Electromagnetic analysis of Induction motor using FEM

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***Abstract*— Rotating electrical machines play an important role in the world's industry. Hence there is a strong demand on their reliable and safe operation. This project presents the basic guidelines to develop a coupled FEM for the study of electromagnetic phenomena in induction motors and attempts to model a three phase squirrel cage induction motor. It is used to analyze the behavior of the machine having broken rotor bars.FEM model is formulated using the ANSYS Maxwell software.**

(Keywords—Induction motor; Fem;Ansys maxwell)

I. INTRODUCTION

Nowadays most of the motors used in industry are squirrel-cage induction motors because of their simple design, rugged construction, reliable operation, low initial cost, easy operation and maintenance, relatively high efficiency, etc. Hence numerous studies were presented in recent years in the field of fault detection of these machines. It is becoming a highly important issue to avoid any kind of failure of induction machine. Moreover it is well known that unexpected failures on electrical drive system could result in many unpleasant events. In many applications

induction machine's failures can shut down the entire industrial process. Such unplanned machines shut down cost both time and money. The one of the most inconvenient failure in squirrel-cage induction machine are the rotor failures because these faults practically can not be repaired.

Finite Element Methods are widely used today to correctly compute operating properties and characteristics of electrical machines without physically constructing a prototype, thus saving on costs and enabling us to try out changes to parameters so as to design a machine with the optimum parameters. There are varied tools for finite element analysis, the more popular ones being AnsysMultiphysics, COMSOL Multiphysics, ElecNet etc.

The FEM methods have been successfully used in the past to design synchronous permanent magnet machines and synchronous generators. The two main methods used are as follows. Rotor and stator currents are calculated using the circuit models of induction motor. This is known as the circuit approach. The alternative approach, involves calculating the stator currents but they calculate rotor currents directly as eddy currents. Both approaches have their advantages and disadvantages but by combining them it has been possible to eliminate the principle disadvantage of the consideration of the actual current distribution in rotor bars. The purpose of this project is to attempt to describe a method for the determination of the parameters of the three phase induction motor model under different operating conditions. The choice of magnetic excitations will be confirmed by the derivation of a corresponding two axis equivalent circuit model in the general frame of reference that considers saturation as well. This will make it possible to determine the magnetizing inductance as well as the real values of the stator and rotor leakage inductances which cannot be separated arbitrarily with classic measurements. The method is not completely new but eliminates some of the drawbacks of the current methods and so may be considered as an alternative approach.

Rotor faults of induction machines yield asymmetrical operation of this one, causing unbalanced currents, torque pulsation, increased losses and decreased average torque. The need for detection of rotor faults at an earlier stage, so that maintenance can be scheduled. For that, a model closer to reality considering faults conditions must be established. An analytical analysis method based on the rotating field theory and coupled circuit was used.

II. FEM

In recent years the Finite Element Method (FEM) become widely used in the design and analysis of electric machines and of her electromagnetic devices. So far a lot of program packages for computation of magnetic field, especially for two dimensional (2D) analysis have been developed . This method it is based on Maxwell's equations for magnetic and electric field

$\nabla\times H = J$ and dt

$\nabla\times E = -\, dB$

where H is the magnetic field strength [A/m], E is the electric field strength [V/m], J is the electric current density [A/m2], B is the magnetic flux density [T]. Moreover the electric and magnetic filed quantities are related with the material properties expressed by the following relations: $J = \sigma E$ and $B = \mu H$

where σ is the electrical conductivity [S/m], μ is the magnetic permeability [H/m]. Based on these equations FEM based programs compute the magnetic field distribution of any electrical machine. In the case of the 2D analysis the computations are performed for a transversal plane to the axes of the machine. Well-developed fault detection of any electrical machine requires a wellgrounded theoretical basis. The use of simulation tools helps the researchers to emphasis the effects caused by faults in an electrical machine and to develop efficient fault detection methods. Using FEM analysis the changes in electric, magnetic and

mechanic behavior of the machine due to any fault can be easily observed without the need of destroying a machine, or experimenting in laboratories machines with different fault types. The main idea was to understand the electric, magnetic and mechanical behavior of the machine in the healthy state and under fault condition.To perform the FEM analysis of the induction machine ANSYS maxwell Software was used. This program is one of the best electromagnetic field simulation software worldwide used by hundreds of engineers and designers to design and analyze electromagnetic devices.To reduce computational time usually the electrical machine models are created on the smallest symmetrical part of the machine, in order to reduce de geometrical complexity and the number of finite element meshnodes. In conclusion to obtain a correct result on changes in magnetic field distribution caused by rotor fault of induction machine, the calculation must be performed over the whole cross section of the machine.To build any simulation model in ANSYS, only a few steps have to be done.

