journal homepage: https://journal.pktm.com.my/

International Journal of Technical Vocational and Engineering Technology

e-SSN2710-7094, Vol. 6, No. 1 (2025)

Experimental Speed Control of DC Shunt Motor Using Field Control Method via MATLAB Simulink

Mohd Faiz Husny Yusof[1]*, Junekh Eyat Eng Tian Juan[1], Mohd Shakirurahman Ismail[1], Rikki Vitria[2]

[1]Electrical Engineering Department, Politeknik Kota Bharu, 16450 Ketereh, Kelantan, Malaysia.

[2]Politeknik Negeri Padang, Kampus Limau Manis, 25165 Padang Timur, Padang, Indonesia.

*Corresponding Author email: faizhusny@pkb.edu.my

ARTICLE INFO

Article History:
Received 8 September 2024
Revised 26 November 2024
Accepted 20 June 2025
Publish 30 June 2025

Keywords:
DC Shunt Motor;
Speed Control;
MATLAB/Simulink.

ABSTRACT

DC Shunt motor speed control using a field control method is a method that researchers have studied. The study of the characteristics of the motor, primarily in controlling the motor speed, is performed by this research with a constant input voltage. The research was done to indicate that both techniques, which are laboratory experiments and the MATLAB/Simulink model, can be executed. The outcome is to produce the desired speed of the DC Shunt Motor model via MATLAB/Simulink, as well as the result from the laboratory experiment. The external resistor is used in this experiment as a rheostat, where the resistance is varied. Variation of external resistance appears to reflect on the control of the speed of the DC motor. Simulation and laboratory experiment results indicate that the speed using the simulation model via MATLAB/Simulink is quite similar to the speed using the laboratory experiment result, and based on that, it shows the DC Shunt motor speed can be controlled using a field control method.

1.0 Introduction

Modern systems are complex, and new approaches in electric motor control are demanded, having high-precision requirements of speed and position under variable load torque (Ruben, 2016). The capability to modify the rotation velocity of a direct current motor by adjusting the applied voltage to the armature is known as speed control. Standard speed regulation methods have long been researched, and armature voltage control is one of the most frequently used techniques to control DC drives (Baavarajappa,2024). The simulation model nowadays is often referred to as an alternative way to experiment with motor control besides using traditional methods of data collection, such as laboratory experiments. Although running the DC Motor is more technically experiment and needs more time, safety precautions need to be addressed well during the experiments compared to the simulation model using a block diagram in MATLAB. Many researchers used laboratory experiments as their research method. However, few of them execute the comparison using a simulation model because designing a model of the DC Motors is not quite similar to the block in the simulation model. The choice of the simulation model is important to ensure that the parameters of the DC Motor in the laboratory can be compared with the design model in the simulation. Based on that, MATLAB R2022a is used to implement the experiment via simulation I this research.

A review study of different tuning controllers for speed control of a DC motor. It is widely used in industries even if its maintenance cost is higher than the induction motor (Baavarajappa,2024). The laboratory experiment on the DC Shunt motor was regularly done in the laboratory by researchers to get the desired output for learning purposes. The experiment of the DC Shunt motor began with the connection to the motor using cables based on circuit diagrams, and all the parameters of the motor were measured using meters when the motor was run with an input of 200V. The speed of the motor is measured and recorded, but the value of the speed acquired is not constant due to the vibration of the tachometer during measurement. Although they still have the tolerance for the value recorded, by using MATLAB/Simulink for the simulation model, the comparison between those values can be observed to ensure that the speed values are within a suitable range. Moreover, nowadays, there are alternative ways of doing laboratory experiments besides the researchers attending the laboratory regularly. With this simulation using MATLAB/Simulink models and results, the researchers were able to simulate for DC Shunt motor speed control

2.0 Literature review

DC Motors are widely used in electrical applications, especially in industrial applications, robotics, and home appliances, due to high flexibility, reliability, and low cost, where the speed and position control of the motor is required (Md Akram, 2014). The control speed of the DC Motor is required for easy control based on the purposes of usage. Home appliances and industrial applications are mostly used to ensure that the variation of usage can be done correctly. Controlling the speed of the motor is important to ensure that the motor is driven at the desired speed for certain and suitable applications. The innovation using motor really reduces the time of work and helps reduce the usage of human resources' energy (Abdul Rahman, 2020). In industry, DC motors are widely used as a motor for driving mechanical loads, because DC motors have greater torque characteristics compared to an induction motor (Jehan,2020).

