

Assignment 2

by James Thomas

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Prifysgol Cymru
Y Drindod Dewi Sant
University of Wales
Trinity Saint David

UWTSD

Electrical Machines (M6X00373)

Stator Modelling Part 2

James Thomas (1708737)
4-3-2019

Declaration

The work of this report completed under the supervision of declare that this report is the product of my own work and is not being submitted for any other degree etc.

Sign the declaration

James Thomas

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1.0. Introduction



The aim of this assignment is to improve the design of the DC motor to improve the **FLF**. To achieve this, sure aspects will be changed and other won't be to keep the test as consistent and reliable as possible. This report will have 8 models and the compare each results in a table and graph form to easily see the each differences.

2.0. Summary of Initial DC Motor (Part 1)



Figure 1 Original DC Motor Design



The design is from assignment one and it's a simple design. The FLF for this was 64.475, showing how inefficient this design is. There are calculations below to show how this result came from.

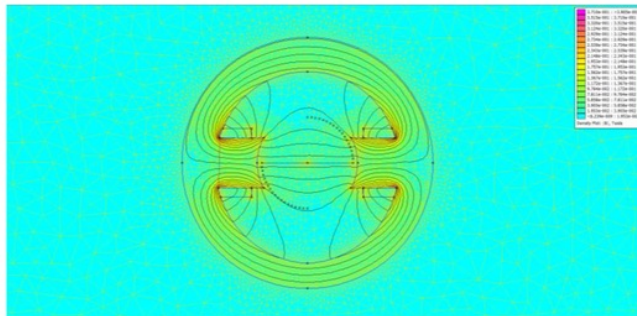


Figure 2 Original DC Motor Flux Lines

Total Flux = 0.000251912

Useful flux = 8.95E-05

$$FLF = 1 - \frac{\text{Useful Flux}}{\text{Total Flux}}$$

$$FLF = 1 - \frac{8.95E-05}{0.000251912}$$

$$FLF = 0.6447 \times 100\%$$

$$FLF = 64.47\%$$

3.0. Background Research

3.1. DC Motor

A DC motor converts electrical power into mechanical power. The entire input power can never be converted into output power in a practical machine as certain power is lost in the transfer process. This results in a reduction in the machine's efficiency. Efficiency is the ratio of power output to power input. Therefore, it is important to study the losses that occur in them in order to design rotating dc machines with higher efficiency. Different losses can be characterized as follows in a rotating DC machine: [1]

Copper losses:



- Armature Cu loss
- Field Cu loss
- Loss due to brush contact resistance

Iron Losses:

- Hysteresis loss
- Eddy current loss

Mechanical losses:

- Friction loss
- Windages loss

Stray Losses:

- Heat

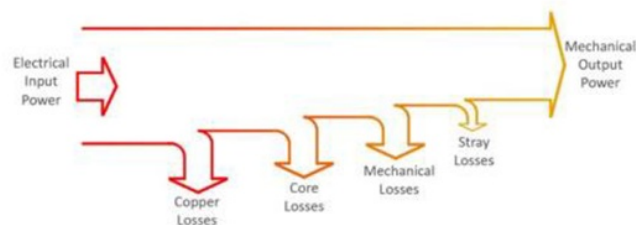


Figure 3 Electrical Power into Mechanical Power Diagram

3.2. Lenz Law

Lenz's law is a good way of understanding how Newton's third law and energy conservation complies with electromagnetic circuits. The law of Lenz is named after Heinrich Lenz and it says: an induced electromotive force (emf) always produces a current whose magnetic field is opposed to the change in the original magnetic flux. [2]

