Loyola – ICAM College of Engineering & Technology (LICET)

Department of Electrical & Electronics Engineering

OPTIMIZATION IN PMSM FOR ELECTRIC VEHICLE

EE 8611 MINI PROJECT

BATCH NO: A6

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CONTENTS

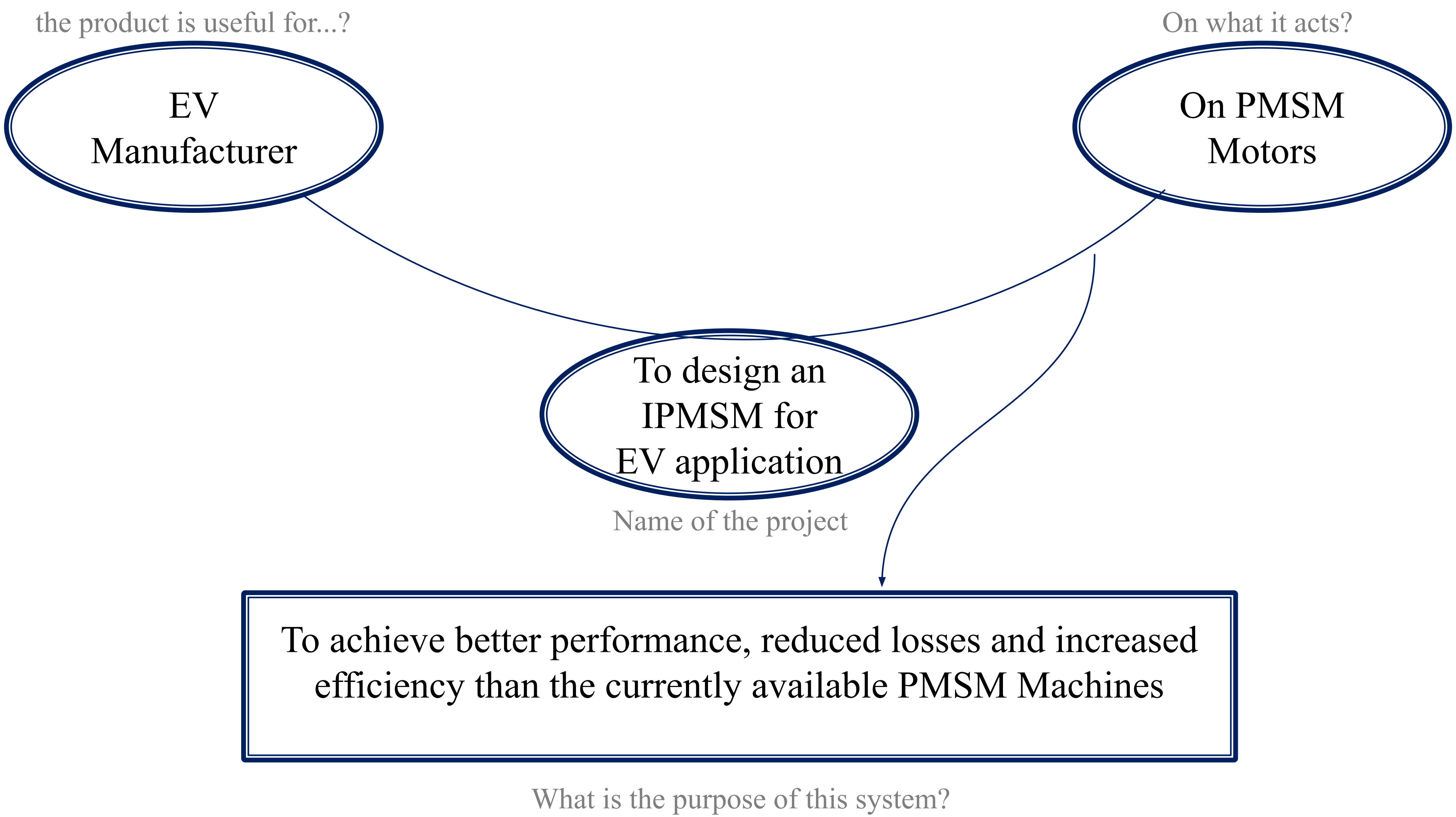
OBJECTIVE

- To design and simulate IPM PMSM using FEA for the specific EV Application.
- The power rating is fixed to 11KW as it is used in the existing EVs.
- To theoretically calculate the stator dimensions and slots based on the required design.
- To select the magnet shape and material of the Permanent magnet mounted on the Rotor
- Verify the design and simulate to estimate the losses in the PMSM.
- To consider the factors affecting the losses and use one of the methods to reduce the losses.
- Obtain the final output results of the PMSM motor using finite element analysis.
- To analyze the future scope in the design of the PMSM motor.

