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Determination of Characteristics of Dc Motors used in Light Motor Electric Vehicles using Inter-Operable Cad & Femm

Dhananjaya B., Satyendra Kumar

Abstract- ***Electric vehicles (EV's) were invented and had been a part of transportation industry before 1900's. Being popular, they had good turn outs in the market till 1918. As the inventions of internal combustion engines grew in the transportation industry, EV's usage started to die. The usage of EV's was totally zero by 1933, due to slow response and high expenses. The shortcomings faced by EV's then, are not overcome totally till date. Advancement in the field of Microelectronics and power electronics have made EV power trains competitive with ICE power trains. The developments in the materials and manufacturing technologies provide optimistic battery. The vital factors that revive EV's: cost of energy, energy independency, pollution free operation. The upcoming shortage of fossil fuels, shortage of supply, growing demands and their cost have made people look around for an alternative mode of transportation. As electricity production can be made from different energy resources, EV's promise to be a future of vehicles. However the recharging can be done when there is excess energy in power utilities. The biggest reason of interest towards EV's is environmental factors such as reduction in air pollution in congested traffics thereby meeting national energy strategy policies***

Index Terms: EV, ICEV, PMBLDC Motor, FEM.

I.INTRODUCTION

Electric vehicles (EV's) were invented and had been a part of transportation industry before 1900's. Being popular, they had good turn outs in the market till 1918. As the inventions of internal combustion engines grew in the transportation industry, EV's usage started to die. The usage of EV's was totally zero by 1933, due to slow response and high expenses. The shortcomings faced by EV's then, are not overcome totally till date. Advancement in the field of Microelectronics and power electronics have made EV power trains competitive with ICE power trains. The developments in the materials and manufacturing technologies provide optimistic battery. The vital factors that revive EV's: cost of energy, energy independency, pollution free operation. The upcoming shortage of fossil fuels, shortage of supply, growing demands and their cost have made people look around for an alternative mode of transportation. As electricity production can be made from different energy resources, EV's promise to be a future of vehicles. However the recharging can be done when there is excess energy in power utilities.

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* Correspondence Author
Dhananjaya B, Assistant Professor grade in the Department of EEE at Canara Engineering College Mangalore.
Dr.Satyendra Kumar, Professor grade in the Department of EEE at NMAMIT, Nitte

The biggest reason of interest towards EV's is environmental factors such as reduction in air pollution in congested traffics thereby meeting national energy strategy policies. The reduction in the quality of air and the emanative effects of greenhouse has made some authorities to set emission-free zones and enforce strict regulations, to promote EV's. EV evolution aims to build merchandising EV's over long period, providing performance, personal luxury, secure, facile operation like ICE counterparts at competitive cost. On this state-of- affairs the evolution of high-performance, mediocre, reliable EV's with better performing batteries are very much needed. The evolution of power train that has high power density, high- efficacy and blended electric propulsion is essential. The torque-speed curve of the drive comprises constant torque region for starting/climbing and constant power region for cruising. It is learnt from literature survey that the bigger vehicles needs smaller torque, power and continuous speed. During early 1900's, EV's failed to meet these specifications resulting the peak speed and performance parameters of the EV's failing to compete on-par with ICEV in urban and rural traffic. The design of EV concentrates on Energy system and Management. The objective of the work is to compare different motors such as PMBLDC, DC and AC using Finite Element Method (FEM) and to build motors with immense power density and efficiency & to develop drives for EV exercise.

FEM primarily determines the fields due to electric and magnetic energy distribution. The entire analysis domain gets divided into small elementary sub-domains, called Finite Elements. It permits analysis of dangerous field gradient, magnetic field strength, saturation etc. reducing computation time. The analysis carried out leads to accurate results due to consideration of air gap.

II.INTRODUCTION TO AUTOCAD

Automatic Computer Aided Design (AutoCad) tool is developed and marketed by Autodesk Inc. It is used for design and drafting of 2-Dimensional and 3-Dimensional layouts. AutoCad being the first CAD program to be executed on personal computer is used in the industry by electrical, Civil, Mechanical engineers and other professionals. The early release had only primitive entities for the construction of complex commodity. Further the support was extended to custom objects through a interface based on C++ application programming. The Latest version incorporates tools for solid modeling. It also contains 3Dimensional support application program interface for automation and object customization. DWG (Drawing) and DWF (Design Web Format) are the native file format in AutoCAD for CAD data interoperability. It is a format developed by Autodesk for publishing CAD data.AutoCAD provides professionals a exclusive drafting tool to bring their unique engineering ideas to reality with the perfection. In this bulge, AutoCAD provides a platform to design mechanical elements, analyze electrical and piping systems and decipher design issues. AUTOCAD helps in engineering elements drawings, design of infrastructure and study of HVAC systems with minimal errors contributing a major part in engineering fields. AutoCAD also supports export of files through its interface to CAD applications to assist building animation projects, structures and architectural plans reducing the production cost. CAD interface helps industries to draft real-time prototypes of object virtually and test the operation during the design process. AutoCAD assists the design of initial prototype and simulate the working before the actual production. The virtual prototype can be used by the designers for presentations during advertising.