The greatest advantage of the DC Motor may be speed control due to the method being easy and convenient, and the power loss in the shunt field is small due to the small volume in the shunt field. Since the speed is directly proportional to armature voltage and inversely proportional to the magnetic flux produced by the poles, adjusting the armature voltage or the field current will change the rotor or motor speed. The speed of a DC Shunt motor may be regulated in two ways: inserting resistance in series with the armature, thus decreasing the speed, and inserting resistance in series with the field; the speed will vary with each change in load (S.M. Labaran, 2018). In this paper, the discussion is more on inserting resistance in series in the field, and the speed is measured. The speed is measured in two ways, which are based on the laboratory result using a DC Machine in the lab and the simulation result using MATLAB/Simulink. The DC Machine used in the lab is designed and setting is the same as MATLAB/Simulink prior to the comparison result at the end of this paper.

2.1 Structure of DC Shunt Motor

DC Motors consist of armature and stationary windings (field poles) (Md Akram, 2014). In particular, the analysis and design of DC motor controllers is emphasized for so-called direct current permanent magnet, or separate excitation, reaching simple linear models, and justifying its performance against certain operating conditions (Ruben, 2016). The conversion can be expressed in a diagram, but in this paper, the discussion is only based on the electrical diagram. The type of motor used in this experiment is a DC Shunt Motor. The DC motor, or direct current motors, are usually used as a motor to drive mechanical loads. The advantage of using this motor is for speed regulation (Jehan, 2020). The circuit diagram for the DC Shunt Motor used as a reference in this simulation model can be expressed as follows:

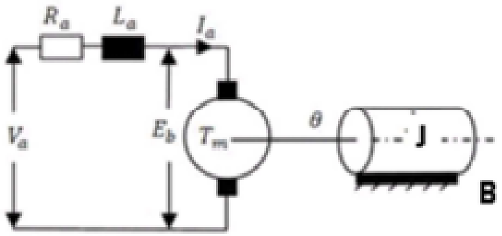

Figure 2.1.1 DC Shunt Motor Model [2]

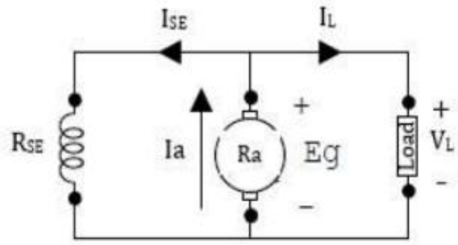

Figure 2.1.2 DC Shunt Motor circuit diagram [3]

Based on *Figure 2.1.1* and *Figure 2.1.2,* the voltage equation of the circuit is given by (Akram, 2024; Ruben, 2016):

Voltage Equation: $Va(t) = R_a I_a(t) + L_a \frac{dIa(t)}{dt} + E_B$ ...... *Equation 2.1*

Armature current: $I_a = I_L + I_{SE}$ ...... *Equation 2.2*

Equation for Back EMF: $E_B(t) = K_b \omega(t)$ ...... *Equation 2.3*

Speed Equation: $N = K_b V - \frac{I_a(R_a)}{\emptyset}$ ...... *Equation 2.4*

Based on the equation given above, the calculation was made prior to the simulation model using MATLAB Simulink. This paper does not discuss complete calculations due to its greater focus on MATLAB Simulink and experimental laboratory results.

3.0 Methodology

In this paper, the discussions of the speed control of the DC Motor are based on two types of experiments, which are laboratory experiments and MATLAB Simulink results. Moreover, simulation results are exhibited for design performance evaluation (Ruben, 2016). Both experiments had been done with the technical aspects of the motor selection and rating, with a suitable load range also being discussed in this chapter. The DC motor available in the laboratory is chosen in this experiment with MATLAB R2022a as a medium for simulation experiments.

