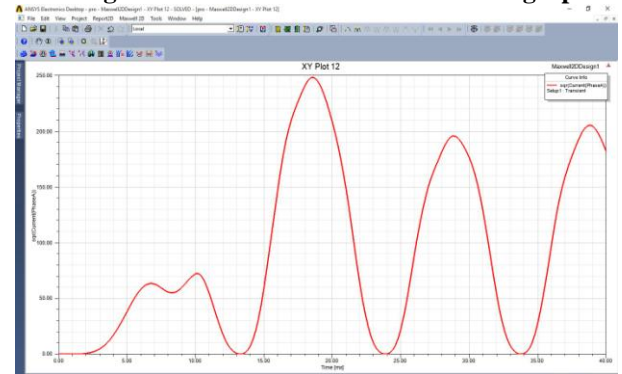


Fig 21: Current vs time graph

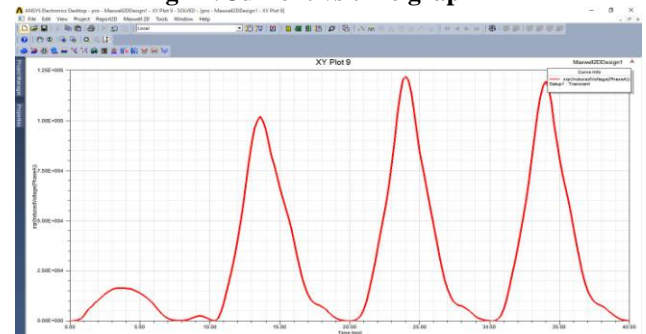


Fig 22: voltage vs time graph

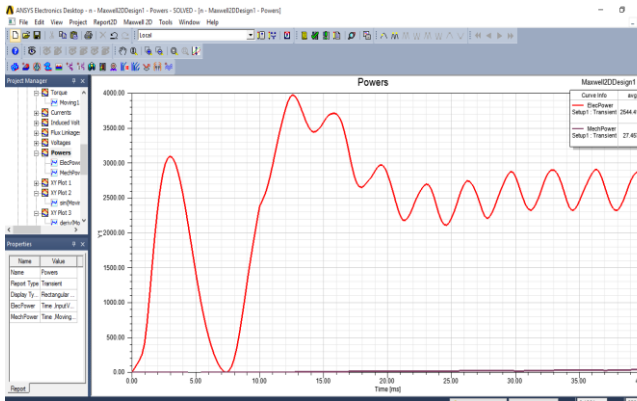


Fig 23: Power vs time graph

The results are tabulated in table VI.

Table VI:Performance results

Torque	6.5Nm
Power factor	0.65
Efficiency	75%

VI. CONCLUSION

Squirrel cage induction motor is suitable for industrial applications: driving machine tools and various pumps. ANSYS Maxwell and RMXprt are important tools for analyzing electromagnetic parameters and mesh operation .The better performance of the machine is suitable for various applications.

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