III.INTRODUCTION TO FEMM

FEMM is a package of programs for solving low frequency electromagnetic problems on 2D planar and 3D axisymmetric. The program articulates problems like linear/nonlinear magneto- static, linear/nonlinear time harmonic magnetic, linear electrostatic, and steady-state heat flow.

FEMM has three major divisions:

Interactive shell (femm.exe). This suite is a Multiple Document Interface for the different types of problems solved by FEMM. It has a interface similar to CAD to draw the outline of the issue to be addressed, to define properties of material and periphery conditions. DXF files are imported from AUTOCAD to analyze existing design .This allows the display of field solutions in terms of contour and density. It permits the user to inspect field strength in arbitrary points and calculate different integrals with plotting of various quantities along defined contours.

Triangle.exe.:being a vital part of FEMM splits down the elucidation region into smaller triangles of various numbers.

Solvers(fkern.exe: for magnetics; belasolv: for electrostatics, hsolv: for heat flow problems and csolv: for current flow problems) The values of desired fields are obtained by solving the partial differential equations from the data set describing the problem.

A scripting language called “Lua” is embedded into the interactive shell. The latest version of FEMM entertains only one instance of scripting language to be running at a time. This helps in developing and analyzing the layout, thereby evaluating the post processing outcomes. The mathematical expressions and equations are entered into the edit boxes of user interface with the corresponding numerical values. The expressions and equations in any edit boxes can be evaluated by using selection menu through the right button of the mouse.

This aims at giving a brief description to the user regarding the problems that FEMM solves. Here enough boundary conditions are assigned to pointers to get a solvable problem.

Assumptions are made between electromagnetism Maxwell’s, since the material cannot be reviewed within the scope of the. Several references have been found to understand the derivation and solution of Maxwell’s equations. Plonus’s Applied electromagnetic is a good introductory level understanding for magnetic and electromagnetic problems. Hoole’s Computer-aided analysis and design of electromagnetic devices gives intermediate level views on Maxwells equations. Jackson’s Classical electrodynamics provides advanced treatment. White’s Heat and mass transfer for Thermal problems and Haberman’s Elementary applied partial differential equations to understand the derivation and solve steady-state temperature problems.

IV.METHODOLOGY

DXF IMPORT/EXPORT

Import/Export is a common feature available with all modes of preprocessor. FEMM allows only 2D DXF files to be imported effectively.

To start the import, select Import *DXF off* of the File menu. A dialog box asking for tolerance will appear. This tolerance defines maximum distance between two points. The default tolerance values are enough, however at times it has to be increased to facilitate importing. FEMM cannot get all tags in the DXF file. It strips the commands included with geometry and rest are ignored.

DXF import facilitates the user to sketch any layout using the CAD package. The layout is sketched, and imported to FEMM. Details such as properties of material and boundary conditions are to be defined. The importing process will be time consuming as the process needs to do lot consistency checks to convert the DXF file into finite element geometry. The final geometry will be exported to DXF form by choosing the option from menu in the preprocessor window, which in turn is imported to Cad package to assist the mechanical detailing for final design.

Specifications of Light electric Vehicle

Vehicle Mass including Commuter	200 Kg
Max Power Output	1.5KW
Battery	2.16 KWh
Tyre size	1000 Â 300
City estimated Range	50 Km
Top Speed	50 Kmph
Acceleration	0.65 M/s^2

Drag Co-efficient	0.6
Slope angle	12 Deg

Technical Specifications of Motor drive

Rated Voltage	48 V (DC)
Rated Power	500 W
Rated Torque	1.27 N-m
Rated Speed	3000 Rpm
Rated Current	11.4 A
Max Current	34.2 A
Max Torque	3.81 N-m
Motor Length	130 mm
Motor weight	1.67 kg

SQUIRREL CAGE INDUCTION MOTOR

After drawing the two dimensional figure of the squirrel cage induction motor in Auto-Cad to the required dimensions and importing it to the FEMM Software.

