Design and Optimisation of 3-Phase Induction Motor

PARESH.S. PARMAR[1], MR.KIRAN.LIMBACHIYA [2]
[1]*PG Student (Power System) / P.I.T Engi.College/ vadodara/Gujarat/.*
[2]Assistant Proffesor of Electrical Department/ P.I.T Engi.College/Vadodara/Gujarat
[1]pareshparmar120@gmail.Com
[2]kiran7487@gmail.com

Abstract:- This paper presents the design of two different speed three phase inductions motor. This motor develops two different speeds in a single machine according to the pole ratio. It, also the presents the optimization technique to increase the efficiency of the machine with help of Maxwell's 14.0 v software. Design is obtained in the RMXprt and the analysis of the machine is done in the Maxwell 2D view. The efficiency is improved by changing the design of slot of the stator of the machine.

Keywords:- Two Speed Induction Motor, Analysis through Maxwell software.

I. INTRODUCTION

The A.C. system is universally used for generation of electricity and so for transmission and distribution on account of its various advantages. As an Electrical drive, A.C 3 phase and single phase Motors are therefore find the wide application in various industries. Out of the so many types of 3 phases A.C Motors the 3 phase induction motor is very popular in the industries due to its advantages.

The main Advantages of 3 phase induction motor are as follows:

- Compact and very simple construction.
- Shape and weight is small in comparison with other types.
- Cheaper in cost.
- Maintenance cost is very low.
- Efficiency is better.
- It is self starting.
- Frictional losses are lesser.

II. Design of Induction Motor : The design of I M consists of,

1. Main dimensions of stator,
2. Design of stator and its winding,
3. Design of rotor,
4. Calculation of Iron losses, copper losses, efficiency, no load current, power factor.

1. Main Dimensions: The Stator bore D and stator core length L are known as the main dimensions of an induction machine.

2. Specific Magnetic Loading (B_{av}): The total flux around the stator periphery at the air gap is called total magnetic loading.The specific magnetic loading depends upon the size of machine,power factor,iron losses,overload capacity.

Total Magnetic Loading = P□

3. Specific Electric Loading (ac): The total number of ampere conductors around the stator periphery is called total Electric loading.the specific electric loading depends upon the copper losses,voltage,size of machine,overload capacity.

Total Electric Loading = I_Z Z

4. Output Equation:

The output of a machine can be expressed in terms of its main dimensions, specific magnetic and electric loadings and speed, the equation describing this relationship is known as output equation.
KVA rating of Machine

$$Q = C_o D^2 L n_s \text{ Where,}$$
$$C_o = 11 B_{av} ac k_w \times 10^{-3}$$

KVA input $Q = kW/\eta \cos\Phi$
$= h.px0.746/ \eta \cos\Phi$

5. Stator Design:

- Choice of Stator winding
- Type or Shape of stator slots
- No. of turns per phase
- No. stator conductors
- Cross-sectional area of stator conductors
- Area of stator slots
- No. of stator slots
- No. of ventilating ducts
- Length of mean turn of stator winding
- Resistance of stator winding
- Dimensions of stator laminations

III. Preliminary design of Induction Motor with two different poles:

Analytical design of the machine can be obtained according to the specifications of the motor as shown in table 1.1.

Design Parameters	4 pole	6 pole
Outer Dia.(mm)	210	210
Inner Dia.(mm)	135	135
Length(mm)	150	150
Rated Output(KW)	3.725	3.725
Supply voltage(v)	415	415
No of Phase	3	3
Speed(RPM)	1500	1000
Frequency(Hz)	50	50
Type of Motor	Squirrel cage	Squirrel cage
Efficiency (%)	89.00%	89.00%
Power factor	0.90	0.90
Winding factor(K_W)	0.95	0.95
Average flux density(**Wb/m^2**)	0.54	0.54
Ampere turns per meter	19000	19000
Output coefficint(C)	107.78	107.78