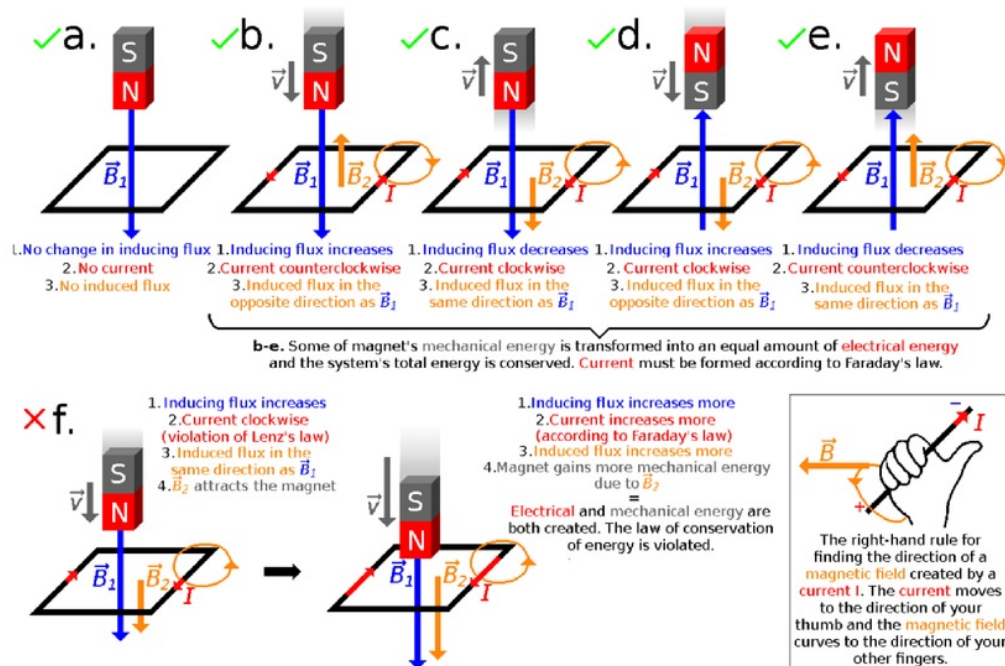


Figure 4 Lenz Law

4.0. Method

When designing and improving the DC motor design to try and reduce the Flux leakage factor, only some aspects can be changed. The table below shows aspects of the DC Motor design that can be changed and ones that can't be. The idea of this assignment is to come up with a design that will improve the Flux leakage factor from the original design being at 64.47%.

Can be Changed	Can't be changed
Stator Inner Radius	The Electrical Properties
Armature Dimensions	Any Materials
Winding Position	Rotor Properties
Armature Face	Outer Radius
Coil Closer Together	Armature Radius

Table 1 Motor Design that can't be Changed and can

The main three changes going to be made in this report will be the stator width, the pole widths and adding a fishtail to the poles. Some design will have one of these changes or two combined changes or even all three aspects changes. The changes will be shown in every model in a specification table.

Key
Modification in Design
Useful Flux

Table 2 Key for Model Design

5.0. Models

5.1. Model 1



Figure 5 DC Motor Model 1

Depth of Circuit	100mm
Outside Stator Diameter	110mm
Inside Stator Diameter	80mm
Pole Face Radius	22mm
Pole Widths	20mm
Fishtail on Pole Faces	22mm
Field Generating Coil Vertical Coordinate	±15mm
Field Generating Coil Horizontal Internal Coordinates	±24.5mm
Rotor Coil Width: 40mm	40mm
Field Generating Coil Current	±1A
Field Generating Coils Number of Turns	500