There are following steps to be followed

1. Inserting of materials for Squirrel Cage Induction motor

This is the inserting step. Under this we insert the various materials of the stator and Rotor by selecting the materials from the library. It also includes the steps to inserting the number of turns and supply current. We selected the boundary condition as air.

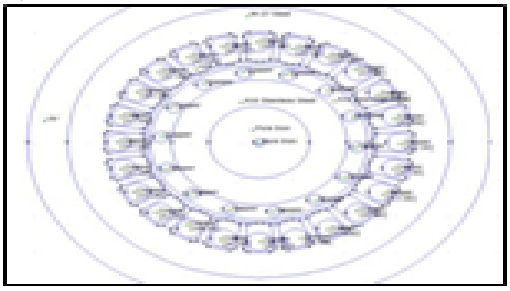


Fig1.Insertion of materials using CAD

2. Creating the mesh and run the crank case

i) Process of generating mesh

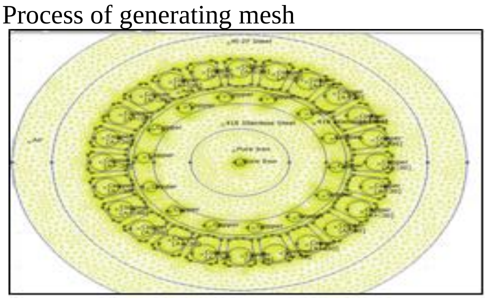


Fig 2.Mesh Creation

ii) After the completion of generating mesh proceed with crank solutions.

The mesh is generated only when the closed area is filled by specified materials. If any part is not specified then the mesh will not be generated.

Fig3. Running mesh for crank solution

3.Flux Lines Generation

Once the mesh is generated the flux lines can be observed. The below graph represents the magnetic flux lines across the motor.

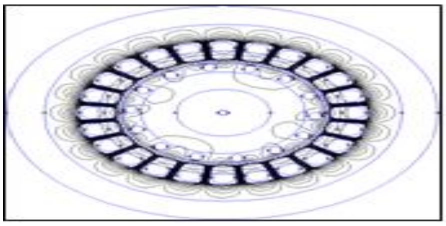


Fig 4.Generated flux lines

4.Selecting the area across the motor to get the characteristics required

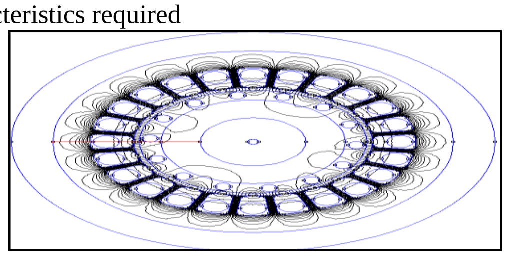


Fig 5.Area selection for characteristic

5. Checking the flux density

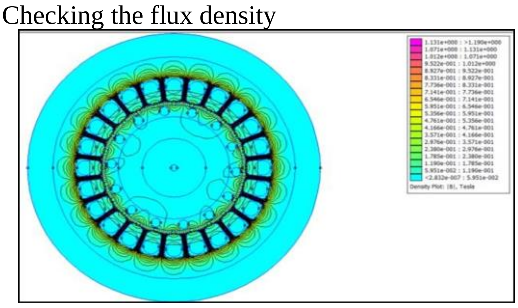


Fig 6.Flux density

6. Grey scale representation for flux density distribution

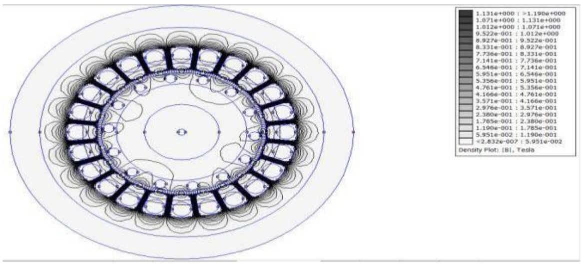


Fig 7. Grey scaling of flux density

This is the method used to calculate the magnetic field co energy in the motor. Here we will get an option to select the area, we need to calculate the magnetic field co-energy.

