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Original Research Article

# DESIGN ANALYSIS OF 3- PHASE INDUCTION MOTOR USING 2D MODELLING

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**Abstract*:*** Induction motor is singly excited motor, which is very simple and compact. This motor is extremely rugged in construction and most reliable with low cost construction. Robustness and reliability made the squirrel-cage induction motor the most used motor in industrial and domestic applications. . Despite the emergence of new types of electric machines, the squirrel-cage induction motor remains the dominant one based on geometric dimensions. In this paper a model was developed in the 2d and 3d Maxwell program by which the transient process at the motor start-up was calculated for different features especially temperature. For detailed and accurate analysis of motor performance in faulty conditions, an accurate model for the motor in which all conditions can be considered is of extreme importance. Thermal analysis is achieved based on a precise knowledge of the test motor geometry, materials, and heat sources (losses). This work will help the induction motor designer in predicting the thermal state of induction motor when modifying the frame, without needing manufacturing and testing expensive prototype motor. In this work the model of induction motor is presented in 2d and its designing is understood with the variation of currents and various characteristics curves have been studied.

**Keywords:** Induction Motor, thermal analysis, Simulation, Losses, Efficiency, flux density.

**Introduction:** With the widespread use of different electric motors, maintaining these machines to extend their life is important and necessary. The housing of the motor is designed to protect the motor from damage such as hot, humid, corrosive, dry and other conditions. To make smaller machines without decreasing the output power, or to have a more output power without increasing the size of the machine, it is important to predict the thermal state of induction motor. For this we have done the 2d modelling of induction motor and simulated it to see the effects of current raising the temperature

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of the machine during load and no load conditions.

**2d Modelling:** 2d Motor Design with ANSYS Maxwell® RMxprt® is the commercial electromagnetic field simulation software for engineers who are working for designing and analyzing 3-D and 2-D electromagnetic and electromechanical devices. In addition to providing classical motor performance calculations, RMxprt can automatically generate a complete transfer of the 3- D or 2-D geometry, including all properties, to Maxwell for detailed finite element analysis calculations. Maxwell and RMxprt are widely used and became an industrial standard [1].

**Table 1. Motor specifications**

General | IndM3

| Name | Value | Unit | Evaluated V... | Description |
|---|---|---|---|---|
| Name | Setup1 | | | |
| Enabled | ☑ | | | |
| Operation Type | Motor | | | Motor or generator |
| Load Type | Const Power | | | Mechanical load t... |
| Rated Output Power | 1100 | W | 1100W | Rated mechanical... |
| Rated Voltage | 380 | V | 380V | Applied or output r... |
| Rated Speed | 1450 | rpm | 1450rpm | Given rated speed |
| Operating Temperature | 75 | cel | 75cel | Operating temper... |

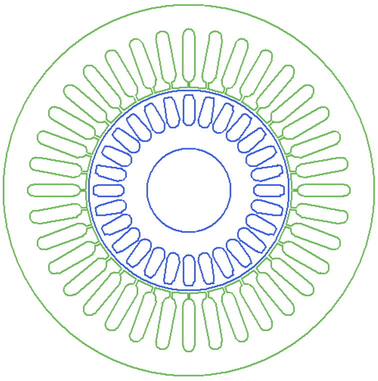

Fig 1. 3-Phase Induction Motor in 2D

**Design Modelling of Induction Motor:** Fig 1. represents the basic 2d model of 3 phase induction motor. The Finite element method FEM software is a suite of programs for 2-dimensional electromagnetic fields analysis. Using the graphical interaction within the pre-processor, the model space is divided into a contiguous set of (triangular) elements. The physical model may be described in Cartesian or cylindrical polar (axi-symmetric) coordinates. The FEM software is used to analyse the design of stator and rotor. The amendments were made in the rotor slot material and tested with different material such as aluminium and copper. Even though different materials are use, but the slot design is same for both the stator design and the rotor design. Based on the two materials the FEM software is use to analyse the design in many aspects that will be discussed appropriately. Table 1 shows the design specification of the induction motor with 1100 watt output power with the overall motor stator and rotor design dimensions, and figure 2 shows the stator slot design.