3.1 Proposed Design of DC Shunt Motor Speed Control Via Laboratory Experiment

For this experiment, a 0.3kW, 220V DC Shunt Wound motor at the Electrical Engineering Department Politeknik Kota Bharu laboratory, as shown in Figure 3.1 below, is used to perform laboratory experiments. In contrast, Figure 3.2 shows the experimental setup. A variable resistor (Left) was connected in series with the armature winding while armature current was measured using a zero-center analogue meter (Right). The variable resistor is connected in series with the field windings circuit, and the resistance values are being increased in steps, starting from 5Ω. The variable resistance was increased in steps of 10Ω, 15Ω, 20Ω, 25Ω, and 30Ω. All data measured are recorded in *Table 4.1* below. The input voltage for the motor is set to 200V, and the motor speed was measured using a hand-held tachometer.

Figure 3.1 0.3kW, 220V DC Shunt Wound Motor Used in Experiment

Figure 3.2 Experimental Set-Up

3.2 Proposed Design for DC Shunt Motor Speed Control via MATLAB R2022a

In this section, the MATLAB R2022a software has been utilized for this circuit simulation. *Figure 3.3* below indicates the simulation model used for this DC Shunt Motor. The design is based on the topology of a DC Shunt motor (Jehan, 2020). The motor has a single DC supply source with a constant value. (Vin = 200V). The parameters of the DC motor are as follows: (Ra = 0.6 Ω, La = 0.012 Ω, R_{field} = 400Ω, L_{field} = 120 Ω), where the field and armature coil are connected in parallel based on the basic DC motor design used for this simulation. The motor parameter includes inductive values for the coil used in the real motor design. The external resistance is used with a variable magnitude to achieve the desired result. The output speed is in Rotations per Minute (RPM) mode using models in MATLAB/Simulink.

