University of West London

Power Systems

Engineering report

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Introduction

The purpose of this assignment is to explain the basic principals of power systems. This was achieved by undertaking a series of practical experiments that involved the analysis of a DC motor in task 1 and a single-phase transformer in task 2 in order to understand their operating principals. this assignment is divided into two main tasks. In task 1 the DC motor is analyzed. Task 1 begins by explaining the methodology used during the experimentation to acquire the data. The data is then used to perform the calculations for the task where the input and output power, and efficiency are calculated. The results are then entered in table 1 and 2 and are used to create graphs- figure 1 to 7 An analysis follows the graphs. In task 2 the transformer is analyzed. The methodology explains the steps made during the experimentation. The data gathered is used in the calculations to produce results table 3. Lastly, the task concludes with the equivalent circuit and the analysis of the results.

Task 1

The purpose of this task is to demonstrate the laws governing the shunt DC single-phase motors and to investigate the relationship of a series of parameters like armature voltage, field strength, and motor speed and torque. The aims of this experiment are to understand the operations of DC motors and the parameters use to measure performance.

Methodology

For the practical of the first task , the universal power supply 60-105 was used in addition to the compound wound DC motor, a torque & speed control panel, and a dynamometer machine. The experiment began by setting the power supply by following the instructions given in the assignment handout. After the power supply is set, the experiment proceeds by checking the connections and turning the power supply on while making sure that the voltage regulator is set to 0. The DC motor is then turned on and the voltage regulator knob is slowly rotated until the DC motor reaches 3200 RPM.At this point, the torque is increased by using the control panel and five different values of the armature and field current, armature and filed voltage, speed of the motor and torque. These values are recorded and used in the calculations of input and output voltage, and efficiency. The same process is then repeated but with different motor field resistances of 0Ω, 182Ω, and 317Ω. This is done by changing the setting on the power supply, all the values were recorded in tables 1 and 2.

Calculations

In the calculations, three parameters of the DC motor were calculated, the input power was calculated by adding field and armature power. Then output power is calculated by speed and torque and applying them into the formula. By using input and output power we then calculate the efficiency of the DC motor

Input Power

$$P_i = V_F \times I_F + V_A \times I_A$$

Equation 1: shows the formula for input power

$$132 \times 0.15 + 130 \times 4.48 = 602.2$$

$$131 \times 0.15 + 129 \times 4.44 = 592.41$$

$$130 \times 0.15 + 128 \times 4.50 = 595.5$$

$$129 \times 0.15 + 127 \times 5.45 = 711.5$$

$$112 \times 0.15 + 110 \times 6.85 = 770.3$$

Output power

$$\frac{2\pi NT}{60}$$

Equation 2:show the formula for output power

$$\frac{2\pi 3200 \times 0.1}{60} = 33.51$$

$$\frac{2\pi 3000 \times 0.2}{60} = 62.83$$

$$\frac{2\pi 2690 \times 0.3}{60} = 84.5$$

$$\frac{2\pi 2010 \times 0.4}{60} = 84.19$$

$$\frac{2\pi 1298 \times 0.5}{60} = 67.96$$

Efficiency

$$\frac{P_o}{P_i} \times 100\%$$

Equation 3:shows the formula of efficiency

$$\frac{33.51}{602.2} \times 100\% = 5.56\%$$

$$\frac{62.83}{595.5} \times 100\% = 10.60\%$$

$$\frac{84.5}{595.5} \times 100\% = 14.1\%$$

$$\frac{84.19}{711.5} \times 100\% = 11.83\%$$

$$\frac{67.96}{770.3} \times 100\% = 8.82\%$$

Results

Part1

Table 1: Results for part 1

Armature Voltage V1 (V)	Field Voltage V2 (V)	Armature Current I1 (A)	Field Current I2 (A)	Torque (Nm)	Speed (rpm)	Input Power (W)	Output Power (W)	Efficiency (%)
130	132	4.48	0.15	0.1	3200	602.2	33.51	5.56
129	131	4.44	0.15	0.2	3000	592.4	62.83	10.6
128	130	4.5	0.15	0.3	2690	595.5	84.5	14.1
127	129	5.45	0.15	0.4	2010	711.5	84.19	11.83
110	112	6.85	0.15	0.5	1298	770.3	67.96	8.82