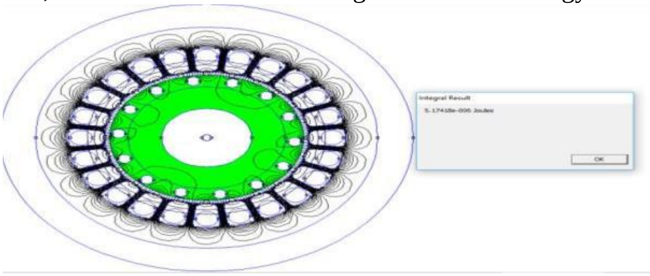


Fig.8. Magnettic Field co-energy

8. Calculation of Magnetic field energy

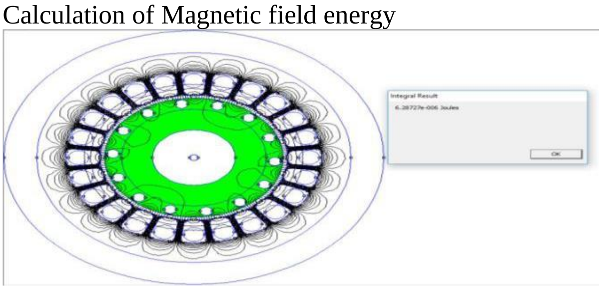


Fig 9. Calculation of Magnetic field energy

Plot of magnitude of Magnetic flux density vs length of selected line This is the magnitude of Magnetic flux density vs length of selected line plot. The initial peak of the curve represents the magnetic flux density in the stator. Next decrease in the waveform represents the flux cutting in the conductors. The second peak gives us the value of flux lines present in the air gap.

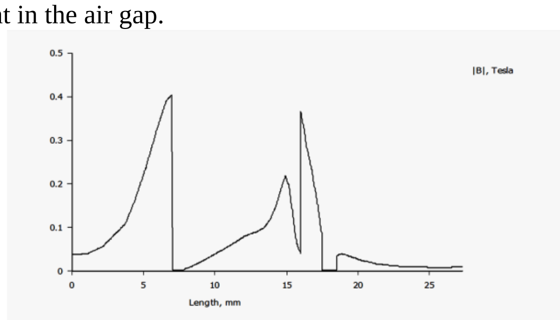


Fig 10. Plot of magnitude of Magnetic flux density vs length of selected line

Plot of Magnitude of Magnetic field intensity vs length of selected lines This is the graph representing the magnetic field intensity v/s length of selected line. The peak value represents the value of maximum field intensity across the selected line.

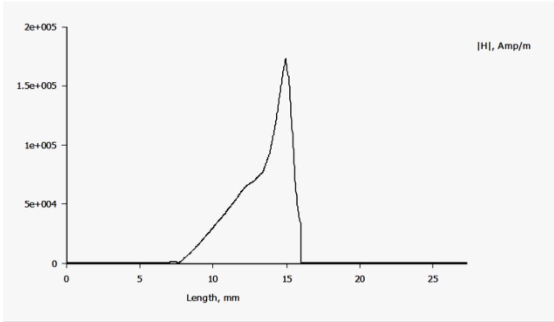


Fig11. Plot of Magnitude of Magnetic field intensity vs length of selected line

BLDC MOTOR

After drawing the two dimensional figure of the squirrel cage induction motor in Auto-Cad to the required dimensions and importing it to the FEMM Software.

These are following steps to be followed

1. 1.Inserting of materials for BLDC motor

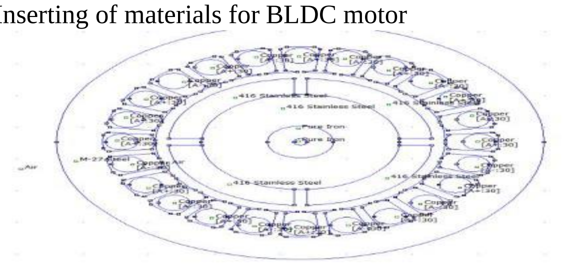


Fig 12. Insertion of materials using CAD

2. Creating the mesh and run the crank case

i) Process of generating mesh

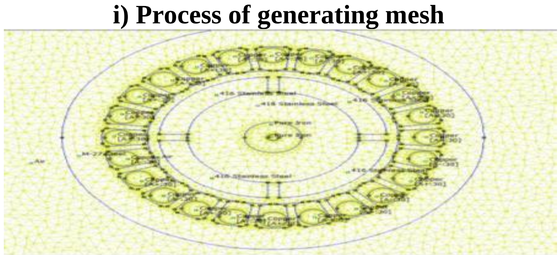


Fig 13. Mesh Creation

After the completion of generating mesh proceed with bcrank solutions, The mesh is generated only when the closed area is filled by specified materials only then it can be preceded. If any part is not specified then the mesh will not be generated.