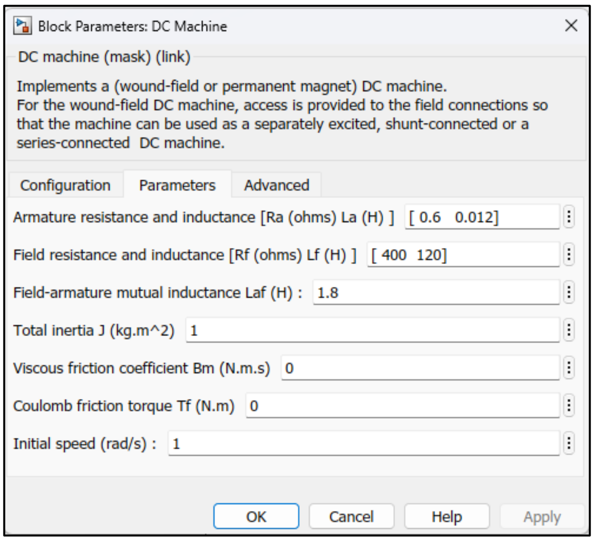

Figure 3.3: DC Shunt Motor MATLAB Parameter

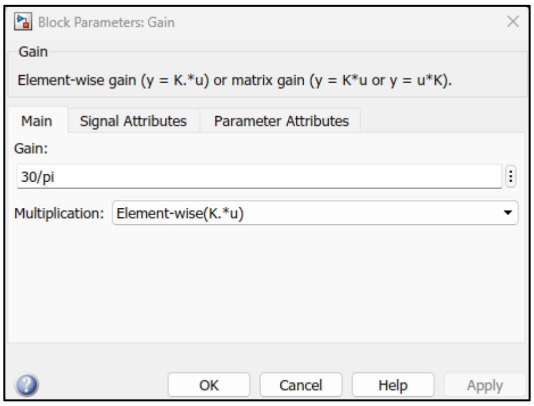

Figure 3.4: RPM in per minute

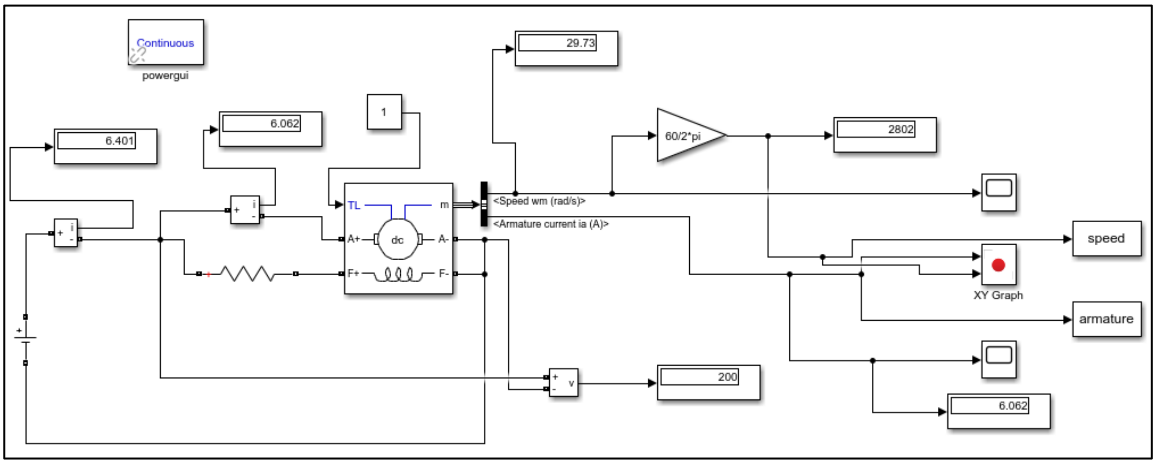

Figure 3.5 The proposed designed for the simulation

The circuit is also designed with a mux that can produce two measurable outputs, which are motor speed and armature current.

4.0 Discussion of analysis and findings

Simulation results using MATLAB/Simulink are given below based on the variable range of the external resistances. The graphs show the differences in speed control for different external ranges of the resistances connected through the field windings. The DC Motors are simulated, and the speed of the motor is recorded in *Table 4.1*. The armature current is recorded when the speed of the motor is 2000 RPM. It is set that the armature current is taken at 2000 RPM to ensure that the comparison can be made between the simulation and the laboratory experiment.

The results shown in Figures 4.1 to 4.4 indicate the speed and current behavior when the DC Motor is driven with a selected resistance range. The data of the speed and current can be measured using the graph and meters, as shown in Figure 3.5, where the values are visualized in digital numbers compared to analyzing using a graph. These numbers are easy to read and give the exact number needed. All the data recorded is based on meter readings in the simulation.