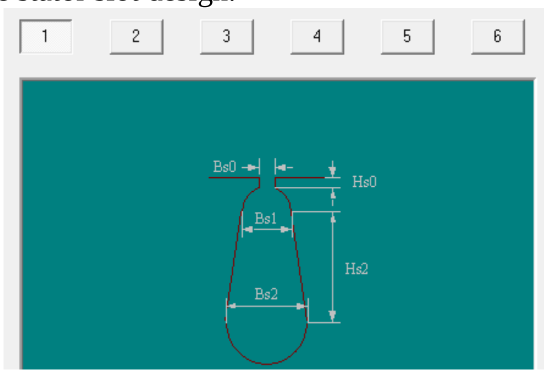


**Fig 2:** Design of slots

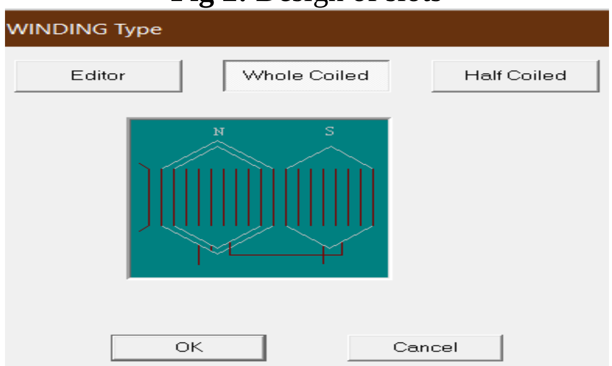


**Fig 3:** Winding Design

**Table 2. Stator dimensions**

Properties: MaxwellProject - RMxprtDesign1 - Machine

Stator

| Name | Value | Unit | Evaluated V... | Description |
|---|---|---|---|---|
| Outer Diameter | 140 | mm | 140mm | Outer diameter of the stator core |
| Inner Diameter | 78 | mm | 78mm | Inner diameter of the stator core |
| Length | 250 | mm | 250mm | Length of the stator core |
| Stacking Factor | 0.95 | | | Stacking factor of the stator core |
| Steel Type | D21_50 | | | Steel type of the stator core |
| Number of Slots | 36 | | | Number of slots of the stator core |
| Slot Type | 1 | | | Slot type of the stator core |
| Lamination Sectors | 3 | | | Number of lamination sectors |
| Press Board Thick... | 0 | mm | | Magnetic press board thickness, 0 for non-magne... |
| Skew Width | 0 | | 0 | Skew width measured in slot number |

Rotor

| Name | Value | Unit | Evaluated V... |
|---|---|---|---|
| Stacking Factor | 0.95 | | |
| Number of Slots | 28 | | |
| Slot Type | 1 | | |
| Outer Diameter | 76 | mm | 76mm |
| Inner Diameter | 32 | mm | 32mm |
| Length | 250 | mm | 250mm |
| Steel Type | D21_50 | | |
| Skew Width | 0 | | 0 |
| Cast Rotor | ☑ | | |
| Half Slot | ☐ | | |
| Double Cage | ☐ | | |

The variation of current, torque, speed and other variables at no load has been demonstrated with the help of different graphical representation as shown below from fig.3 (a),(b),(c) (d),(e) (f) and (g).

The objective of the simulation at no load is to address the influence of temperature increase on the performance of the induction motor. The effect of the temperature rise on the motor performance was investigated by gradually increasing the motor load.

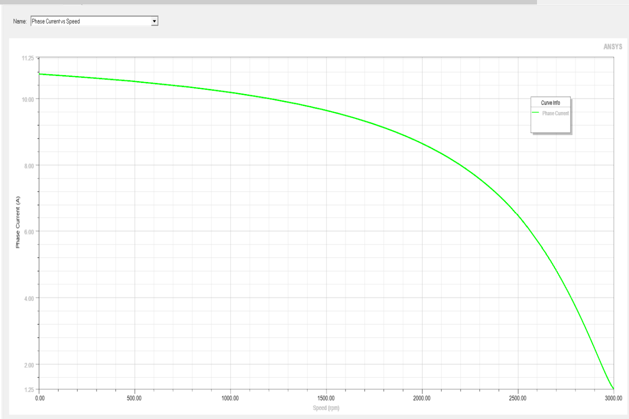

Fig. 3 (a) Current Vs Speed

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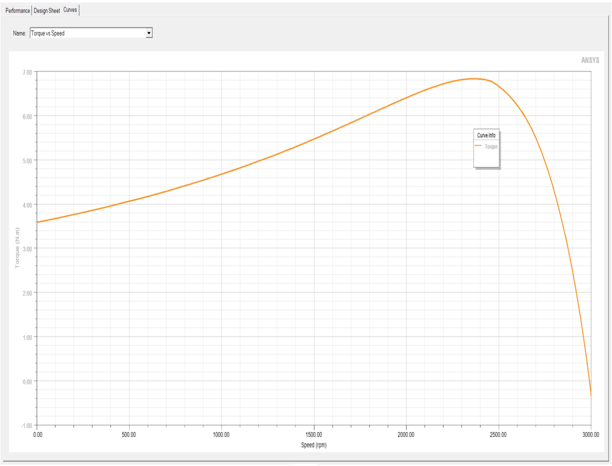