Design Parameters	4 pole	6 pole
Flux(Weber)	0.01513	0.01008
KVA Input(Q)	4.84	4.84
Stator slots	36	36
Total Stator conductor	776	1164
Pole pitch	0.018	0.018
No of conductors per slot	21	32
Conductors per phase	258	388
Input to the Motor(Kw)	4.2157	4.2157
Full load current(Amp)	3.89	3.89
Curren density	4	5
Ares of conductor(mm)	0.97	0.77
Mean turn length(mm)	0.95	0.83
Resistance of winding(ohm)	8.03	13.07
Copper losses(Kw)	364.98	594.17
Efficiency (%)	89.25	90.40

Table 1.1 [Analytical design of the Motor for Two Different poles]

IV. Analysis of The Induction Motor Through Maxwells 14.0 v Software : About Maxwell 14.0 Software :-

- Maxwell 2D is an interactive software package that uses the finite element method (FEM) analysis to simulate and solve two-dimensional electromagnetic field problems.
- Maxwell 2D is used for analyzing electric and magnetic fields in structures with uniform cross-sections or full rotational symmetry.
- Maxwell 2D is used for field solver such as Electrostatic, Magneto static, Eddy current, DC conduction,AC conduction, Transient.

V. Designing of Induction Motor Using RMxprt :-

This is the whole machine view which is designed in the RMxprt model of Maxwell software.

- Stator Design :
  Steel Material : M 19 26G
  Stator slot : 36
  Outer diameter : 210 mm Inner diameter : 135 mm
- Rotor Design :
  Steel Material : M 19
  Rotor slot : 28

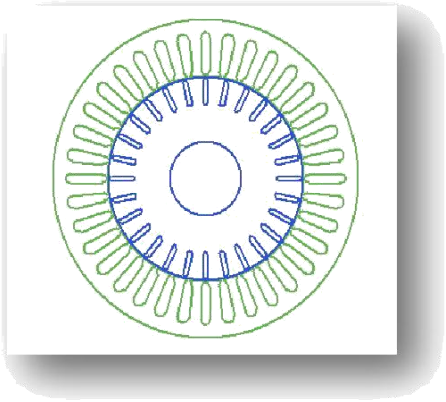

Fig.1.1 [Machine View]

VI. Export RM xprt design in MAXWELL V14.0:

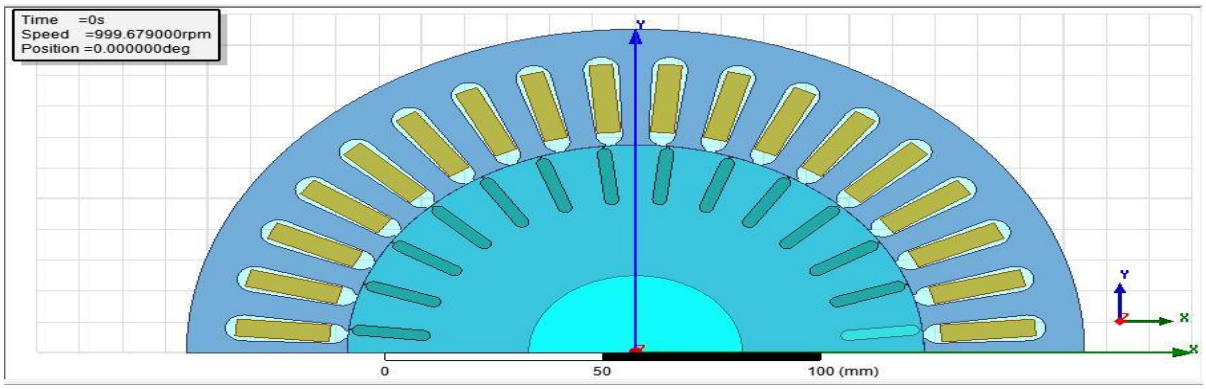

Fig.1.2 [Maxwell 2D Design for 6 pole Machine]