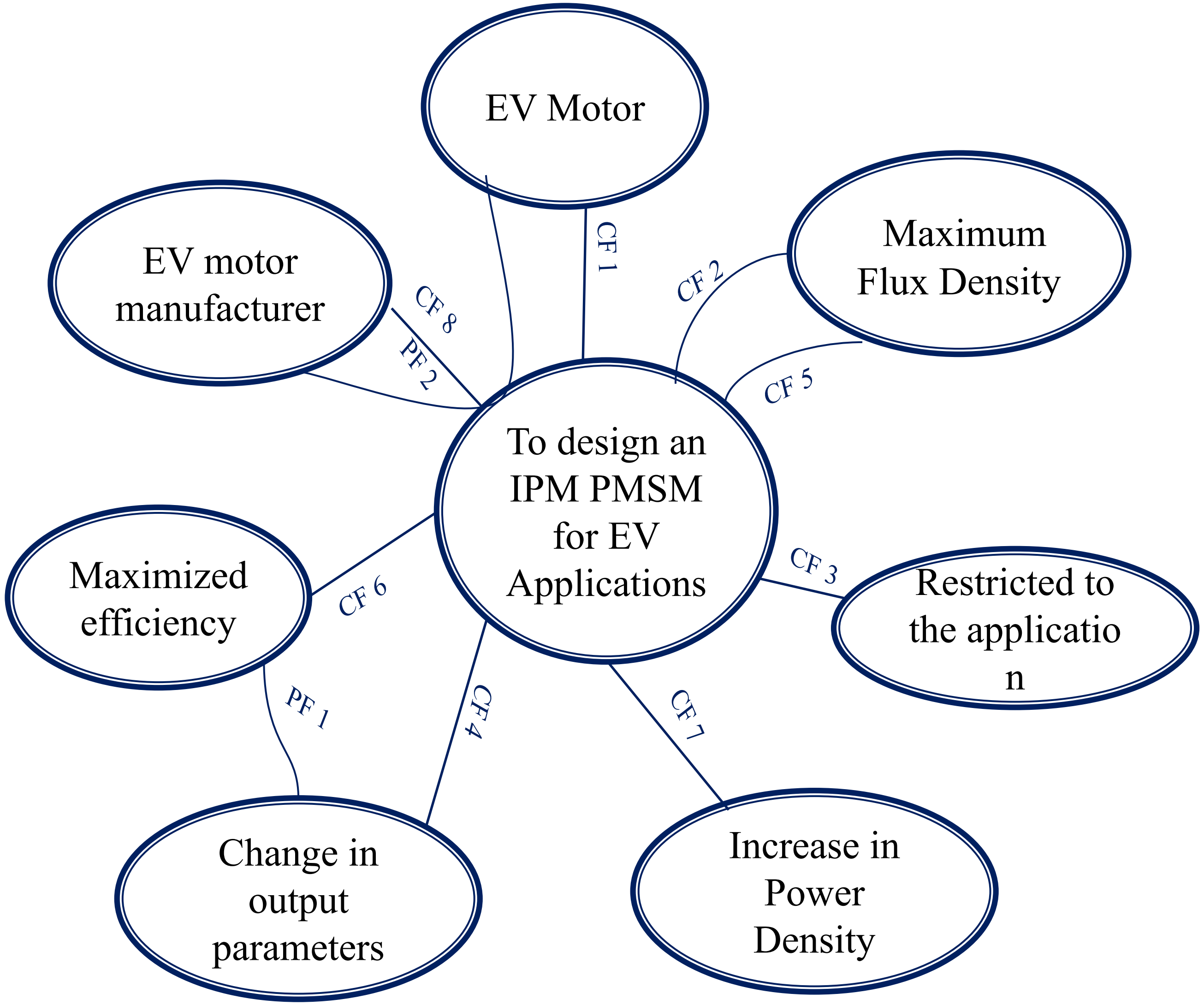
INTRODUCTION

The standard PMSM design used in electric vehicles as well as an improved version that uses magnet thickness modification are both investigated in this study. With the aid of sophisticated FEA simulations and analytical calculations, the ideal magnet thickness for the PMSM rotor may be determined. This research has the potential to increase the technical reliability of electric vehicles and make them more appealing to a wider consumer base.