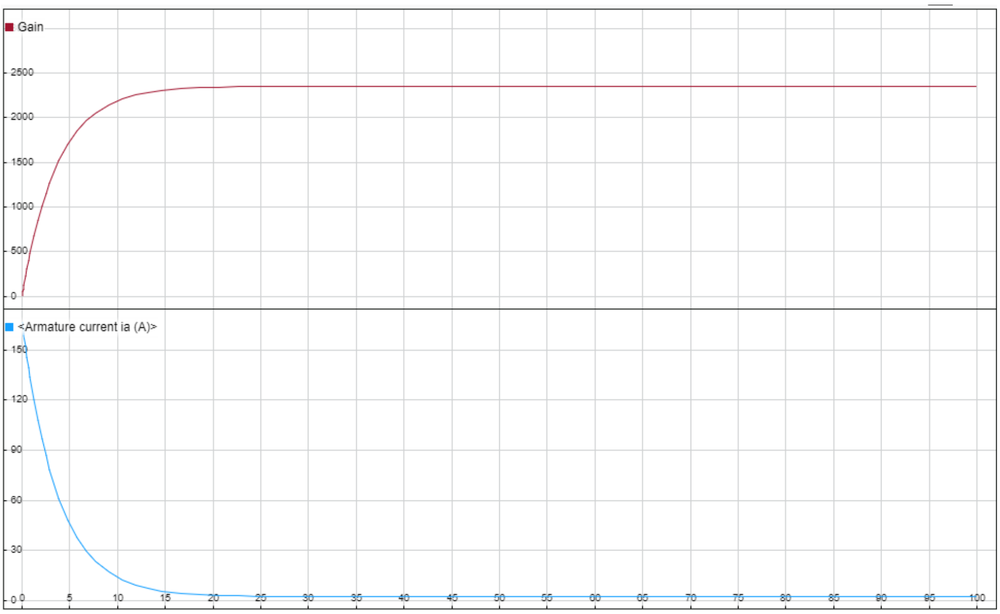

Figure 4.1 Simulation result when R=10 Ω, RExternal = 10 Ω, Speed = 2145 RPM, Armature Current = 2.278A

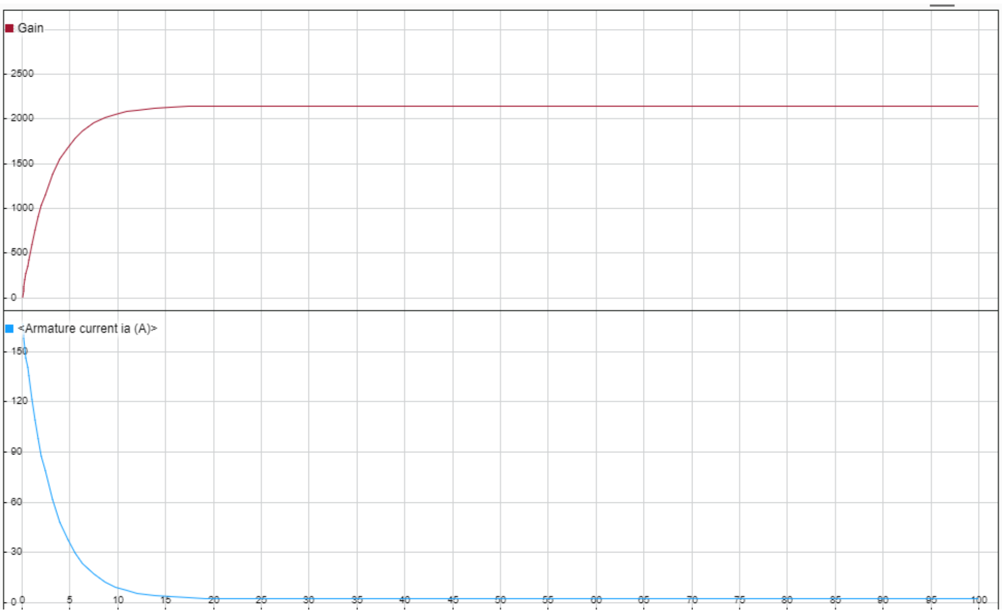

Figure 4.2 Simulation result when R=50 Ω, RExternal = 50 Ω, Speed = 3754 RPM, Armature Current = 6.10A