Table 3 Specification Design for Model 1

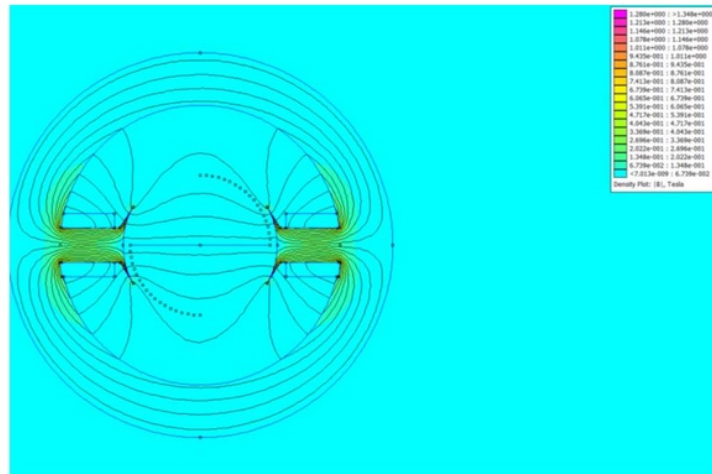


Figure 6 Flux Lines in Model 1 of a DC Motor

Angle	
35	8.19E-05
40	8.42E-05
45	8.47E-05
50	8.43E-05
55	8.36E-05
60	8.20E-05

Table 4 Useful Flux in Model 1

5.2. Model 2



Figure 7 DC Motor Model 2

Depth of Circuit	100mm
Outside Stator Diameter	110mm
Inside Stator Diameter	80mm
Pole Face Radius	22mm
Pole Widths	20mm
Fishtail on Pole Widths	27mm
Field Generating Coil Vertical Coordinate	±15mm
Field Generating Coil Horizontal Internal Coordinates	±24.5mm
Rotor Coil Width:	40mm
Field Generating Coil Current	±1A
Field Generating Coils Number of Turns	500

Table 5 Specification Design for Model 2

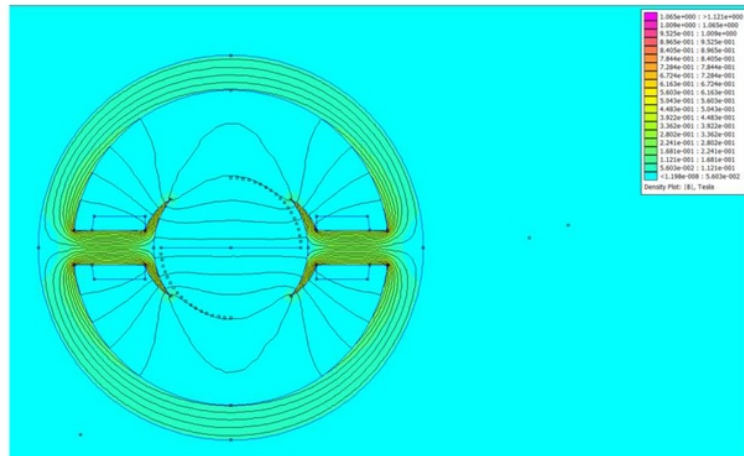


Figure 8 Flux Lines in Model 2 of a DC Motor

Angle	
60	0.000101
65	0.000101
70	0.000101
75	0.000101
80	0.0001
85	0.0001

Table 6 Useful Flux in Model 2

5.3. Model 3



Figure 9 DC Motor Model 3

Depth of Circuit	100mm
Outside Stator Diameter	110mm
Inside Stator Diameter	80mm
Pole Face Radius	22mm
Pole Widths	20mm
Fishtail on Pole Widths	34mm
Field Generating Coil Vertical Coordinate	±15mm
Field Generating Coil Horizontal Internal Coordinates	±24.5mm
Rotor Coil Width: 40mm	40mm
Field Generating Coil Current	±1A
Field Generating Coils Number of Turns	500