NEED ANALYSIS – BULL DIAGRAM



FUNCTIONAL ANALYSIS – OCTOPUS DIAGRAM



Principal Functions (the product links two external elements)	
PF1	To conduct a comparative analysis between the existing PMSM design and an optimised design with altered magnet thickness.
PF2	To optimise the rotor design to help improve the performance and efficiency of PMSMs
Constraint Functions (the product links one external element)	
CF1	To provide smooth function with the advancement
CF2	Achieving Maximum Flux Density
CF3	Designed based on the required application in this case for EV Three Wheelers.
CF4	Change in the dimension yields to increase in power density, Such as thickness of the magnet
CF5	The power supply is given to Motor from the battery through Inverter Circuitry
CF6	Improved efficiency at rated Speed.
CF7	Reduced Power Consumption
CF8	Industry will be benefited by the advancement in the motor

TECHNICAL ANALYSIS – FAST DIAGRAM

How?

Why?

Principal Function → **Technical Function** → **Elementary Function** → **Technical Solution**

PF1 To conduct a comparative analysis between the existing PMSM design and an optimized design with altered magnet thickness

- **TF11**
  - **EF111** Change in rotor magnet material → **TS1111**
  - **EF112** Change in rotor magnet thickness → **TF1121**

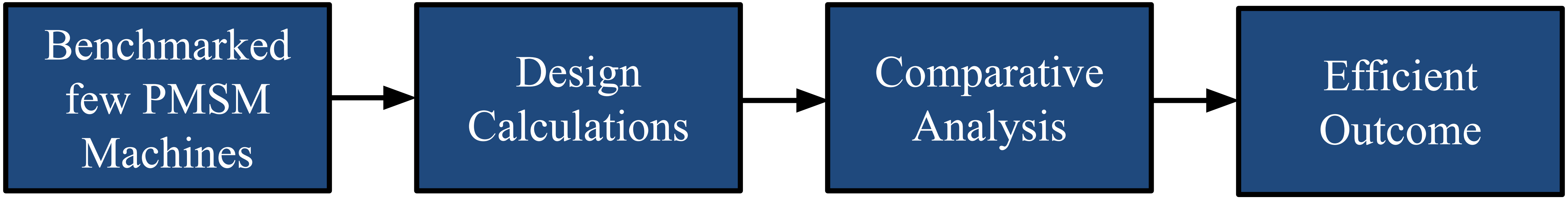
PF2 To optimize the rotor design thereby improving the performance and efficiency of PMSMs

- **TF21**
  - **EF211** Performance between initial and optimized designs are compared → **TS2111**
  - **EF212** Results shows low cogging torque and improved efficiency range → **TS2121**

PROPOSED METHOD

Analytical calculations and FEA simulations are used in a comparative analysis to improve the rotor design of electric three-wheelers. High torque output, better efficiency, fewer losses, and enhanced flux distribution are all guaranteed by the optimised design with the changed magnet thickness. With this design, electric three-wheelers perform better and uses less energy which increases their use and appeal to consumers.

PROCESS DIAGRAM



DESIGN CALCULATION

Rated Power	11 kW
Maximum Speed	1500 rpm
Peak Torque	90 Nm
Air Gap Length	0.5mm
Stator Slots	36
Rotor Poles	12
Supply Voltage	415 V
Magnetic Material	NdFeB
Magnet Thickness	4.25mm

The equation used to find the diameter and length

D2L = Q/C0Ns --------- (1)

D - diameter of the inner stator

L - Length of the inner stator

Where Q is ;

Q = power rating / efficiency x Power factor --------- (2)

Ns = 120 f/P ---------- (3)

Stator slots;

Sss= D/15 ---------- (4)

Where stator slot pitch can be in the range

Yss= 15 to 25 mm

Sss = m x p x q

m - number of poles

p - number of phases

q - slots/ pole / phase

Average flux density Bavg

Bav = P /DL ------------ (5)

Tph= Es/ 4.44 f m Kwm ------------ (6)

Where;

Tph - is the torque developed per phase.