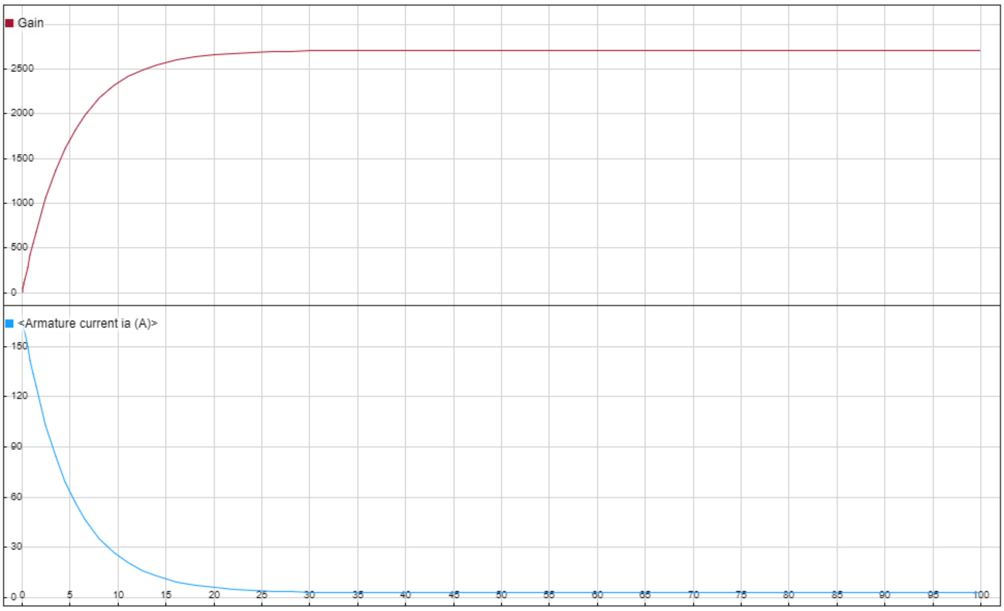

Figure 4.3 Simulation result when R=160 Ω, RExternal = 160 Ω, Speed = 2915 RPM, Armature Current = 3.111A

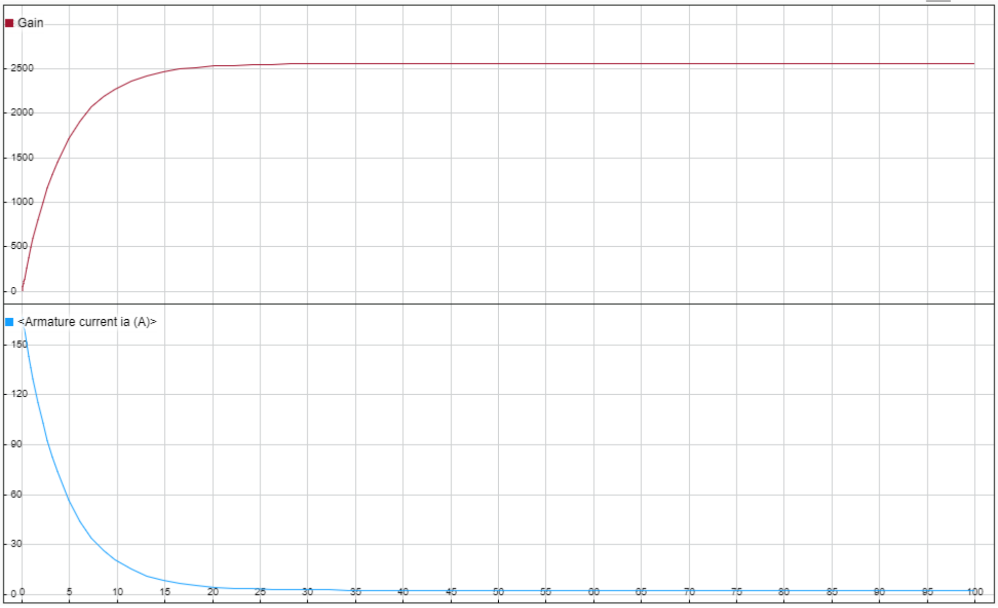

Figure 4.4 Simulation result when R=190 Ω, RExternal = 190 Ω, Speed = 3068 RPM, Armature Current = 3.278A

In this experiment, the DC Motor model used in this simulation is based on the MATLAB/Simulink library. With the simple modification to the model, the DC Shunt motor is designed using the parameters of the motor used in the laboratory. The external resistance, RExternal, used in this simulation is just a resistor compared to the experiment that used a rheostat as an external resistance. The speed of the motor is measured using a tachometer, while in the simulation, the output value of the speed is produced in radians per second. Therefore, the conversion of the speed to rotation per minute (RPM) model is designed to ensure the output speed is visualized as the same as experimental values.

During simulation using MATLAB/Simulink, the external resistance connected to the field windings is varied. The output speed in rotation per minute (RPM) and armature current in amperes are recorded in Table 4.1. Based on the simulation result, a small change in armature current produced a significant change in speed. Where the bigger volume of external resistance was inserted into the field, a slight increase in armature current appeared while the speed of the motor was reduced rapidly.