III. EXPERIMENTAL SETUP

TABLE 1	GENERAL PARAMETERS OF IM	
	GENERAL DATA	VALUE
	Given o/p power (kw)	150
	Rated voltage (v)	415
	Frequency (Hz)	50
	Given speed (rpm)	1480
	No. of poles	4
	Winding connection	Wye
	Stator slots	72
	Rotor slots	58
	Operating temperature(c)	50

TABLE 2	SMULATION RESULT	
	Performance	Value
	Mechanical Shaft Torque (N.m)	959.61
	Efficiency (%)	96.01
	Power Factor	0.9
	Rated slip	0.0053
	Rated Shaft Speed (rpm)	1491.97

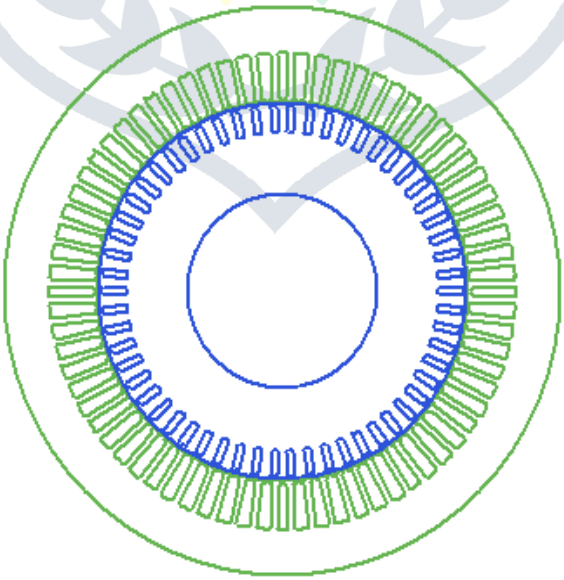


FIG INDUCTION MOTOR

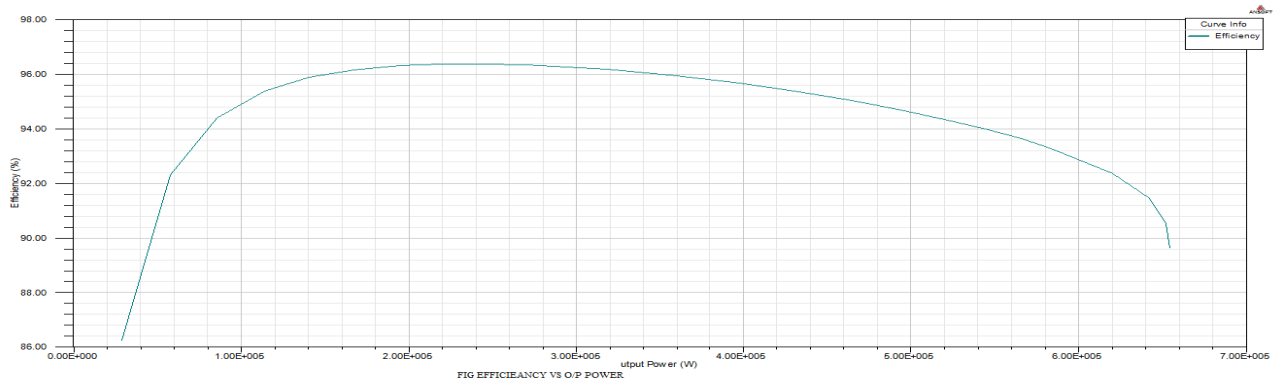
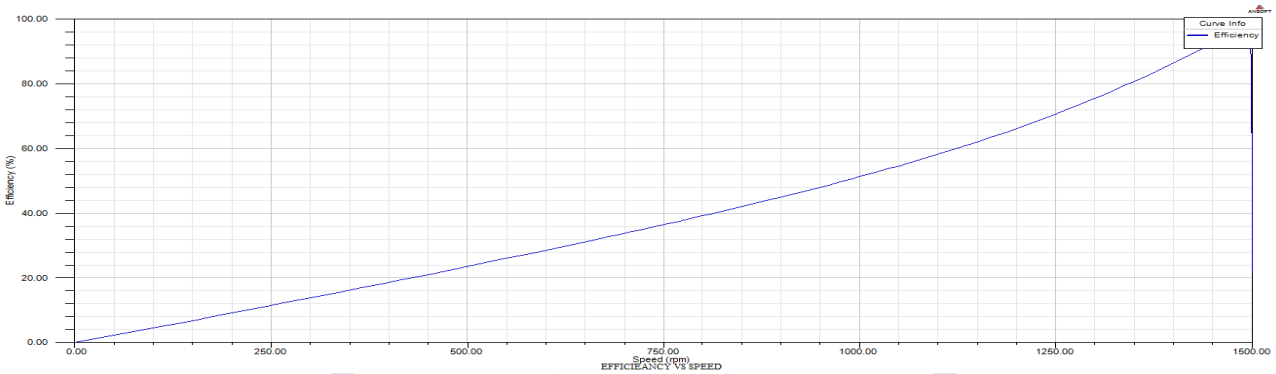