Table 7 Specification Design for Model 3

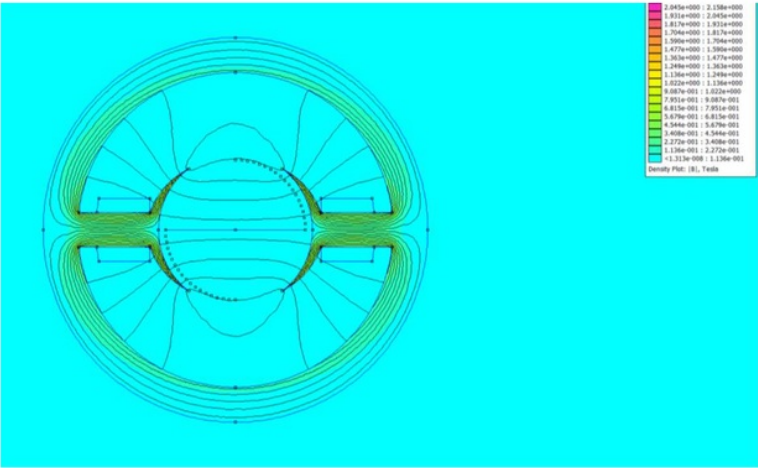


Figure 10 Flux Lines in Model 3 of a DC Motor

Angle	
60	0.000122113
65	0.000124593
70	0.000125388
75	0.000125757
80	0.000125782
85	0.000125755
90	0.000125823

Table 8 Useful Flux in Model 3

5.4. Model 4



Figure 11 DC Motor Model 4

Depth of Circuit	100mm
Outside Stator Diameter	110mm
Inside Stator Diameter	80mm
Pole Face Radius	22mm
Pole Widths	20mm
Fishtail on Pole Faces	N/A
Field Generating Coil Vertical Coordinate	±15mm
Field Generating Coil Horizontal Internal Coordinates	±24.5mm
Rotor Coil Width	50mm
Field Generating Coil Current	±1A
Field Generating Coils Number of Turns	500

Table 9 Specification Design for Model 4

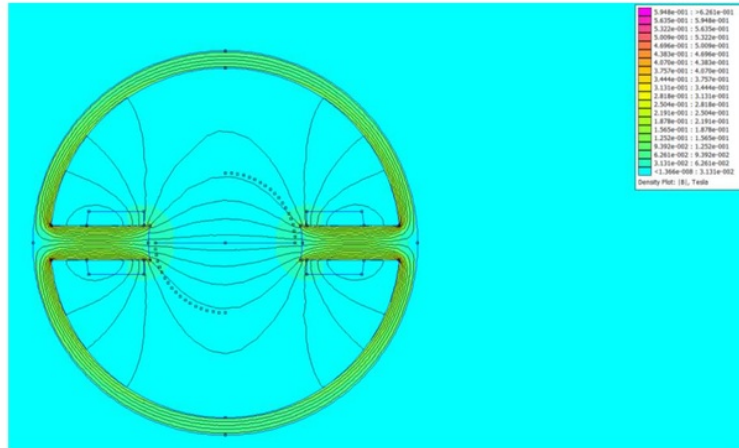


Figure 12 Flux Lines in Model 4 of a DC Motor

Angle	
35	6.36E-05
40	6.42E-05
45	6.43E-05
50	6.41E-05
55	6.39E-05

Table 10 Useful Flux in Model 4

5.5. Model 5

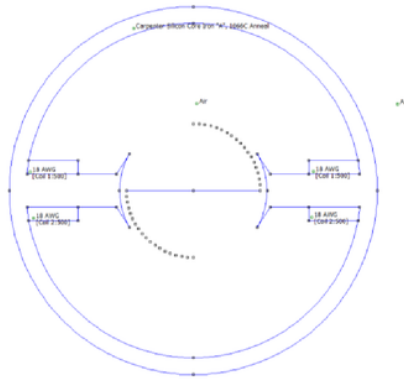


Figure 13 DC Motor Model 5

Depth of Circuit	100mm
Outside Stator Diameter	110mm
Inside Stator Diameter	80mm
Pole Face Radius	22mm
Pole Widths	20mm
Fishtail on Pole Faces	22mm
Field Generating Coil Vertical Coordinate	±15mm
Field Generating Coil Horizontal Internal Coordinates	±24.5mm
Rotor Coil Width	50mm
Field Generating Coil Current	±1A
Field Generating Coils Number of Turns	500

