University of Victoria
Faculty of Engineering
MECH 330 B03 Lab Report
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ECE 365
Group 1
Lab 2

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Introduction

The purpose of this experiment is to obtain the characteristics and performance indices of a DC machine as both a motor and a generator running with separate field excitation. The DC machine was first connected as a DC motor, and measurements were recorded at multiple loads. From this information we can calculate the efficiency and speed regulation of the DC motor from the following equations.

$$\eta = \frac{P_{out}}{P_{in}}$$

$$Speed\ Regulation = \frac{No\ load\ speed - Full\ load\ speed}{Full\ load\ speed} x\ 100\%$$

The DC machine is then set up as a generator, and measurements were recorded at multiple loads. From this information we can calculate the efficiency, same as above, and voltage regulation of the DC generator from the equation below.

$$Voltage\ Regulation = \frac{No\ load\ voltage - Full\ load\ voltage}{Full\ load\ voltage} x\ 100\%$$

Once these values have been calculated, we can easily determine the value of $K\Phi$ where K is a constant for the machine and Φ is the air gap flux per pole from the equation below.

$$E_A = \omega_m K\phi$$

Experimental Data

Table 1: Seperately Excited DC Motor Characteristics

Trials	ω (rpm)	$I_{Armature}$ (A)	$V_{Armature}$ (V)	$T_{Armature}$ (Nm)	Field Current (A)	Load (A)
No Load	1924	2.5	120.25	0	0.808	0
1	1923	0.5	120.6	2.1	0.808	0.5
2	1915	7.5	120.14	3.2	0.806	1
3	1919	12	120.25	5.8	0.808	2
4	1958	19	120.5	9	0.811	4
5	1950	20	120.2	9.1	0.811	8

Table 2: Seperately Excited DC Generator Characteristics

Trials	Load Current (A)	Field Current (A)	$I_{Armature}$ (A)	$V_{terminal}$ (V)	$T_{armature}$ (Nm)
1 - FullL Load	12.5	0.811	11	101.7	6.8
2	12	0.811	10.5	102.1	6.6
3	10	0.81	9	104	5.7
4	8	0.81	7.5	105.75	4.8
5	4	0.81	3.75	109.24	2.8
6	2	0.81	2	111.2	1.7

Table 3: Voltage Regulation for Seperately Excited Generator

$V_{No\text{-}Load}$	112.85
$V_{Full\text{-}Load}$	101.7
Load Regulation	11.0%

Table 4: Measurement of Steady-State Machine Parameters

R_{field} (Ohm)	$R_{Armature}$ (Ohm)
79.3	0.77

Discussion and Calculations

Steps to start and stop a DC motor safely:

1. Acquire rated voltage and current for said DC motor
2. Ensure power supply reads zero, then power on
3. Adjust field current by varying the rheostat to motor's rated value
4. Increase DC power supply voltage slowly until armature voltage reaches its rated value
5. Ensure armature current does not exceed its rated value
6. Decrease DC power supply voltage to 0
7. Descrease field current to 0, then power off

A plot of the speed-torque characteristics of a separately excited DC motor is shown below in Figure 1. One would expect a higher value of torque to occur at lower speeds, but this is not the case in these trials. This may have occurred due to the motor operating at slightly higher speeds then its rated speed of 1800 rpm.

