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# Three phase Induction Motor -Model Design and Performance Analysis in ANSYS RMXprt

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## Abstract :

Optimum design and performance check after manufacturing arethe main processes of manufacturing of any motor. Proper material selection and accurate design improves the performance of electric motor. ANSYS RMxprt is best software for accurate and cost-effective design of various electrical machines.This articleis having discussion about use of RMxprt for machine design and it also presents the modelling and analysis of three phase induction motor made by ANSYS RMxprt.Paper highlights the use of ANSYS RMxprt for the design of three phase induction motor and it also presents the simulation results along with 2-D and 3-D geometry.

*Keywords :-* **Induction motor design; ANSYS Maxwell; ANSYS RMxprt,2-D and 3-D geomtery.**

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## I] Introduction

Design,material selection,production and performance check (testing) are the main steps of manufacturing of any electrical motor.Induction motors are commonly used machines that are used as drive of mechanisms, pumps etc [3]. Manufacturing of these motorsincludes many processes i.e. design, material selection, production, testing, performance check etc. Electromagnetic calculation is an important part of the design process that defines various parameters of the magnetic core, such as voltages, currents, flux, inductances in teeth, core, yoke, coil etc. Due to "ANSYS Maxwell" we can make calculation model and get electromagnetic parameters in a visual convenient form. [2]. A. Kachin and A.Kiselev presented the use of "ANSYS Maxwell" for the research of the synchronous electric motor drive system [4].The ANSYS Maxwell programs also consider the nonlinearity of the magnetic material, losses in the iron as well as the influence of the winding slots etc.[5]

RMxprt is a template-based electrical machine design tool which provides fast analytical calculations of machine performance and 2-D and 3-D geometry creation for detailed finite element calculations. [1] RMxprtcan also used to simulate and analyze the various types of electrical machines.This paper focuses on use of ANSYS RMxprt softwarefor material selection,machine design and obtaining performance characteristics of three-phase induction motor.Induction motor is designed for 3-phase1600 KW,4-pole,690V,50 Hz rating.

## II] Design Details:

### 1.Stator Design:

Major Stator design data:
Number of stator slots:60
Outer Diameter of Stator (mm): 895
Inner Diameter of Stator (mm):600
Stacking factor:0.97
Type of steel:50C530

Coil Pitch:13
Number of conductors per Slot :8
Number of wires per conductor:22
Slot Area ($mm^2$):1129
Wire Resistivity(ohm.mm2/m):0.0217

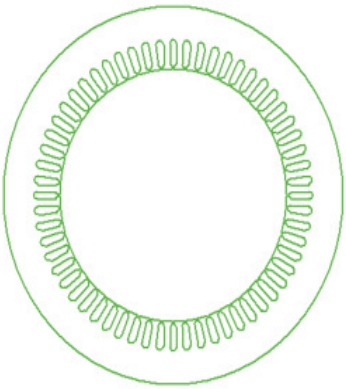


Fig.1 Stator model of 60 slots developed in RMxprttool

**2. Rotor Design:**

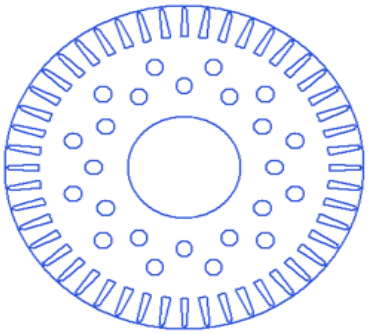


Fig.2 Rotor model of 48 slots developed in RMxprt tool

Major Rotor design data:
No.of Rotor slots:48
Air Gap (mm) :3.5
Inner Diameter of Rotor (mm):190
Length of Rotor (mm):660
Stacking factor of Rotor core:0.97
Type of Steel:50C350
Number of Hole Vents:12