Table 4.1: Comparison Between Laboratory Experiment vs MATLAB/Simulink

		Laboratory Experiment		**MATLAB/Simulink**		
Input Voltage, Vin (V)	External Resistance (Ω)	Armature Current, (A)	Speed (RPM)	Armature Current (A)	Speed (RPM)	Differences in RPM, %
200	10	0.13	2024	2.278	2145	5.97
	50	0.13	2173	2.5	2352	8.24
	90	0.13	2345	2.722	2557	9.05
	120	0.13	2502	2.889	2711	8.35
	160	0.14	2783	3.111	2915	4.74
	190	0.14	2954	3.278	3068	3.86

Laboratory experimentation is done using a DC machine, which can operate in both conditions, either as a motor or as a generator. In this experiment, the machine is operated as a DC motor. The machine speed is measured manually using a hand-held tachometer. The average value for each speed measured is determined to ensure the speed volume is within the range and reduce gross errors (measurement errors) because humans tend to make mistakes while reading, recording, and interpreting (human oversight).

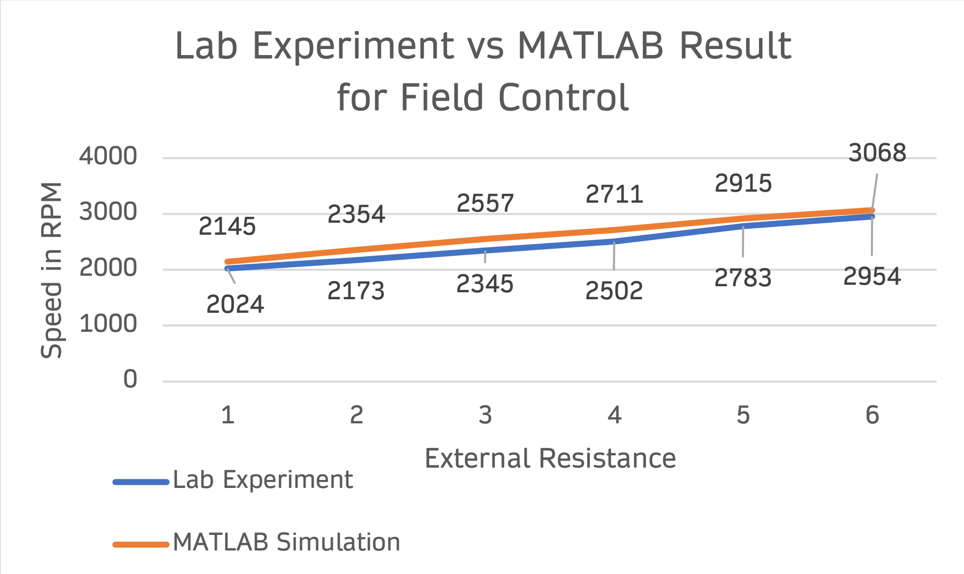

Figure 4.5: Comparison Between Laboratory Experiment vs MATLAB/Simulink for Speed Control

Based on the observation of the data collection and the DC machine, the differences can be expressed as due to:

i. Heat transfer of the DC Motor compared to the simulation when those heats are negligible based on the observation directly.

ii. Friction in the bearing that may tend to slow the DC machine and directly reduce the armature current compared to MATLAB/Simulink.

iii. Power losses in the cable and windings: armature losses, field losses

Although the differences are more on the losses, these comparisons cannot be ignored because they may affect the characteristics of the DC shunt motor and the machine's speed regulation.

5.0 Conclusion and Future Research

As a conclusion, this research proves that the result using laboratory experiments and MATLAB/Simulink can be used to study the characteristics of the DC Shunt for field control purposes. It appears that the MATLAB/Simulink simulation can also be an alternative way for researchers, lecturers, and students to study the characteristics of the machine if the hands-on method cannot be done in a laboratory. Based on the result, the current readings show a massive difference between both experiments, due to the selection of the motor, which is suitable to be used in the lab. Most of the DC motors used in the laboratory are low power and tend to have higher coils to lower the current due to the small volume of resistance used to connect to the motor as a load. It may prevent any failure from the experiment from occurring. By selecting suitable motor ratings for laboratory experiments, this research appears to be a reference for lecturers, who tend to do the simulation using MATLAB/Simulink in classes, although the differences are slightly higher. Based on the simulation, we could conclude that based on the simulation model is able to produce almost the desired output speed with variable field resistance. Although it seems quite difference, still this simulation model can produce the desired output speed as desired.