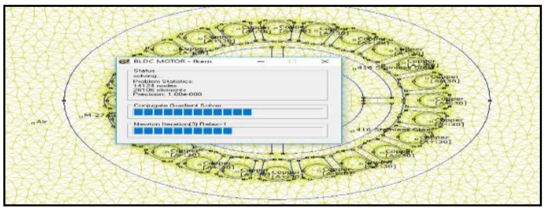


Fig 14. Running mesh for crank solution

3. Checking the flux density

This step is useful to get the flux density across the motor. The area which is shown by the pink color is the higher flux density regions. The area which is shown by blue color is lighter flux density areas

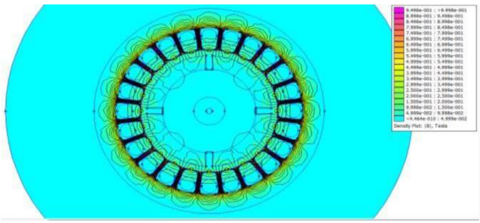


Fig 15. Flux density

4. Selection of area across the motor to get the required characteristics This is the very important step to get the required characteristics of the motor. Here we select the area across the motor where we need to get the required plot.

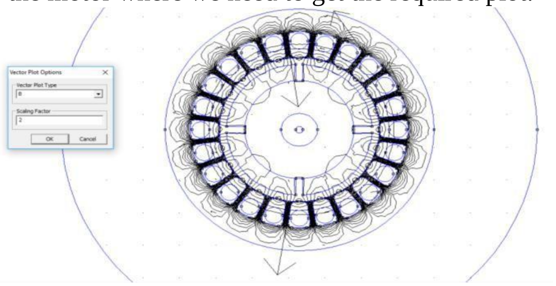


Fig 16. Area Selection for characteristic

5. Grey scale representation for flux density across the motor.

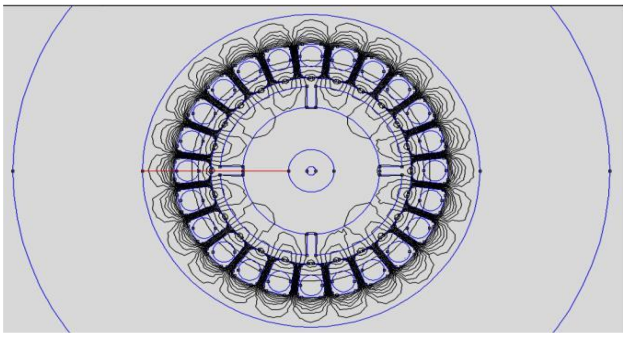


Fig 17.Grey Scale representation of Flux density field

6. Finding the vector direction of Magnetic field

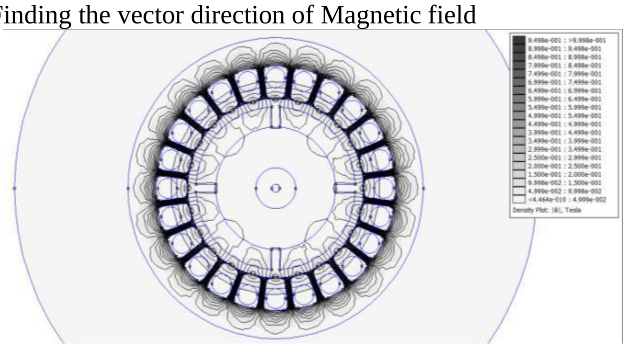


Fig 18. Vector direction of field

7. Calculation of Magnetic field co energy

This is the method used to calculate the magnetic field co energy in the motor. Here we will get an option to select the area we need to calculate the magnetic field co-energy.

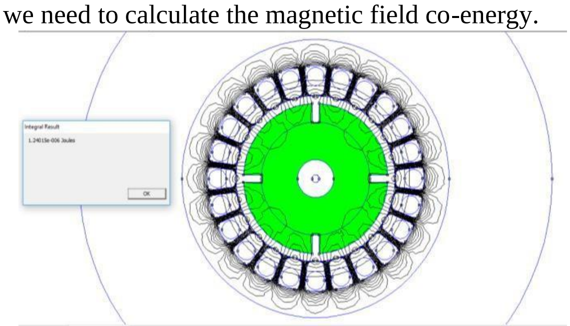


Fig 19. Magnetic field co-energy calculation

8. Calculation of Magnetic Field Energy

This is similar to the magnetic field co energy calculation. We select the area across motor where we need to calculate the magnetic field energy.