Table 11 Specification Design for Model 5

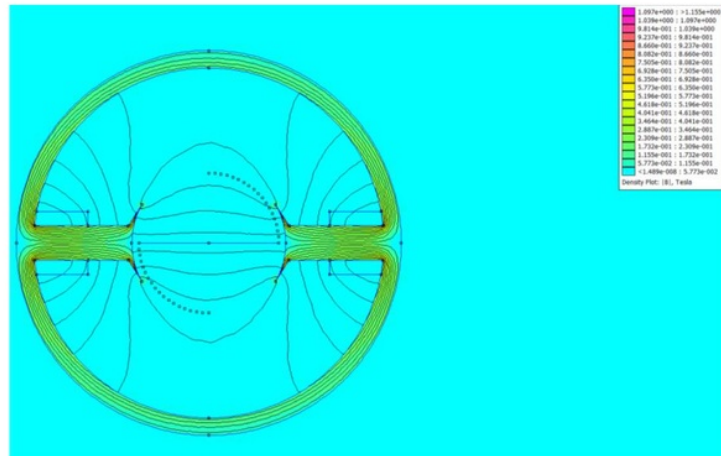


Figure 14 Flux Lines in Model 5 of a DC Motor

Angle	
40	8.36E-05
45	8.53E-05
50	8.60E-05
55	8.63E-05
60	8.64E-05
65	8.62E-05
70	8.61E-05

Table 12 Useful Flux in Model 5

5.6. Model 6



Figure 15 DC Motor Model 6

Depth of Circuit	100mm
Outside Stator Diameter	110mm
Inside Stator Diameter	80mm
Pole Face Radius	22mm
Pole Widths	20mm
Fishtail on Pole Widths (Depth)	34mm (2mm)
Field Generating Coil Vertical Coordinate	±15mm
Field Generating Coil Horizontal Internal Coordinates	±24.5mm
Rotor Coil Width:	50 mm
Field Generating Coil Current	±1A
Field Generating Coils Number of Turns	500

Table 13 Specification Design for Model 6

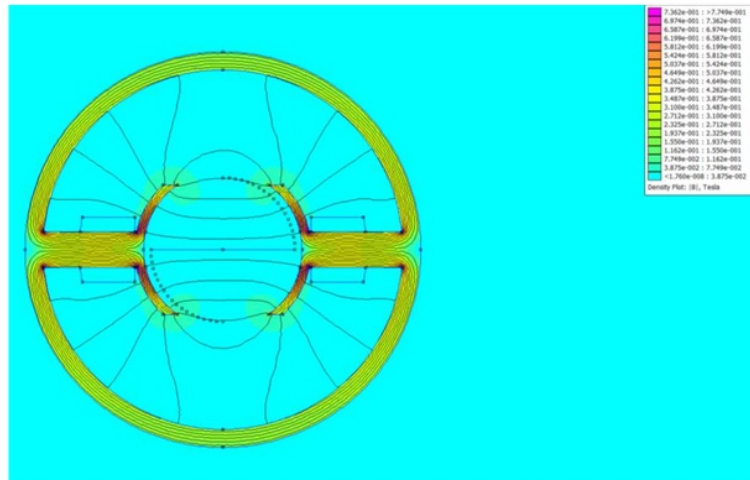


Figure 16 Flux Lines in Model 6 of a DC Motor

Angle	
60	0.000124
65	0.000129
70	0.000131
75	0.000133
80	0.000133
85	0.000133
90	0.000134

Table 14 Useful Flux in Model 6

5.7. Model 7



Figure 17 DC Motor Model 7

Depth of Circuit	100mm
Outside Stator Diameter	110mm
Inside Stator Diameter	80mm
Pole Face Radius	22mm
Pole Widths	5mm
Fishtail on Pole Widths	N/A
Field Generating Coil Vertical Coordinate	$\pm 15\text{mm}$
Field Generating Coil Horizontal Internal Coordinates	$\pm 24.5\text{mm}$
Rotor Coil Width	50mm
Field Generating Coil Current	$\pm 1\text{A}$
Field Generating Coils Number of Turns	500