Based on the results, this research can be expanded or improved on the DC Motor simulation parameters. The parameters of a real DC Motor can differ based on the brand of the motor. They can be measured based on the cumulative values of resistance and resistive values compared to a simulation model, which indicates separately. Therefore, a study on different types or brands of DC Motors can be done and compare those values with simulation, so that the data collection can be a reference to other researchers to narrow the research. Other researchers may also use different simulation software to execute the comparison, such as PSCAD, Power World, etc. Using different simulation software may expand our knowledge and result in studying the characteristics of the DC Shunt motor using the field control method.

Acknowledgements

Many thanks to family and friends for their support and motivation during this process.

Author Contributions

Mohd Faiz Husny Y.: Conceptualization, Methodology, Supervision, Software, Data Curation, Writing, Editing; **Junekh Eyat E. T. J.**: Data Curation, Writing, Editing, Supervision; **Mohd Shakirurahman I.**: Writing-Reviewing, and Editing.

Conflicts of Interest

The manuscript has not been published elsewhere and is not being considered by other journals. All authors have approved the review, agreed with its submission, and declared no conflict of interest in the manuscript.

6.0 References

Md Akram Ahmad, Kamal Kishor, Pankaj Rai. (2024). "*Speed Control of a DC Motor using Controllers*". Science Publishing Group.

Basavarajappa Sokke Rameshappa *, Karibasavaraju Shivalingappa Telagi, Manjunath Malleshappa Hirekeri and Arunkumar Parashuramappa. (2024)." *Speed control and characteristics of DC shunt motor using Simulink".* WJARR CODEN (USA). eISSN 2581-9615

Mohd Faiz Husny Bin Yusof, Adibah Binti Ahmad, Syamzurina Binti Md Hasnan," *Electrical Machines Work with Examples``.* JPPKK e-Book, Perpustakaan Negara Malaysia (2020)

Jehan Aliyya, Yahya Chusna Arif, Ony Asrarul Qudsi. (2020). "*Performance Comparison of PI Control and Fuzzy Logic Control for Speed Control of C Shunt Motor Using Matlab/Simulink".* Journal on Advanced Researched in Electrical Engineering, Vol.4, No.2.

Abdul Rahman @ Abdul Rahim, N.," *Development of an Auto Cupping Machine by Using Arduino Nano Controller"*. (2020). International Journal of Technical Vocational and Engineering Technology, 2(1), 88-92.

Sangeeta Kaiwartya, Shashwati Ray, "*Study on Control of DC Motor Using Matlab Simulink*".IJCRT (2018).

Ruben Tapia-Olvera, Francisco Beltran-Carbajal, Omar Aquilar-Mejia and Antonio Valderrabano-Gonzalez. (2016). *"An Adaptive Speed Control Approach for DC Shunt Motors".* Energies 2016,9,961

S.M Labaran, H.A Bashir. (2018). "DC *Motor Speed Control Analysis: An Overview",* ACICon2018

Khalaf S.Gaeid, "*Optimal Gain Kalman Filter Design with DC Motor Speed Controlled Parameters",* Journal of Asian Scientific Research (2013)

Khalaf S.Gaeid, "*Static DC Motor Speed Controlled Parameters Correction",* Journal of Applied Science & Technology (2013)

Mohd. Abdus Salam, "*Fundamentals of Electrical Machines",* Alpha Science International Ltd Oxford UK (2005).

Mohamed A. El-Sharkawi, "*Fundamentals of Electric Drives*". Brooks/Cole Publishing Company (2000)

John Hindmarsh, "*Electrical Machines and Drives Work Examples 2nd Edition,"* Pergamon Press (1985)

Ishan Luthra, *"Investigation of The Effect of Armature-Resistance Control and Field Resistance Control on The Efficiency of a Dc Shunt Motor for The Same Change in Speed at No-Load".* Think India Journal, ISSN:0971-1260.