Fig 20.Magnetic field energy calculation

9. Plot of Magnitude of Magnetic field intensity v/s length of selected line

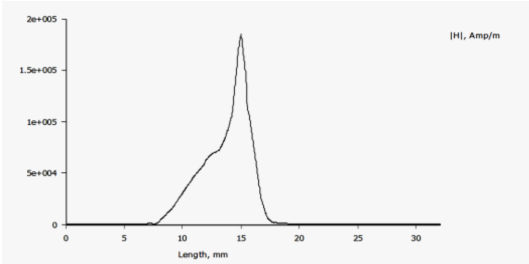


Fig 21. Plot of Magnitude of Magnetic field intensity v/s length of selected lines

PMBLDC MOTOR

PMBLDC motor is a permanent magnet brushless DC motor. After drawing the two dimensional figure of the permanent magnet brushless DC motor in Auto Cad to the required dimensions it is imported to the FEMM Software.

1. Inserting the materials of different parts of PMBLDC motor

This is the inserting step. Under this we insert the various materials of the stator and Rotor by selecting the materials from the library. It also includes the steps to inserting the number of turns and supply current. We selected the boundary condition as air

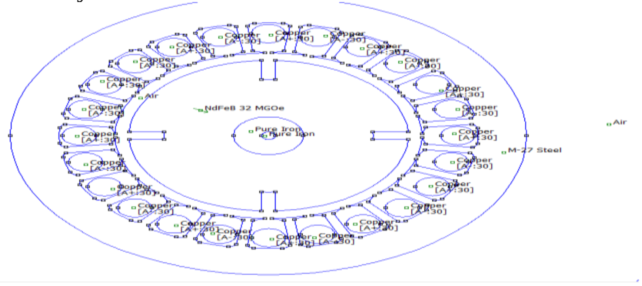


Fig 22.Material insertion using CAD

2. Creating the Mesh for PMBLDC motor and crank case running

i) Generating the mesh for PMBLDC motor

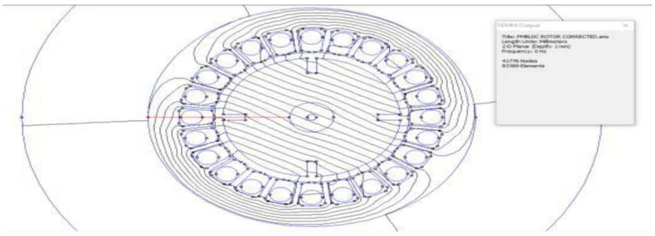


Fig 23. Mesh Creation

ii) After the completion of generating mesh proceed with crank solutions

The mesh is generated only when the closed area is filled by specified materials. If any part is not specified then the mesh will not be generated.

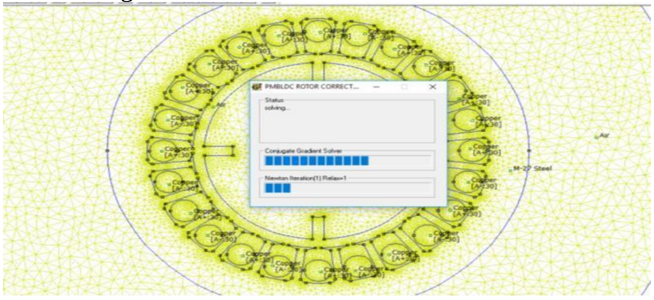
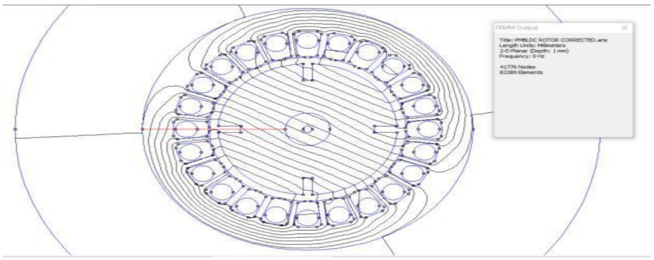


Fig 24. Running mesh for Crank Solution

3. Checking flux density

After the creation of mesh the flux lines distributed across the motor can be observed. Since it is a PMBLDC motor we



can observe the more number of flux lines cutting the rotor

Fig 25. Flux distribution

4. Selection of area across the motor to get the required characteristic curves

This is the very important stage. In this we draw a line through where we need to calculate the necessary parameters like magnetic flux density and magnetic field strength.