Fig. 3 (b) Torque Vs Speed

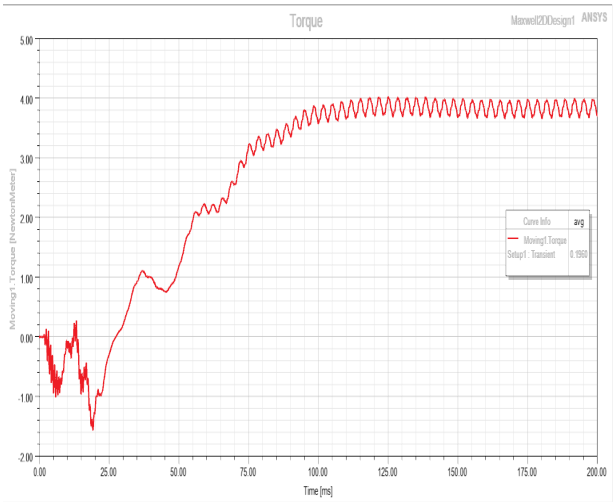


Fig.3 (c)Torque Vs Time

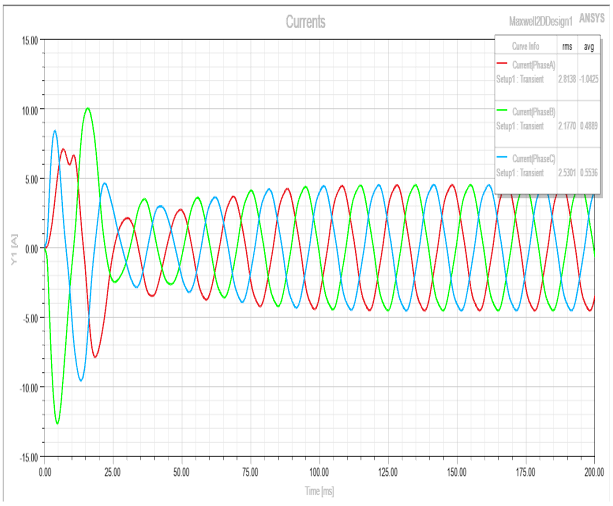


Fig. 3 (d) Current Vs Time

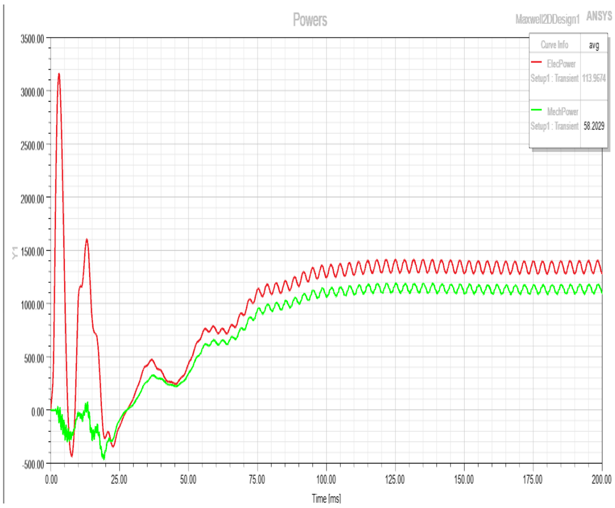


Fig. 3 (e) Variation of o/p Power vs Time

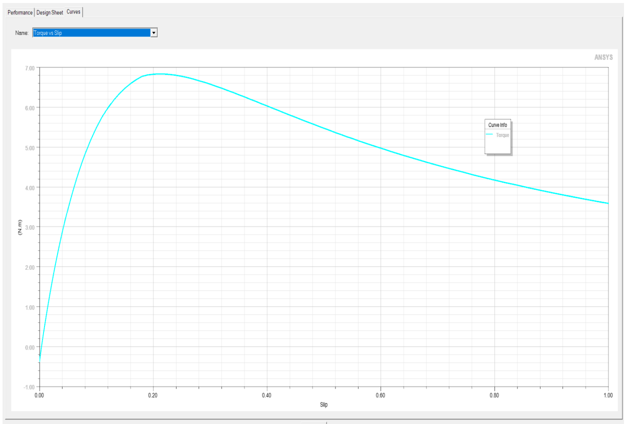

Fig. 3 (f) Variation of Torque vs Slip

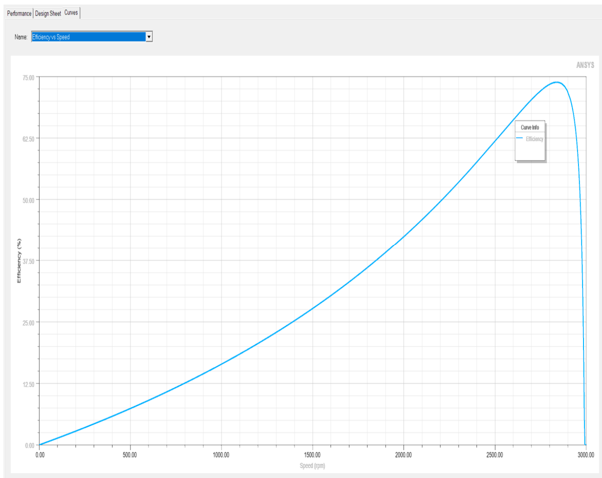

Fig. 3 (g) Efficiency vs Speed

As can be seen from the Fig.4 (a) Flux Distribution and Fig. 4 (b) Flux Density Analysis,the motor is under no load condition and all the design parameters are satisfied.

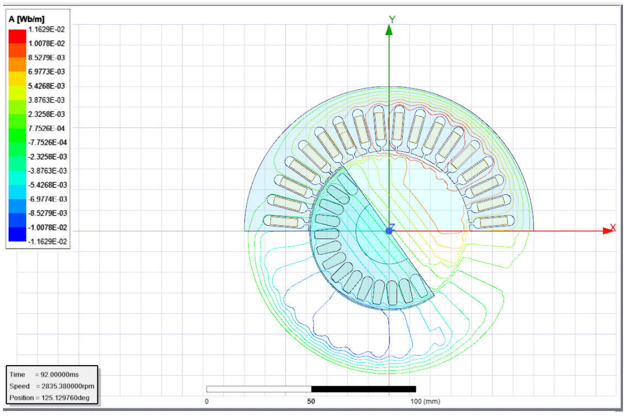


Fig.4 (a) Flux Distribution

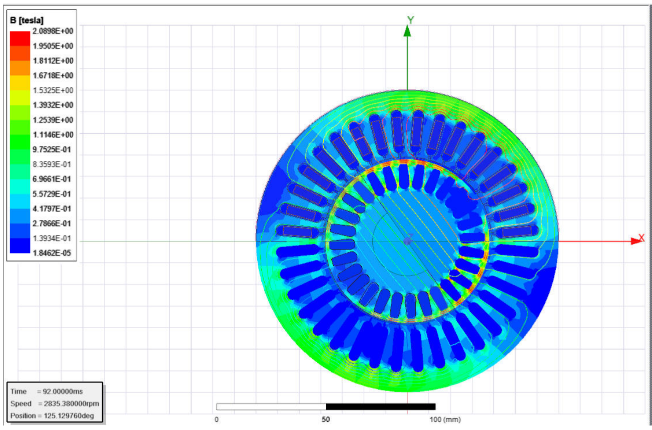


Fig. 4 (b) Flux Density Analysis

**Estimation of heat:** The estimation of heat distribution inside the test motor by this three software is done successfully with a good agreement between its results. An electric motor is an electrical machine that converts electrical energy into mechanical energy. While converting energy from one form to another, it produces losses. These losses are responsible for generating heat inside the motor. Temperature is an important factor that affects the performance of electric machines. Due to their thermal design, electric machines can suffer problems such as insulation breakdown, reduction in torque provided, shortened lifetimes and so on. Other problems are changes in geometry caused by thermal expansion of the machine components and mechanical stresses. Therefore, because of these problems, the temperatures inside the machines must be kept within safe limits. To predict the machine temperatures, thermal models are used to determine the temperature for different parts of motor. So, thermal analysis is a very important stage in the design of electric machines. To study the thermal behaviour of the machines, and show how heat is distributed inside it. In order to avoid the problem of heat in the machines, the temperature of the windings are monitored by thermal analysis, since the windings are considered the weakest part of the machine, as an increase in the temperature of the windings by the rate of 10 oC than the permissible limit will weaken the life of the insulation by half [2].

**Conclusion:** In this paper, ANSYS Maxwell 2D and RMxprt software tools are used to create a 3 phase induction motor to understand its design and analyse its various characteristics curves under no load. The objective of the work at no load is to address the influence of temperature increase on the performance of the induction motor. The effect of the temperature rise on the motor performance was investigated by gradually increasing the motor load or can be varied with current variation.

Further studies are to be conducted in order to show the influence of other types of eccentricity in the motor temperature.

The objective of the simulation at no load is to address the influence of temperature increase on the performance of the induction motor. The effect of the temperature rise on the motor performance was investigated by gradually increasing the motor load.

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