Table 15 Specification Design for Model 7

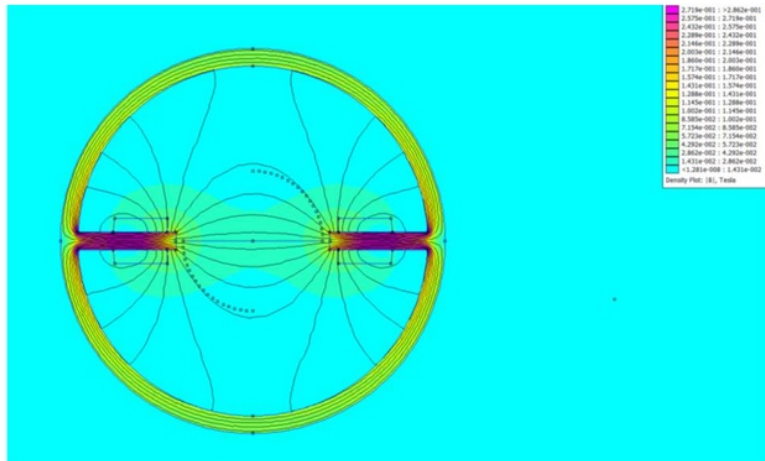


Figure 18 Flux Lines in Model 7 of a DC Motor

Angle	
35	5.32E-05
40	5.34E-05
45	5.32E-05
50	5.31E-05

Table 16 Useful Flux in Model 7

5.8. Model 8



Figure 19 DC Motor Model 8

Depth of Circuit	100mm
Outside Stator Diameter	110mm
Inside Stator Diameter	80mm
Pole Face Radius	22mm
Pole Widths	5mm
Fishtail on Pole Widths	34mm
Field Generating Coil Vertical Coordinate	±15mm
Field Generating Coil Horizontal Internal Coordinates	±24.5mm
Rotor Coil Width	50mm
Field Generating Coil Current	±1A
Field Generating Coils Number of Turns	500

Table 17 Specification Design for Model 8

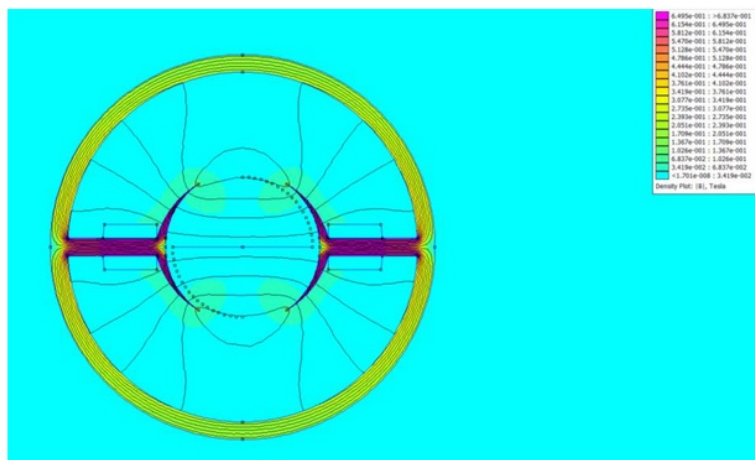


Figure 20 Flux Lines in Model 8 of a DC Motor

Angle	
60	0.000122347
65	0.000125387
70	0.000126527
75	0.000127099
80	0.00012733
85	0.000127399
90	0.000127461