SIMULATION MODEL

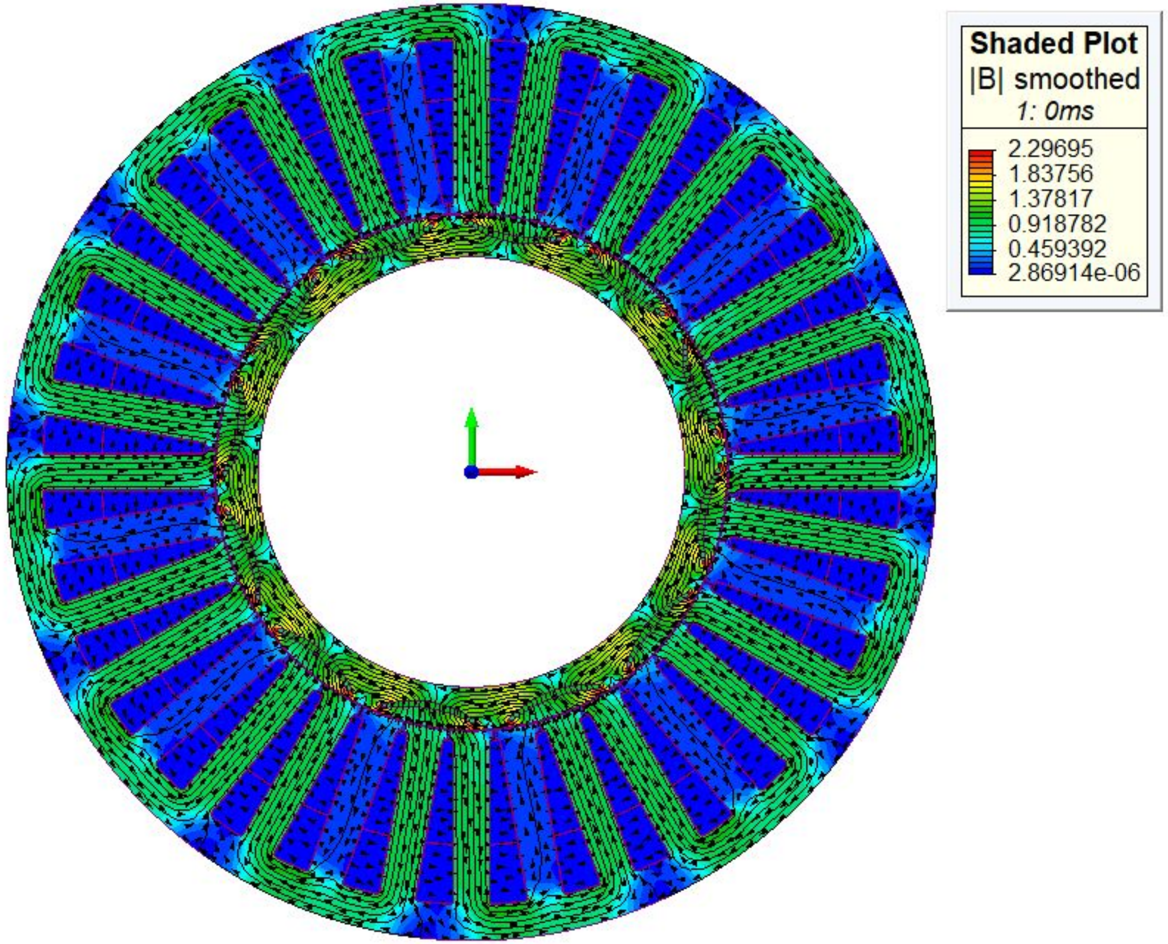


Image 1.1 Magnetic Flux Path

RESULT ANALYSIS AND DISCUSSION

For NdFeB type magnet having an air gap of thickness 4.25mm

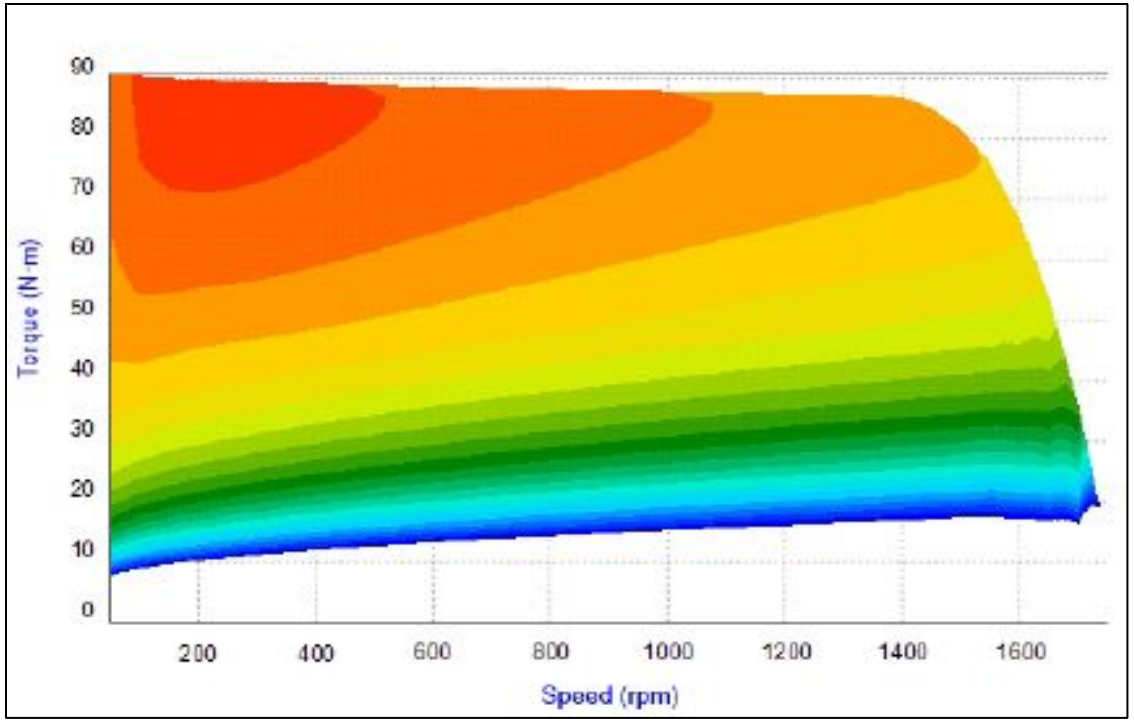


Image 1.2 Efficiency

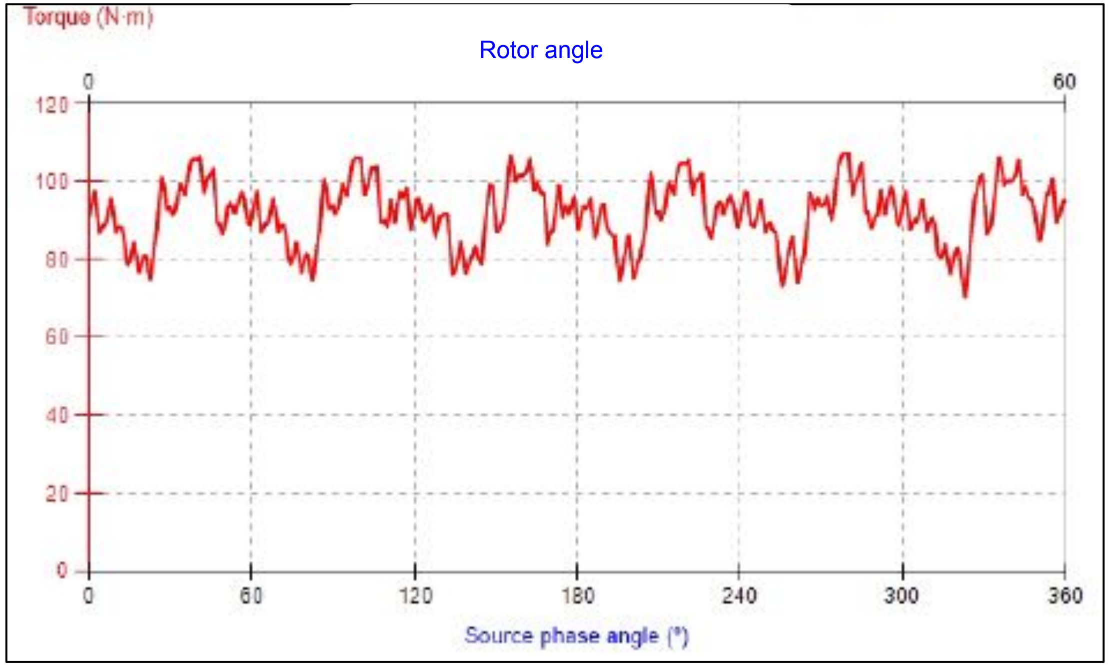