**3.Motor Design:(Shaft):**

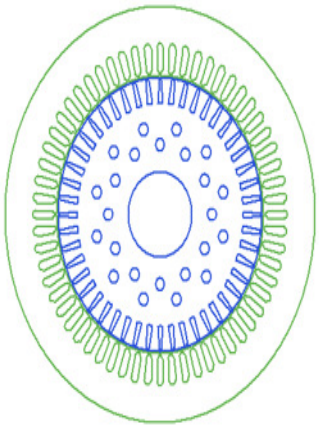


Fig.3 Motor model designed in RMxprt tool

Output Power (kW): 1600
Rated Voltage (V): 690
Winding connection: Delta
Number of poles:4
Frequency (Hz):50

**4.Winding arrangement:**

The 3-phase,2-layer winding is arranged in 15 slots as below:
AAAAAZZZZZBBBBB

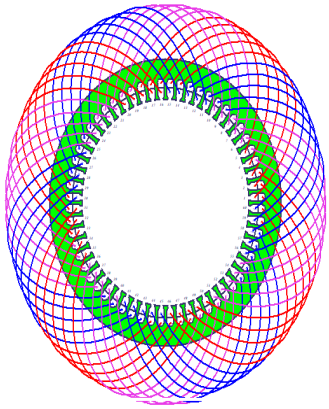


Fig.4 Winding arrangement view in RMxprt tool

**III].Performance of Motor:**

Rated -Load Operation:
Stator Resistance (Ohm):0.0056952
Rotor Resistance (Ohm):0.00409092
Iron-Core loss (W):9113.26
Input Power (kW):1649.6

Output Power (kW):1599.76
Efficiency (%) :96.979
Power Factor:0.872091
Rated Slip:0.00660975
Rated Shaft Speed (rpm):1490.09

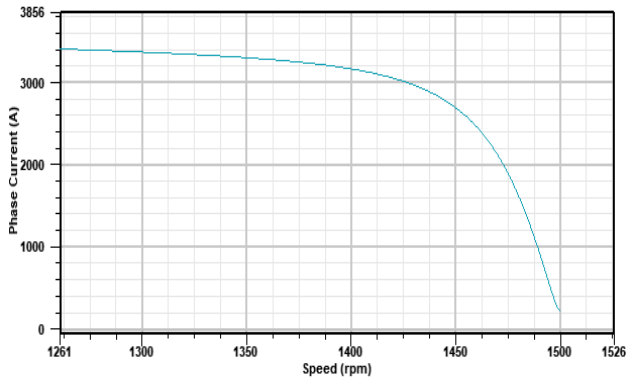
No-Load Operation:
No-Load Stator Phase Current:206.001 mA
No-Load Stator Resistance (Ohm):0.0056952
No-Load Rotor Resistance (Ohm):0.00495123
No-Load Iron-Core loss (W):9787.88
No-Load Input Power (W):27284.1
No-Load Power Factor:0.0452231
No-Load Slip:3.22742e$^{-005}$
No-Load Shaft Speed (rpm) :1499.95

Break-Down Operation:
Break-Down Slip: 0.026
Break-Down Torque (N-m):20102.7
Break-Down Torque Ratio :1.96083
Break-Down Phase Current (A):2428.41

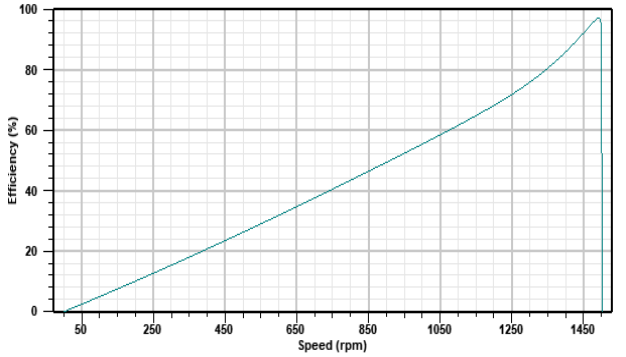
**IV] Material consumption details:**
Armature Copper weight:467.691 Kg
Rotor bar material weight:167.667 Kg
Rotor ring material weight:70.7057 Kg
Armature core steel weight:1427.32Kg
Rotor core steel weight:1025.15Kg
Total Net Weight:3158.53 Kg
Armature core steel consumption:2701.67 Kg
Rotor core steel consumption:1407.75Kg