FIG EFFICIEANCY VS O/P POWER



EFFICIEANCY VS SPEED

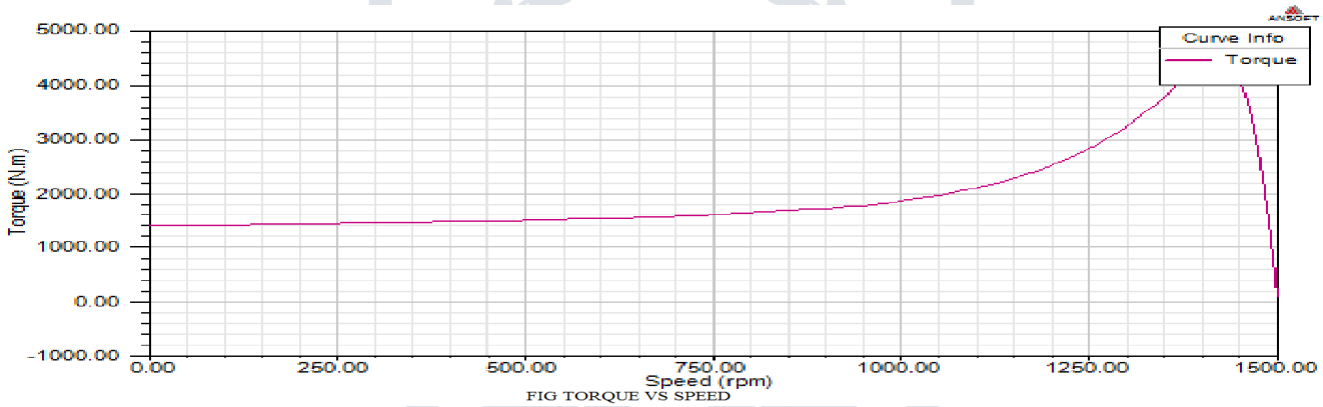


FIG TORQUE VS SPEED

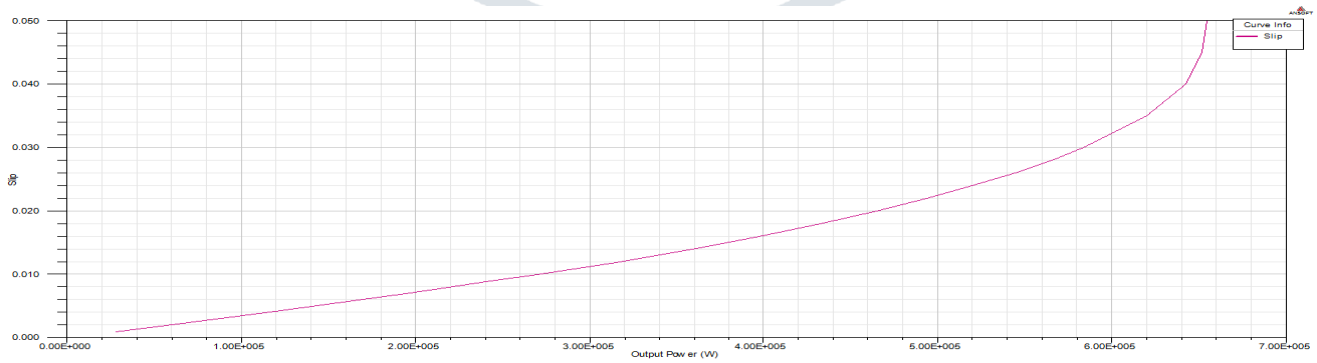
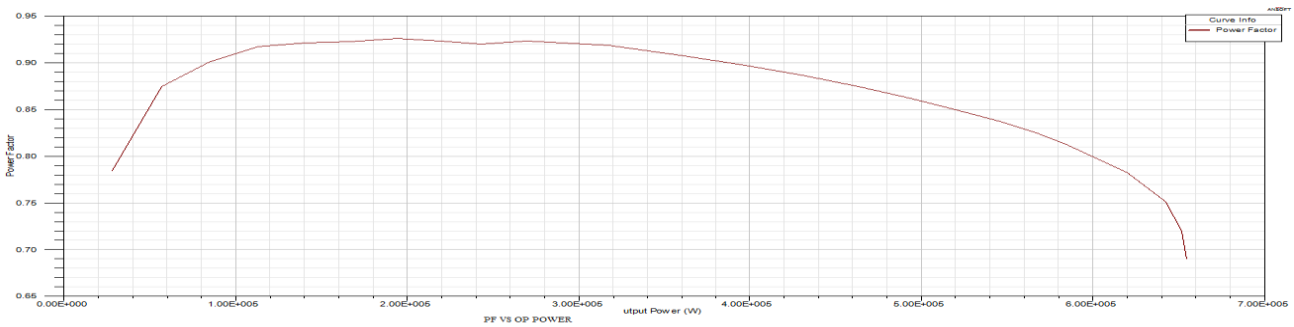