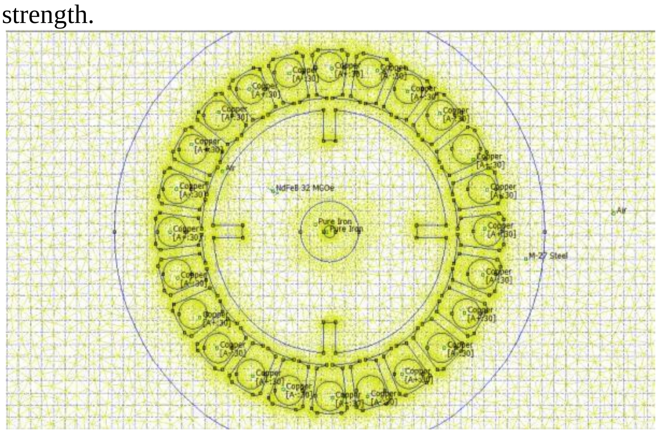


Fig 26. Area selection for characteristics

5. Grey scale representation for flux density distribution

The grey scale plot is similar to the density plot it helps in the better understanding of the magnetic flux density

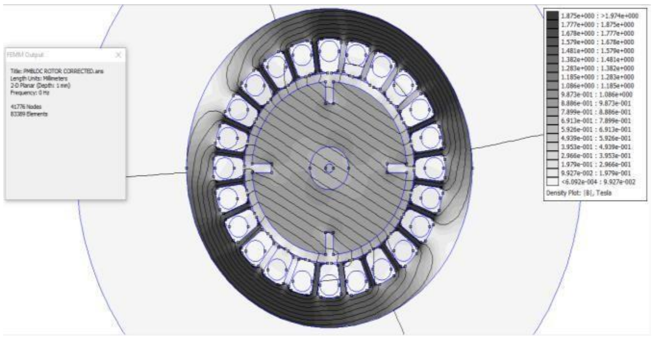


Fig. 27 Grey scale representation for flux density distribution

6. Finding the vector direction of Magnetic field

It is used to get the magnetic field vector showing the directions of the field lines across the stator and rotor.

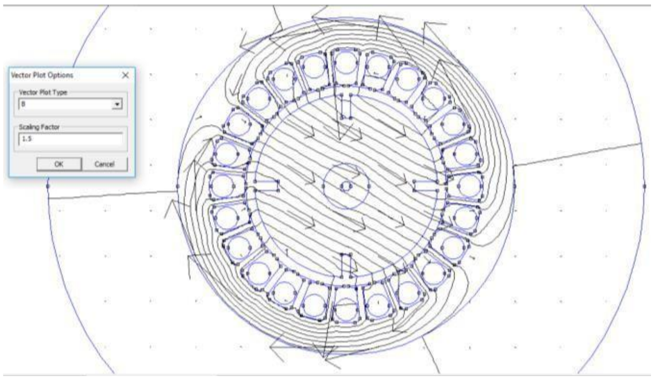


Fig. 28. Vector direction of Magnetic field

7. Calculation of Magnetic field co energy

This is the method used to calculate the magnetic field co energy in the motor. Here we will get an option to select the area we need to calculate the magnetic field co energy.

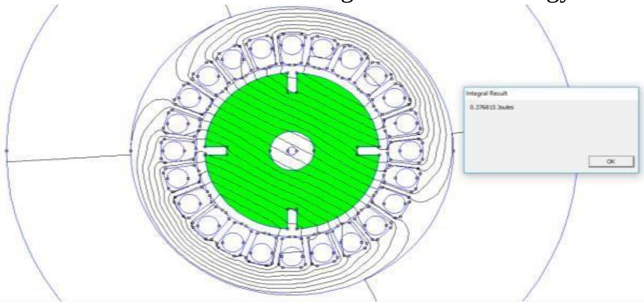


Fig 29. Magnetic field co-energy calculation

8. Calculation of Magnetic field energy

This is similar to the magnetic field co energy calculation. We select the area across motor where we need to calculate the magnetic field energy

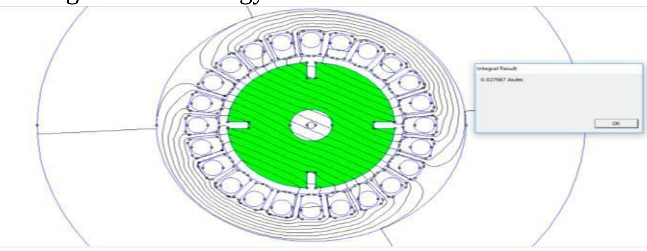


Fig. 30. Magnetic field energy calculation

9. Plot of Magnitude of Magnetic field intensity vs length of selected lines

This is the graph representing the magnetic field intensity v/s length of selected line. The peak value represents the value of maximum field intensity across the selected line.