**V]Performance characteristics**

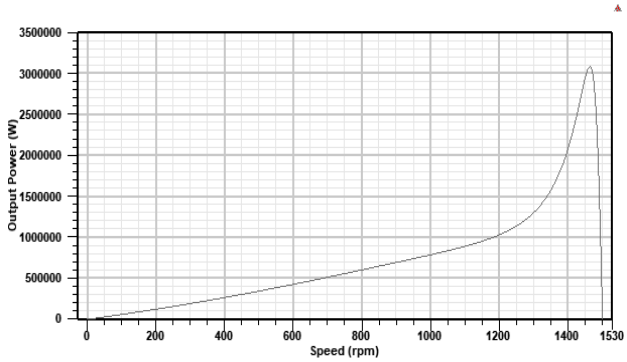
1.Phase Current Vs Speed characteristic



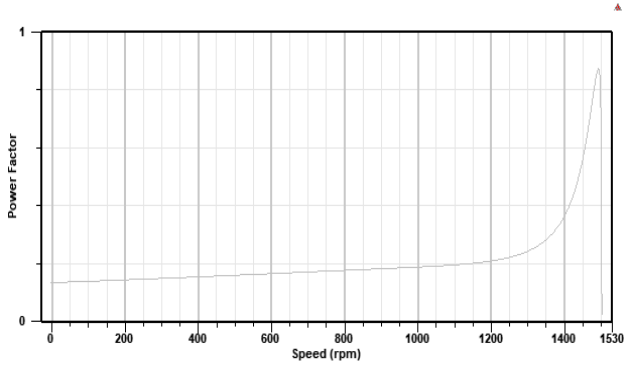

2.Efficiency Vs Speed




3.Output Mechanical Power Vs Speed

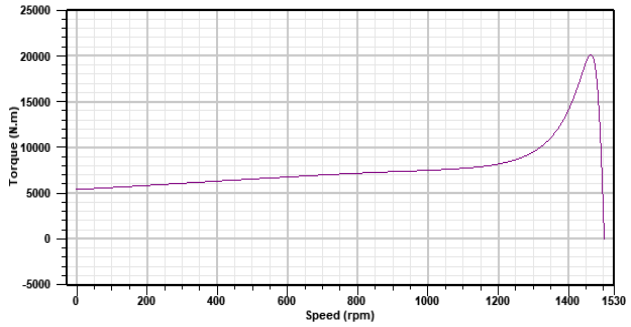



4.Power Factor Vs Speed

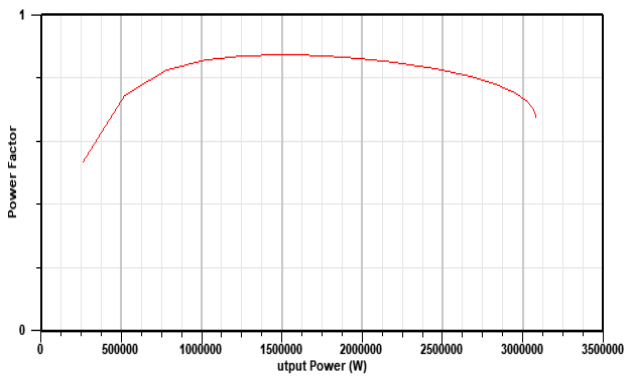


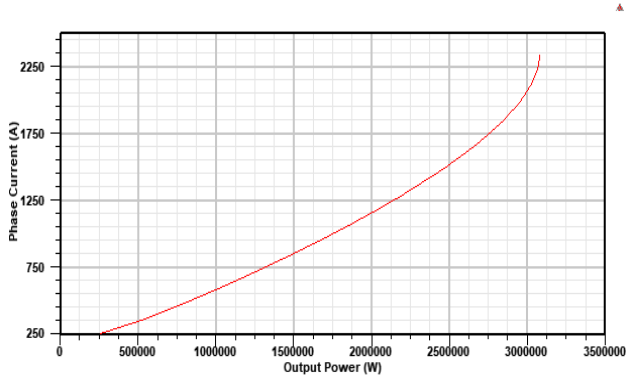
5.Torque Vs Speed



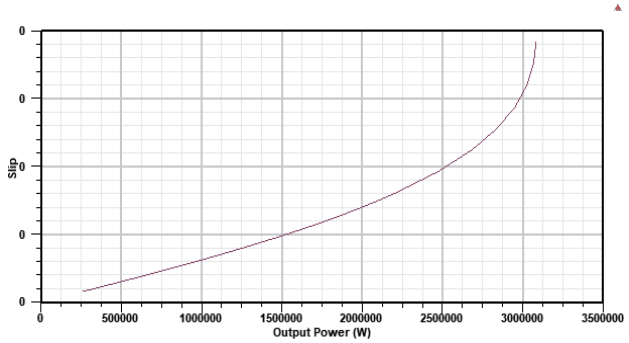

8.Power Factor Vs Output Power



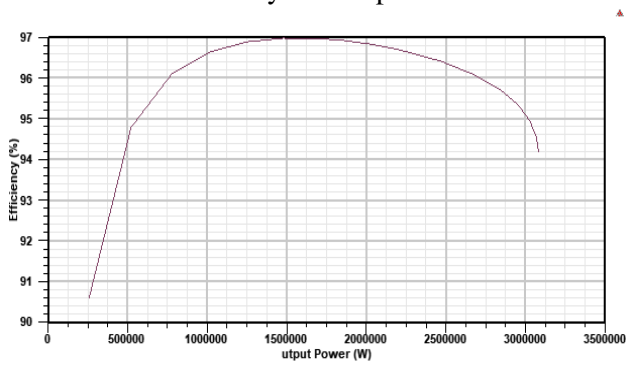

6.Phase Current Vs Output Power



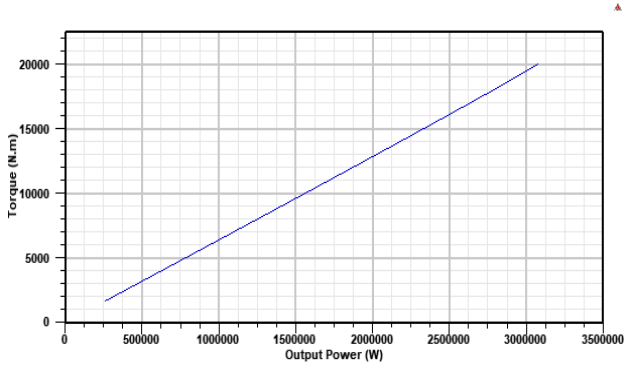

9.Slip Vs Output Power




7.Efficiency Vs Output Power

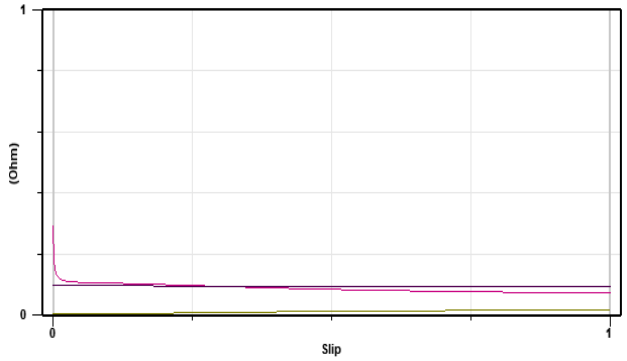



10.Torque Vs Output Power

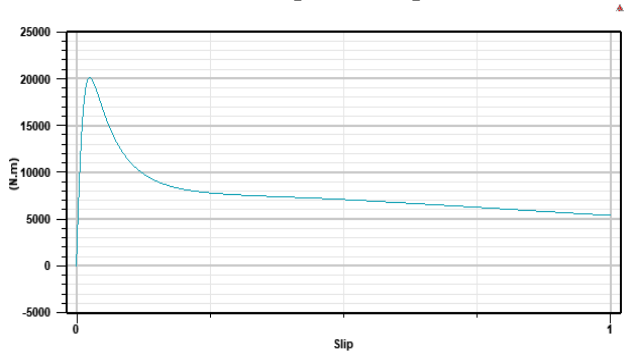