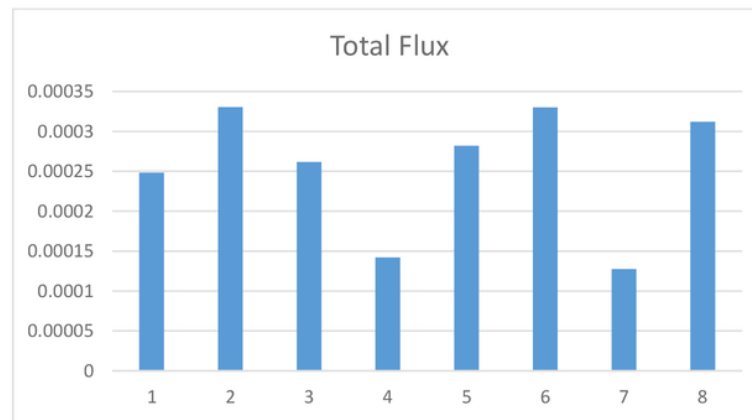
Table 18 Useful Flux in Model 8

6. Results

Model	Total Flux	Useful Flux	FLF
1	0.000248281	8.47E-05	65.87%
2	0.000330439	0.000125823	61.92%
3	0.000261573	0.000101	61.51%
4	0.000142002	6.43E-05	54.73%
5	0.000281846	8.64E-05	69.36%
6	0.000330052	0.000134	59.52%
7	0.000127516	5.34E-05	58.15%
8	0.000312003	0.000127461	59.15%

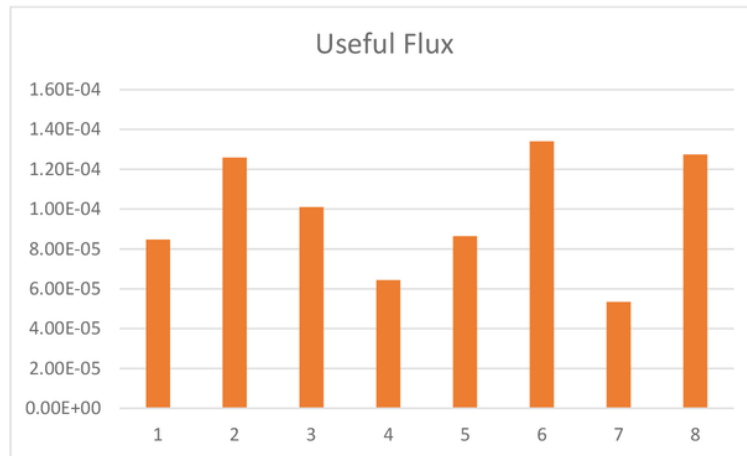
Table 19 Result Table for all Models

The table above are the result for all models and will be shown in graphs below to compare to each other.



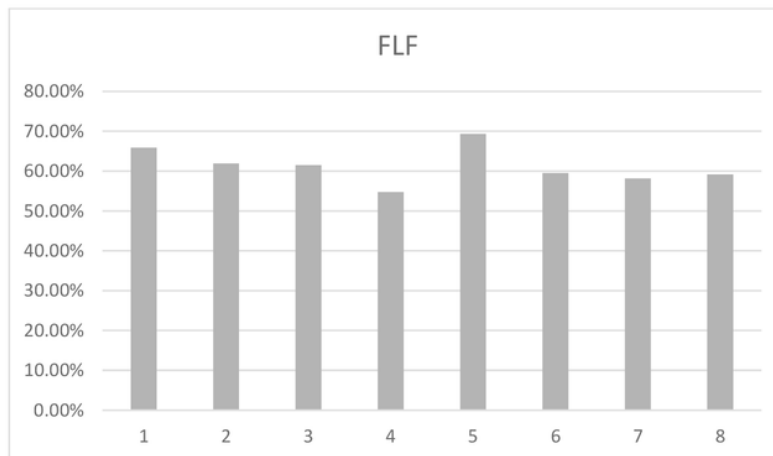
Graph 1 Total Flux

The graph above shows that model 6 design has the most flux out of all the designs but this that's mean this is the best design. There could be more flux but that doesn't mean more flux will pass directly through the rotor.