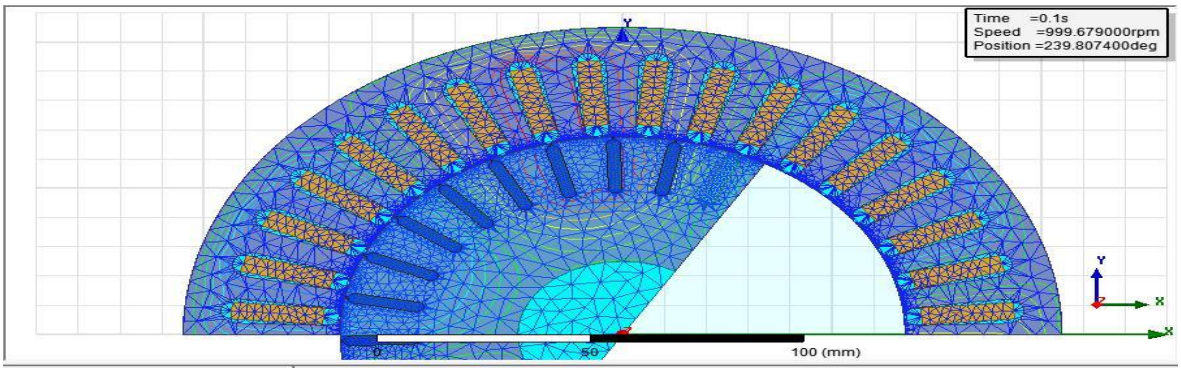

Fig.1.3 [Mesh Operation of The Machine]

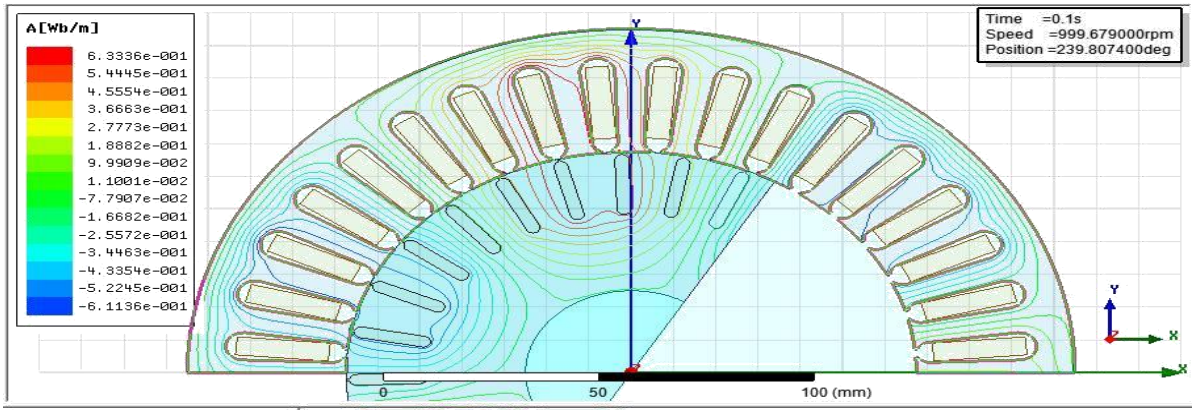

FIG.1.4 [PLOT OF DISTRIBUTING FLUX LINES IN THE MACHINE]

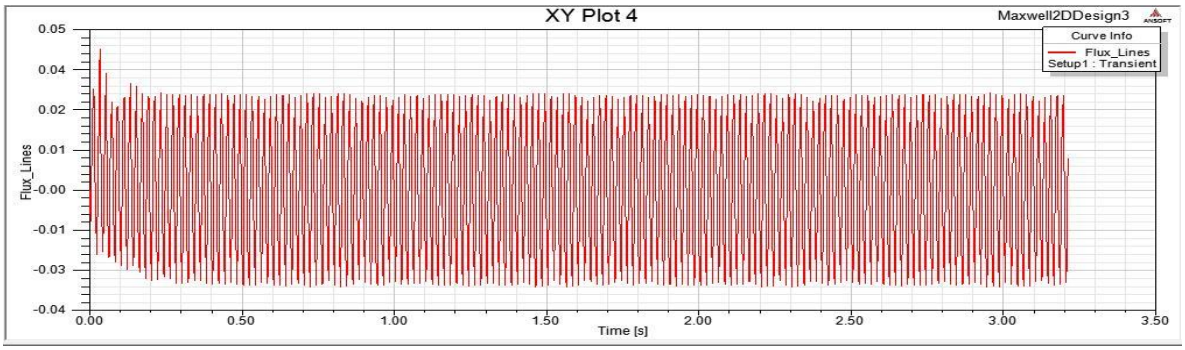

FIG.1.5 [PLOT OF FLUX LINES WITH RESPECT TO TIME]