Image 1.3 Electromagnetic Torque

RESULT ANALYSIS AND DISCUSSION

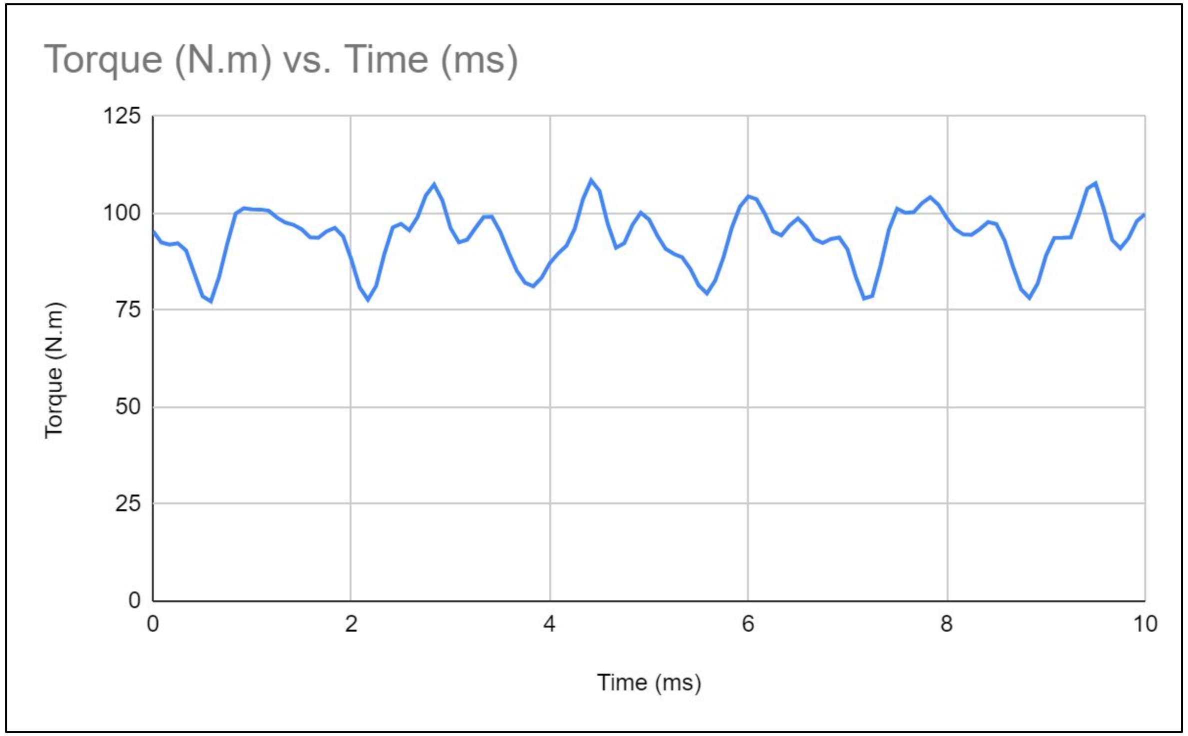


Image 1.4 Torque graph of magnetic thickness 4.25mm

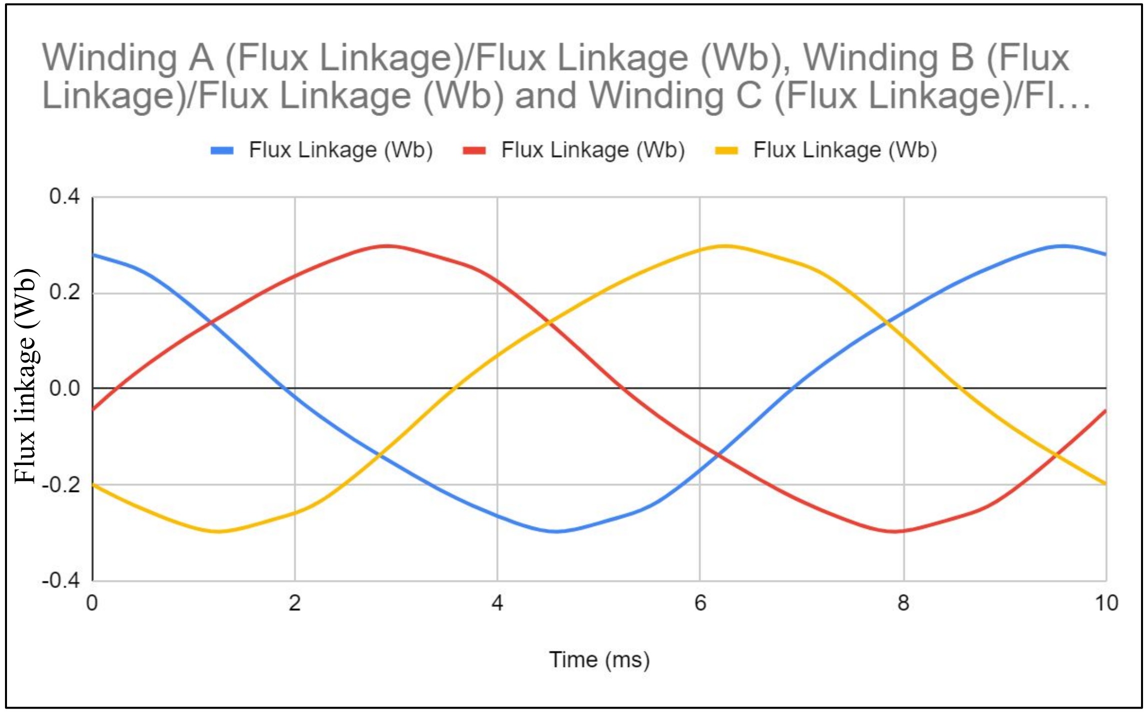


Image 1.5 Flux linkage graph of magnetic thickness 4.25mm

RESULT ANALYSIS AND DISCUSSION