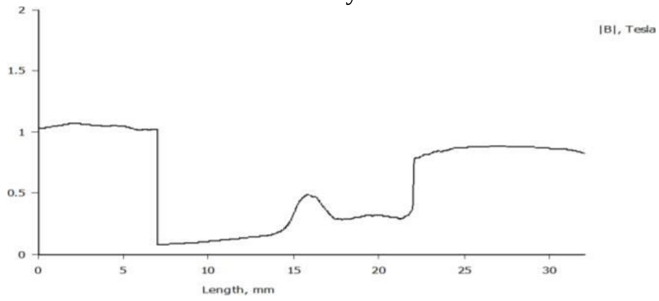


Fig. 31. Plot of Magnitude of Magnetic field intensity vs length of selected line

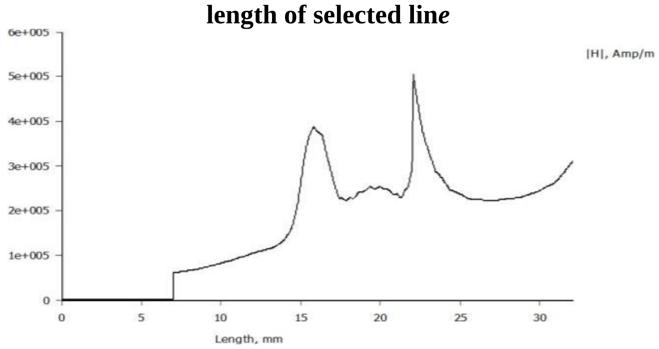
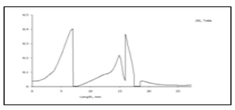
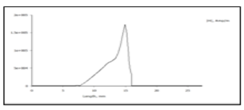
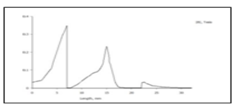
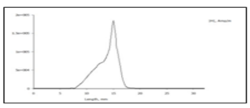
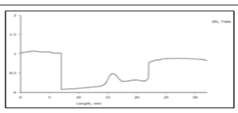
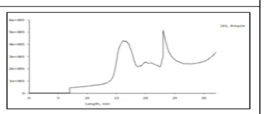


Fig.32.Plot of magnetic field density vs length of selected line

V.RESULTS

Comparison between the Motors

Table 1.Comparison of characteristics of Motors

NAME OF THE MOTOR	MAGNETIC FLUX DENSITY PLOT	MAGNETIC FIELD INTENSITY PLOT
SQUIRREL CAGE INDUCTION MOTOR	 |B| = 0.38 Tesla	 |H| = 1.7*10^5 Amps/m
BLDC MOTOR WITH 2mm AIR GAP	 |B| = 0.23 Tesla	 |H| = 1.9*10^5 Amps/m
PMBLDC MOTOR WITH 2mm AIR GAP	 |B| = 0.59 Tesla	 |H| = 4.5*10^5 Amps/m

VI.CONCLUSION

In PMBLDC motor the magnetic field intensity is greater thus indicating that the variation of flux still does not give major problems to the electric vehicle. The Magnetic Flux Density(b) tesla value is considerably high thus proving it to be more highly efficient and reliable.The comparison of the squirrel cage induction motor, blushless dc motor and permanent magnet brushless dc motor is completed successfully. The efficient motor that is permanent magnet brushless dc motor in the project is obtained. The comparison done and concluded that PMBLDC is best suited for the electric vehicle because of its uniform flux distribution characteristics and torque characteristics. The comparison study between squirrel cage induction motor, BLDC and squirrel cage induction motor, BLDC and PMBLDC we can choose PMBLDC for uniform flux density. This study is based on flux distribution without applying load. The future scope is to improve by changing air gap and also doing 3 dimensional analysis for speed torque.

REFERENCES

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AUTHORS PROFILE

Dhananjaya B is presently working in the Assistant Professor grade in the Department of EEE at Canara Engineering College Mangalore. He has pursued his Bachelor degree in EEE and M.Tech in Microelectronics and Control systems from VTU, Belagavi. He is presently pursuing his Doctoral studies in the field of Motors and Drives, His areas of interest are Power Electronics, Micro-Electronics, Motor Drives and Electric vehicles.

Dr.M Satyendra Kumar Shet is presently working in the professor grade in the department of EEE at NMAMIT, Nitte. He has pursued his Bacheor degree in electrical from Mangalore university. M.Tech in Power Electronics from Bangalore University and Doctoral Degree in Power Electronics and Drives from NITK, Suratkal. His areas of interest are Power Electronics & Drives, Renewable energy Systems, switch mode power converters, Energy audit and energy management and Electric Vehicles.