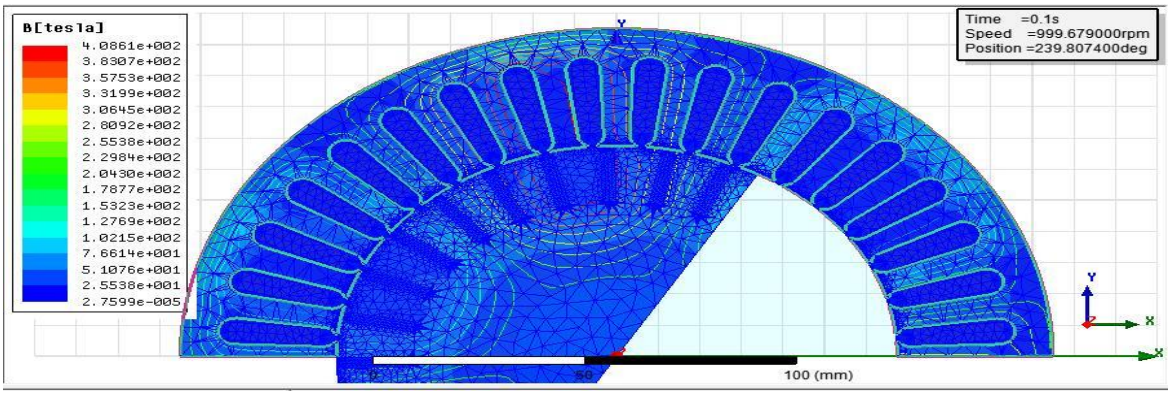

FIG.1.6. [PLOT OF DISTRIBUTING FLUX DENSITY IN THE MACHINE]

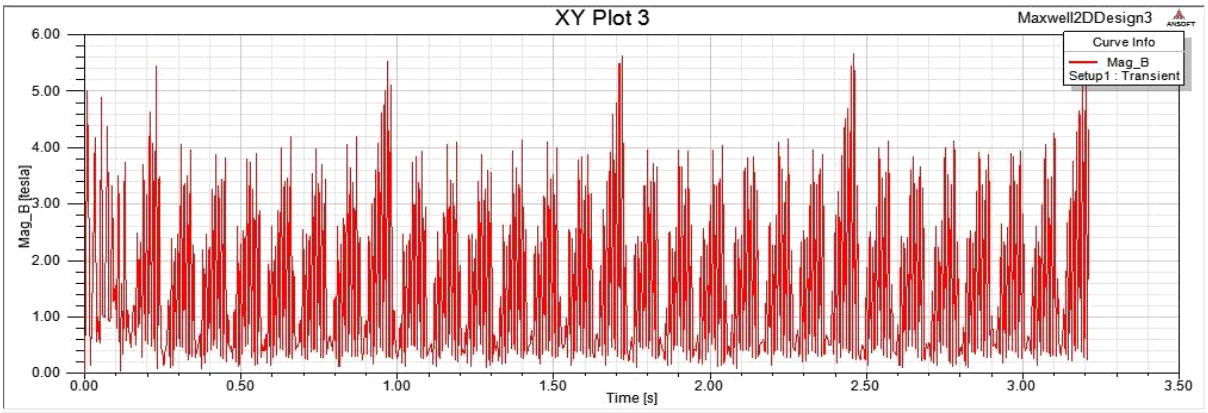

FIG.1.7. [PLOT OF FLUX DENSITY WITH RESPECT TO TIME]

VII. CONCLUSION

In this paper the machine is designed analytically as well as Analysed in the Maxwell software for both the poles 4 pole and 6 pole.Another thing is that the efficieny is increased by changing the design of the stator slot of the machine and compared for both the poles.

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