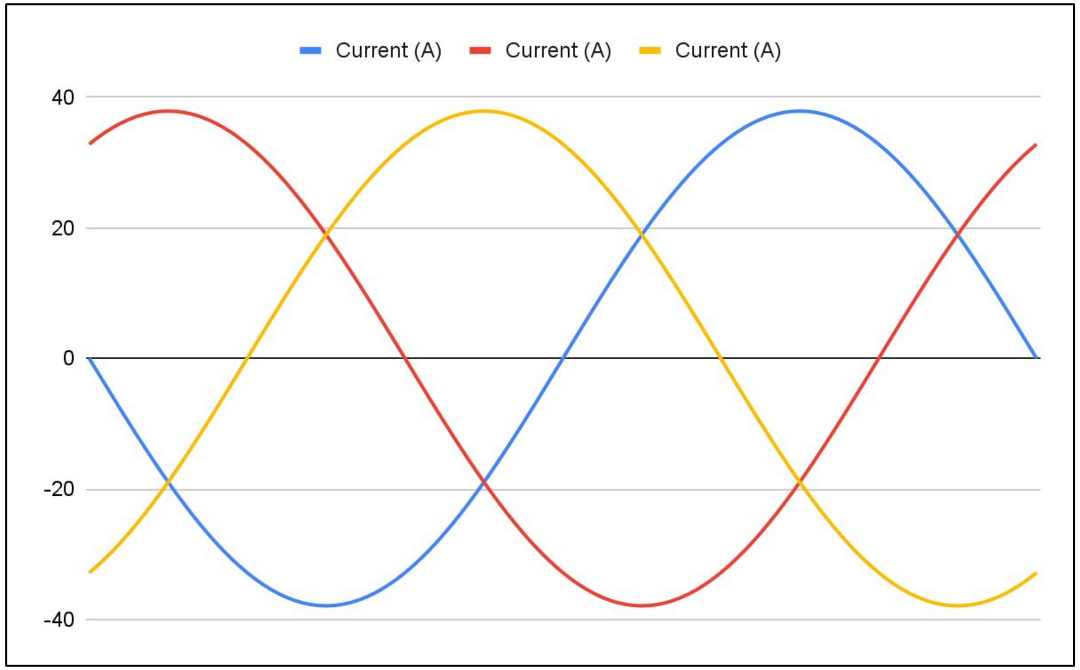


Image 1.6 Current

RESULT ANALYSIS AND DISCUSSION

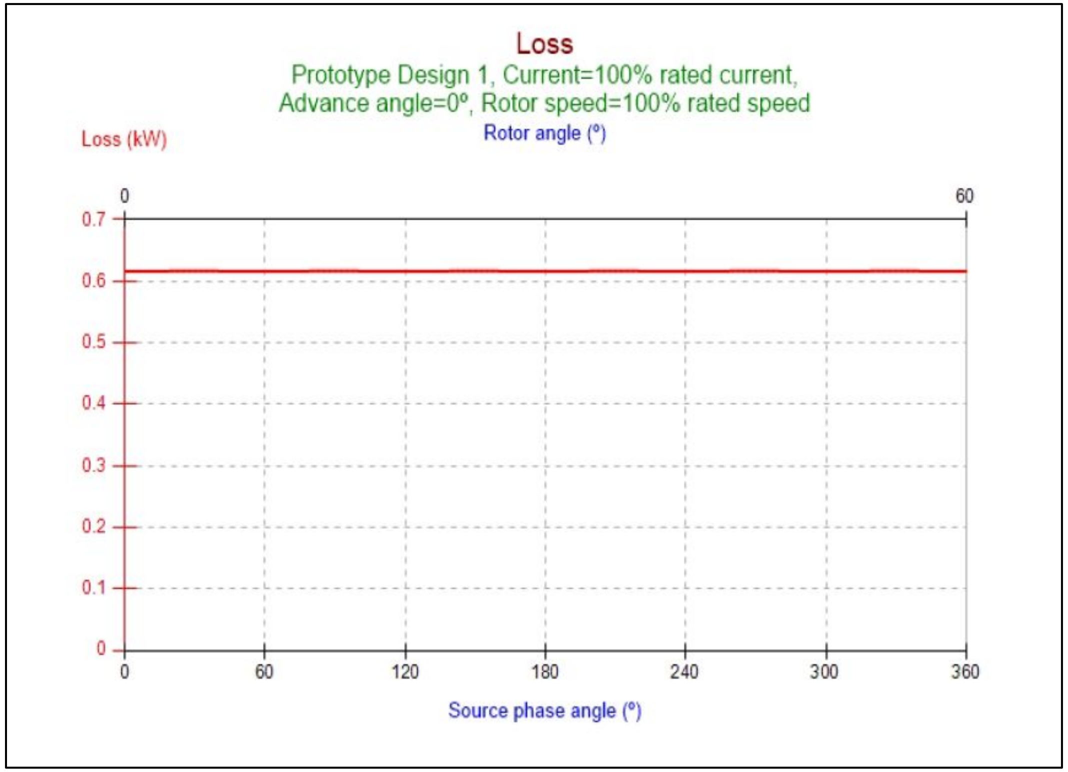


Image 1.7 Iron loss of 4.25 Magnetic Thickness

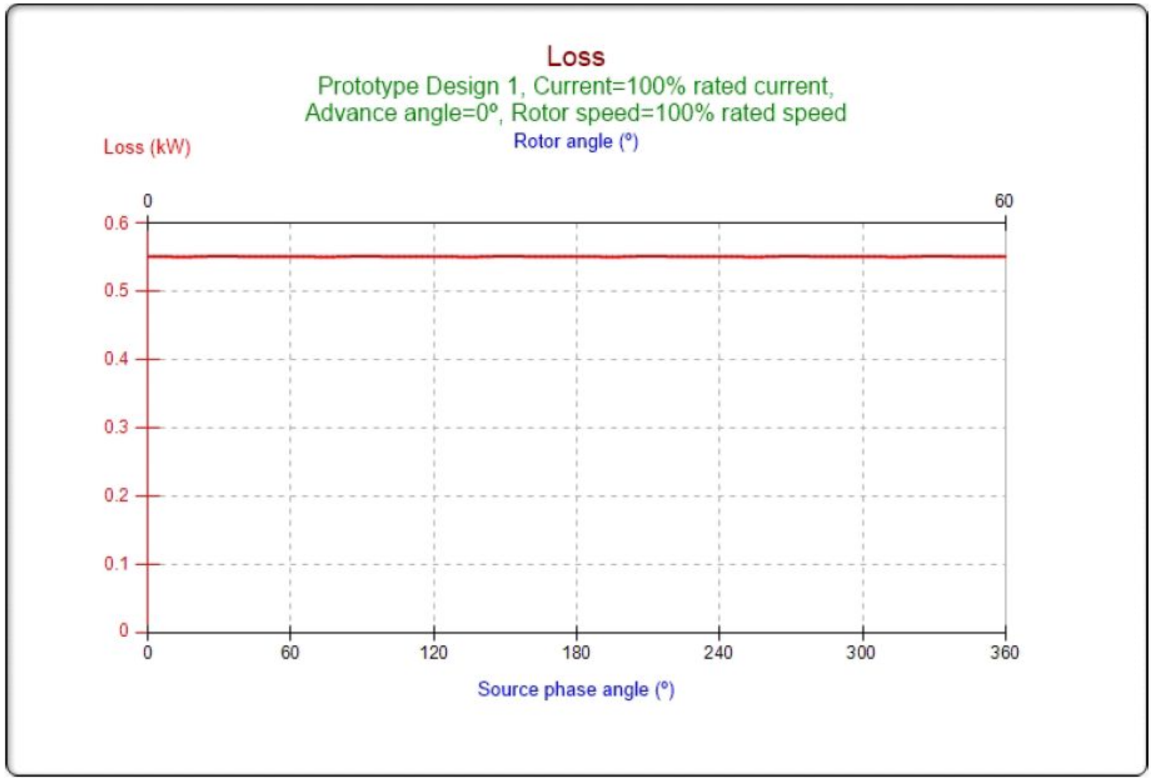


Image 1.8 Iron loss of 3.25 Magnetic Thickness

CONCLUSION

According to the study, increasing magnet thickness improved eddy current losses, efficiency, and motor torque output. Further increases, however, reached a point of diminishing returns and did not considerably boost torque output. The ideal thickness minimised the losses while increasing flux density and distribution. These discoveries have implications for the electric vehicle market, improving the performance and the effectiveness of electric three-wheelers while also increasing their customer appeal.

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