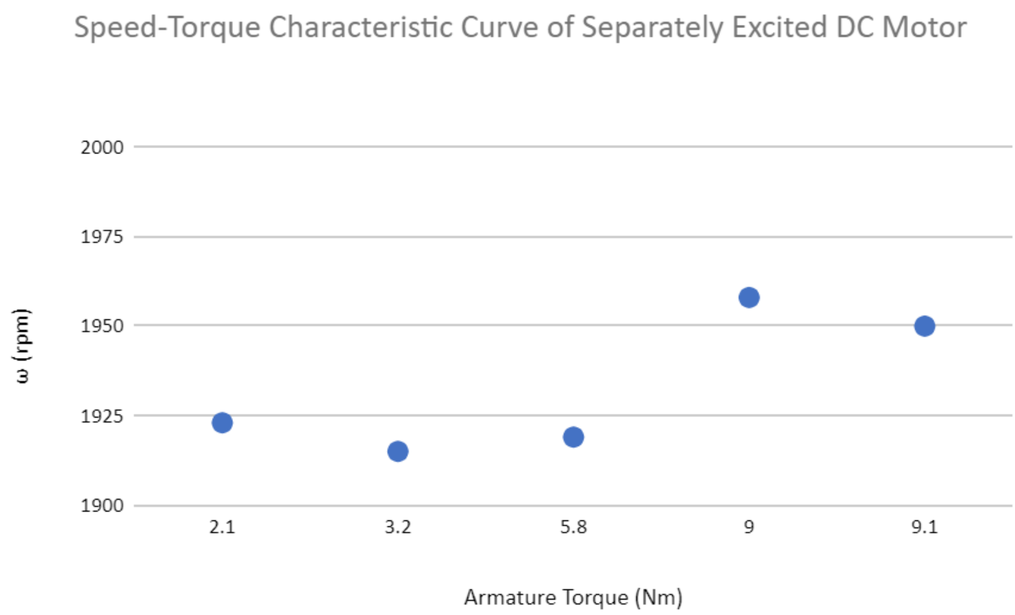

Figure 1: Speed-Torque Characteristics of DC Motor

The speed regulation of separately excited DC motor:

$$SR = \frac{1924-1950}{1950} x100\% = \; -1.33\%$$

Efficiency of separately excited DC motor:

$$\eta = \frac{P_{out}}{P_{in}} = \frac{T\omega}{I_A V_A}$$

$$\eta = \frac{(2.1)(1923)}{(0.5)(120.6)} = 66.97\%$$

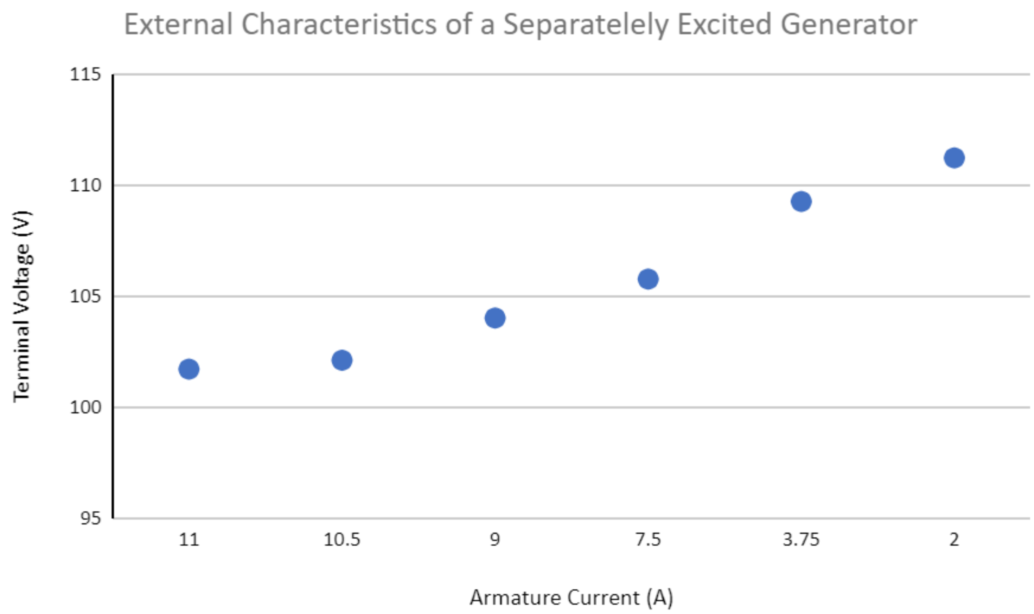

Figure 2: External Characteristics of DC Generator

Voltage Regulation of Sperately Excited DC Generator (Values from Table 3):

$$Voltage\ Regulation\ =\ (\frac{V_{NL}-V_L}{V_L})\ *\ 100\%$$

$$Voltage\ Regulation\ =\ (\frac{112.85-101.7}{101.7})\ *\ 100\%\ =\ 11.0\%$$

The equivalent circuit parameters were found by measuring the resistance in the armature and the field windings. These equivalent circuits are shown below.