Graph 2 Useful Flux for all Models

The graph above shows that model 6 design has the most useful flux out of the designs. Again this does mean this design is the best, between the total and useful flux, a calculation can be done to find the FLF



Graph 3 FLF for all Models

The design with the most flux leakage factor is model 5, being around 69%. Meaning that model 5 design is the worse. The design with the least flux leakage factor is design model 4. This model was the simplest designs out of all 8 and seemed to be the most efficient, with only having 54.7% FLF. All models bar 1 and 5, have improved on the FLF from the original design from assignment 1. The results show that the fishtail wasn't the best way to improve FLF but just making the pole widths smaller and the Rotor width bigger, creating more air space in the motor and creating more resistance for the flux meaning the flux to use the metal path more due to having a lesser resistance to the air itself.

7. Conclusion

Orthogonal array testing technique was used for this assignment and it helped to find reliable and relevant results. By going back and analysing my models it seem to improve when the coils where closer together and the keeping the design simple. The fishtail did improve the FLF from the original but it did seem to improve by much with different size fishtails, it seemed to cause the same about flux scatter with each type of fishtail. Improvements could have been made by changing other aspects of the DC Motor, one of these could have been to wider the armature, the test only used thinner ones. This was found that, because of the system's reluctance, how the flux is directed has more of an effect on efficiency than total flux.

References

- [1] electricaleasy, "Losses In A DC Generator And DC Motor," [Online]. Available: <https://www.electricaleasy.com/2014/01/losses-in-dc-machine.html>. [Accessed 01 04 2019].
- [2] wikipedia, "Lenz's law," [Online]. Available: https://en.wikipedia.org/wiki/Lenz%27s_law. [Accessed 1 4 2019].

Assignment 2

GRADEMARK REPORT

FINAL GRADE

GENERAL COMMENTS

Instructor

51 / 100

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Comment 1

You should introduce acronyms before you use them so the reader understands what you are talking about.

PAGE 6



Comment 2

Units?

PAGE 7



Comment 3

first use of acronym



Comment 4

Heat is the result of the losses above. Energy is never lost it is only converted to other forms. In this case, most of the energy 'lost' is converted to heat and sound.

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Comment 5

I'm not sure what you mean here.

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GRADING FORM: SMU GENERIC_SMOSEY

JAMES THOMAS

51.20

ENGAGEMENT WITH LITERATURE

including reading, referencing, academic conventions and academic honesty



You have only referenced two sources. You should try to use better quality sources, such as: peer reviewed journals, theses submitted to universities, text books, and other academic writings. Wikipedia should not be used as the information cannot be relied upon as it can be edited by anyone.

4.2

KNOWLEDGE & UNDERSTANDING

Knowledge of the basic underlying concepts and principles of a subject.



You have shown a good knowledge and understanding of the subject.

18.6

COGNITIVE & INTELLECTUAL

Evaluate underlying concepts and principles of a subject and interpret qualitative and quantitative data in order to develop lines of argument and make sound judgements.



Evidence of some logical, analytical thinking and synthesis. Can analyse new and/or abstract data

10.6

and situations without guidance, although a single table with all the experimental parameters would have made the report easier to read. More correlation of results with design parameters would have made a better analysis.

PRACTICAL APPLICATION SKILLS

Different approaches to solving problems in particular contexts.



A good and appropriate application of standard methods, materials, tools and/or techniques. Your orthogonal array testing could have been made clearer. Good appreciation of the context of the application.

11.6

TRANSFERABLE SKILLS

Communicate the results of their study/work accurately and reliably, and with structured and coherent arguments; the qualities needed for employment requiring the exercise of some personal responsibility within a structured and managed environment.



Can communicate well, confidently and consistently in a suitable format. Only a few minor spelling and grammar errors. Work is coherent and fluent and is well structured and organised.

6.2