FIG SLIP VS OUTPUT POWER



PF VS OP POWER

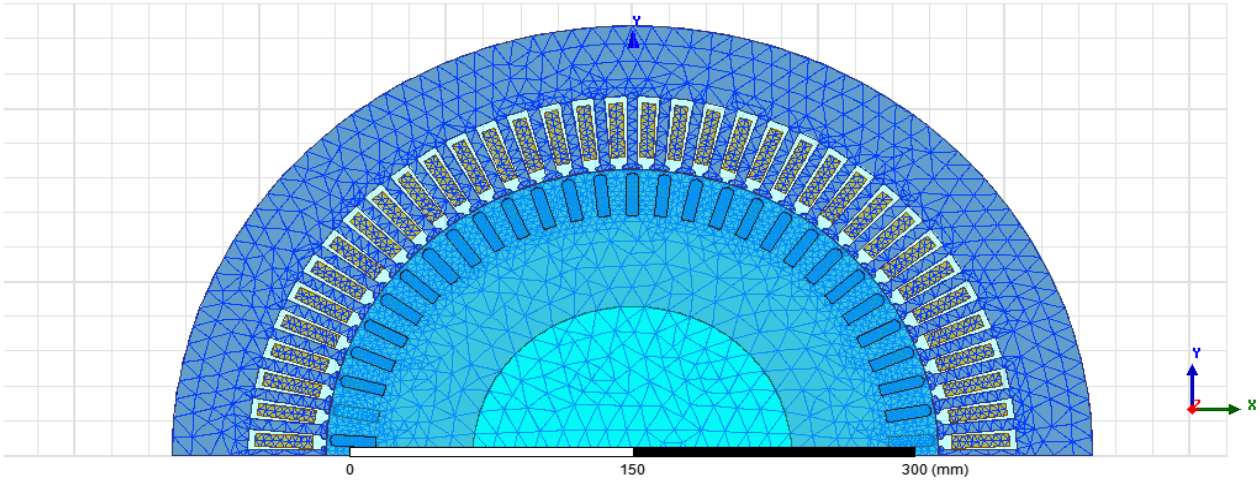


FIG PLOT MESH

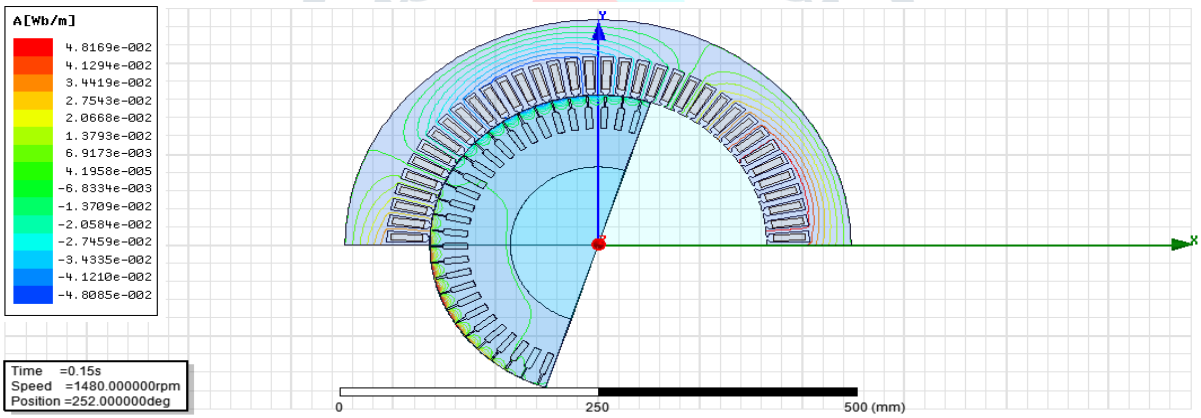


FIG POSITION OF ROTOR AFTER 0.15 S ITH A(WB/M)

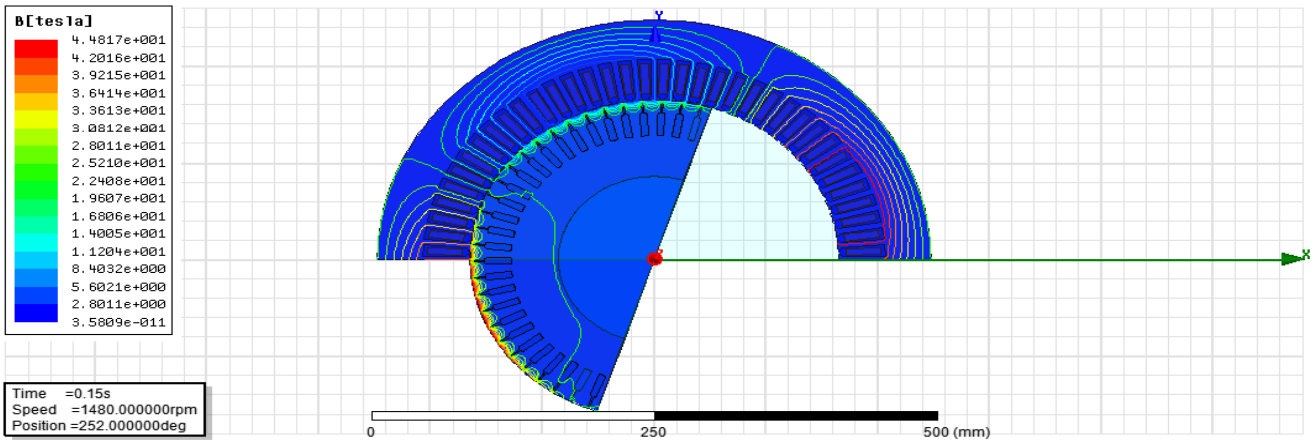


FIG FLUXDENSITY IN IM

IV. CONCLUSION

The ANSYS software can be used to solve various kinds of problems for electromagnetic analysis.Induction motor is designed with considerable parameters and obtained different characteristics.Fem is done for maxell 2D design for IM and gained electromagnetic analysis.

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