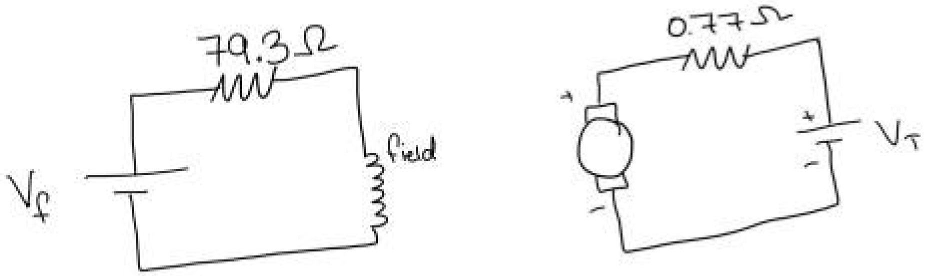

Figure 3: Equivalent Circuit of the DC Machine as a Motor

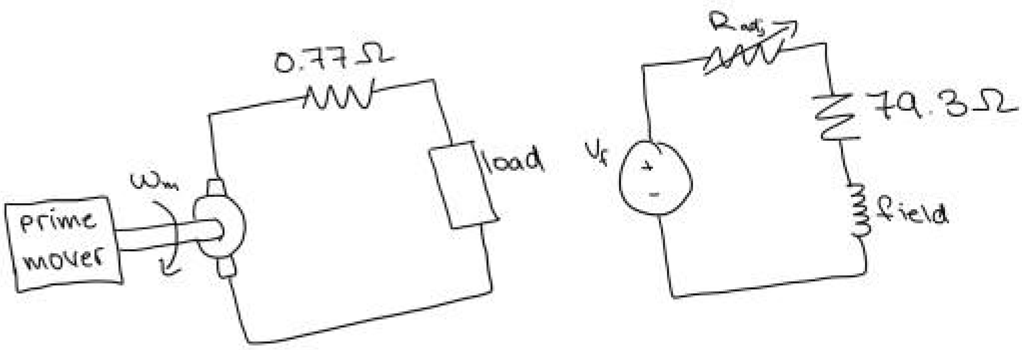

Figure 4: Equivalent Circuit of the DC Machine as a Generator

Calculation of Kϕ using measured value of R_A and nameplate data for DC generator:

$$\omega_m = \frac{V_T - I_A R_A}{K\phi}$$

$$K\phi = \frac{V_T - I_A R_A}{\omega_m}$$

$$K\phi = \frac{120-(12.5)(0.77)}{1800}$$

$$K\phi = 0.061319$$

Estimating Kϕ using measurements at no-load:

$$\omega_{nl} = \frac{V_T}{K\phi}$$

$$K\phi = \frac{V_T}{\omega_{nl}}$$

$$K\phi = \frac{120.25}{1924}$$

$$K\phi = 0.0625$$

Calculating Percent difference for the two values of Kϕ:

$$\left(\frac{0.0625-0.061319}{0.061319}\right) * 100\% = 1.9\,\%$$

As seen in the calculation above, the value of Kϕ is consistent when calculating it using either measured values of R_A and nameplate data, as well as, using experimental values for the DC generator at no-load conditions.

Conclusion

This experiment successfully demonstrated how to operate a DC machine as both a motor and a generator. With these two set ups, different characteristics of the DC machine can be found through some simple calculations and load testing. Overall, the majority of the experimental data and calculations are consistent with expected theoretical values.

References

LABORATORY MANUAL, ECE 365, APPLIED ELECTRONICS AND ELECTRICAL MACHINES / EXPERIMENT 2 - DC MACHINES, University of Victoria, Department of Electrical and Computer Engineering, 2020