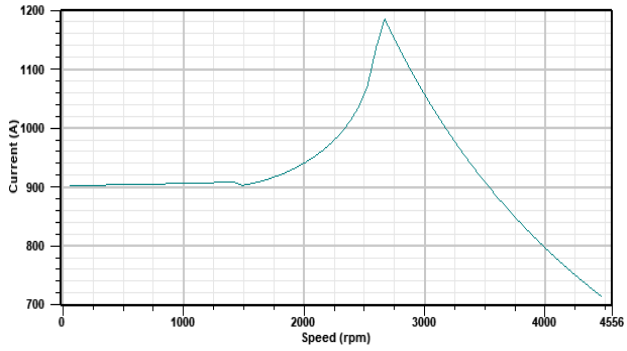
11.Leakage Impedance Vs Slip



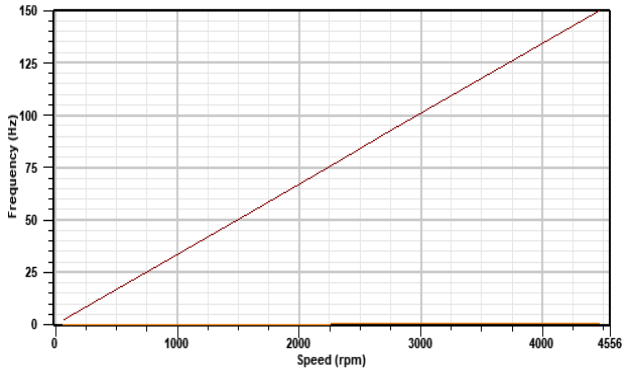

12.Torque Vs Slip



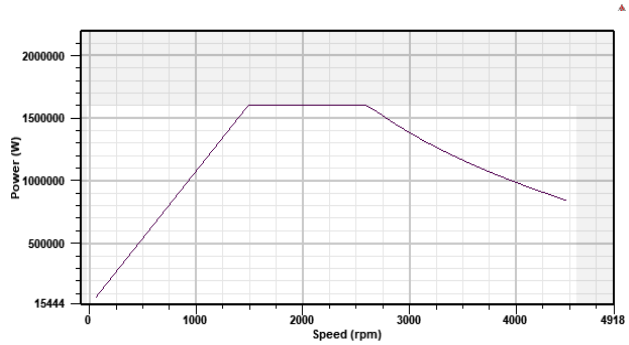

13.Input Current with Flux-weakening Control



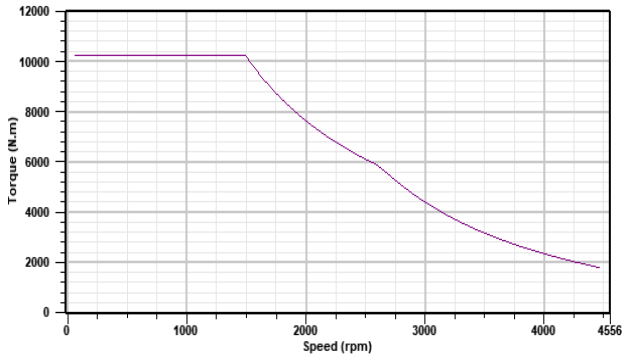

14.Frequency with Flux-weakening Control




15.Output Power with Flux-weakening Control

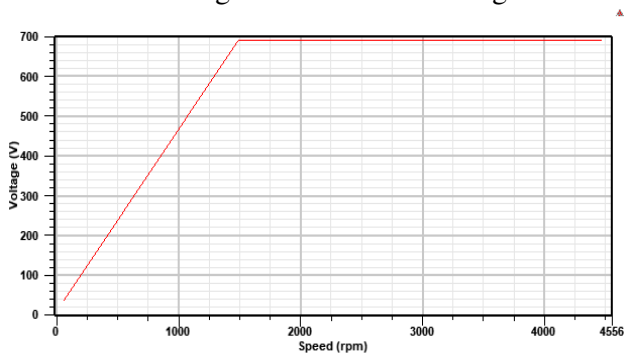



16.Output Torque with Flux-weakening Control



17.Phase Voltage with Flux-weakening control




## VI] Maxwell 2D geometry:

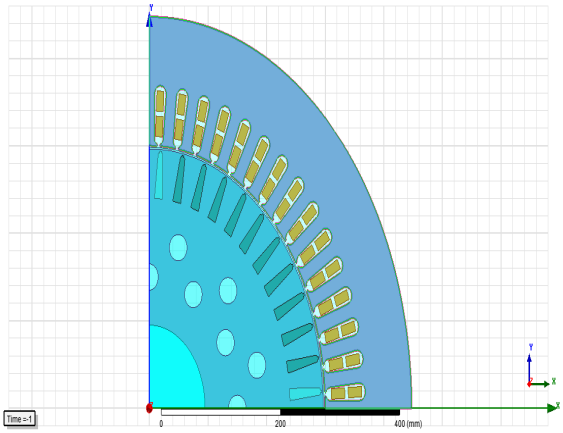


Fig.6 Maxwell 2-D geometry of designed motor

## VII] Maxwell 3D geometry:

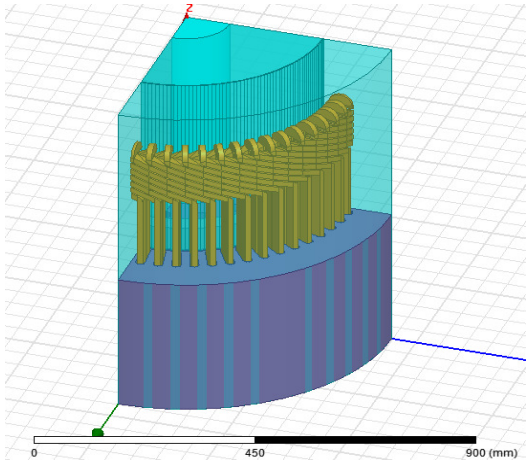



Fig.7 Maxwell 3-D geometry of designed motor

## VIII]Advantages of design with ANSYS RMxprt

- Fast analytical machine calculations
- Calculates machine performance in less time
- Makes initial sizing decisions
- Performs what-if analysis in less time.
- Economical method of design.[2]
- Provides option of material selection
- Provides 2-D and 3-D geometry of designed motor
- Possible to make electromagnetic calculation model and get electromagnetic parameters in a visual convenient form.[2]
- Machine performance can be checked before actual production of motor.

## IX]Applications of ANSYSRMxprt

Analysis and simulation of various types of electrical machines as follow:

- Induction motors
- Three phase synchronous machines
- Brushless permanent-magnet DC motors
- Synchronous motors and generators
- Permanent-magnet DC motors
- Switched reluctance motors
- Line-start permanent-magnet synchronous motors
- Universal motors
- General DC machines
- Claw-pole alternators
- Three phase non-salient synchronous machine
- Generic rotating machine etc.

## CONCLUSION

Accurate design and proper material selection is most important in manufacturing of high performance and economical motor.ANSYS RMxprt is useful machine design tool which provides fast analytical calculations of machine performance.ANSYS RMxprt machine design is best option to design and calculate performance of motor before production.It provides the option of proper material selection,material consumption

details,provides 2-D and 3-D geometry of designed motor and also allows to make any changes to optimize the design.

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