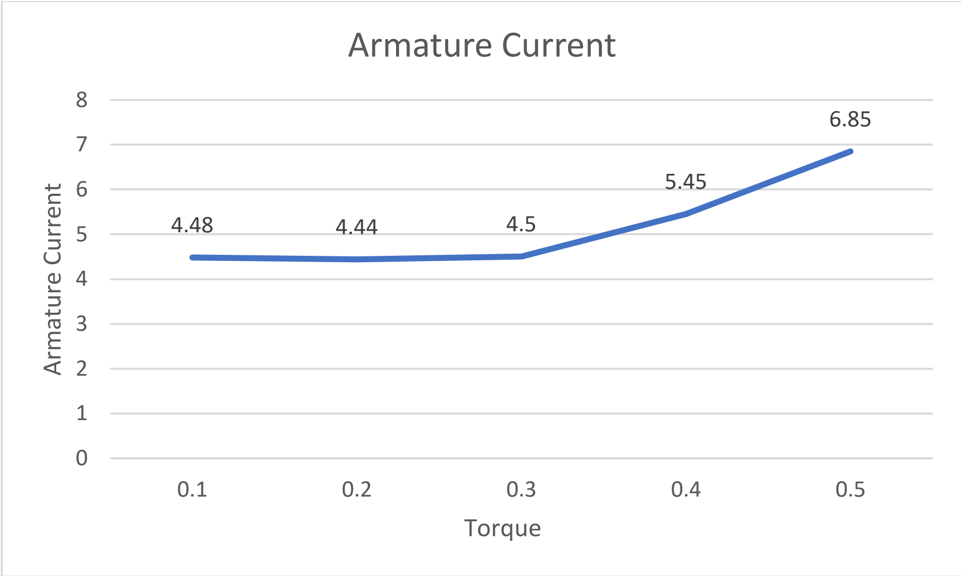

Figure 1: armature vs current graph

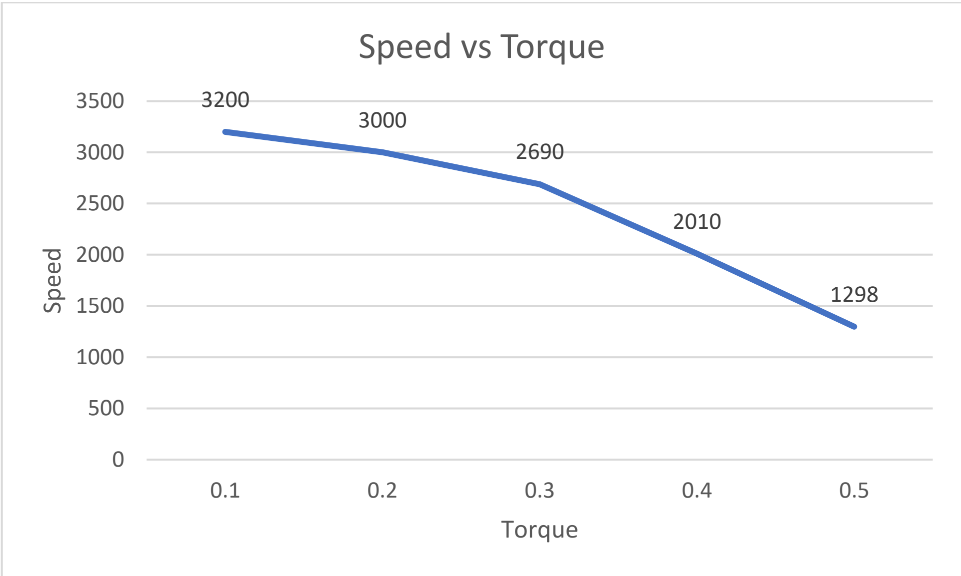

Figure 2:shows speed vs torque graph

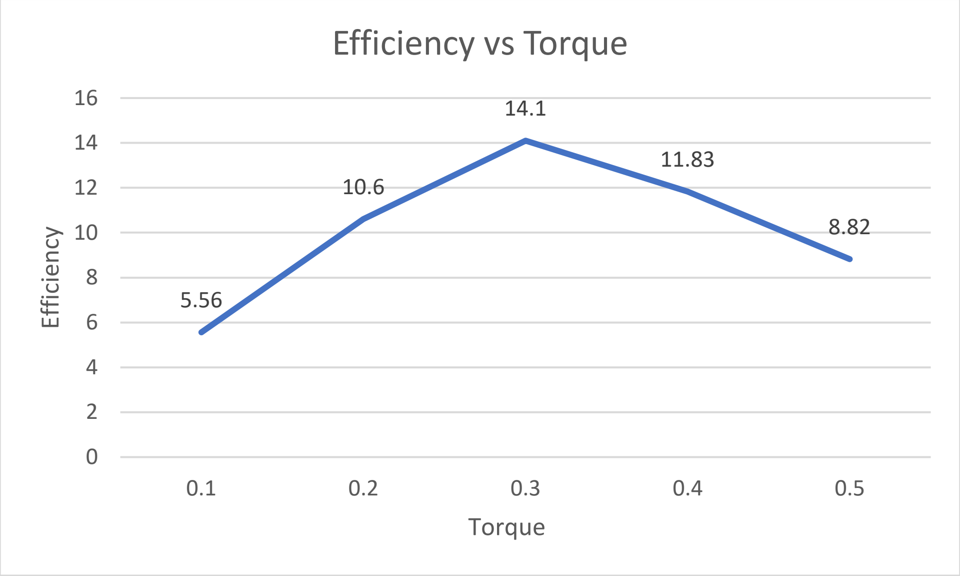

Figure 3:shows efficiency vs torque graph

Part 2

Table 2:shows the results of part 2

No resistance in series with field winding			182Ω Resistance in series with field winding			317Ω Resistance in series with field winding		
Field Current I2 (A)	Torque (Nm)	Speed (rpm)	Field Current I2 (A)	Torque (Nm)	Speed (rpm)	Field Current I2 (A)	Torque (Nm)	Speed (rpm)
0.14	0.1	3200	0.14	0.1	3200	0.14	0.1	3200
0.14	0.2	2930	0.14	0.2	2829	0.14	0.2	2870
0.14	0.3	2360	0.14	0.3	2464	0.14	0.3	2472
0.14	0.4	2168	0.14	0.4	1995	0.14	0.4	2164
0.14	0.5	1798	0.14	0.5	1537	0.14	0.5	1595

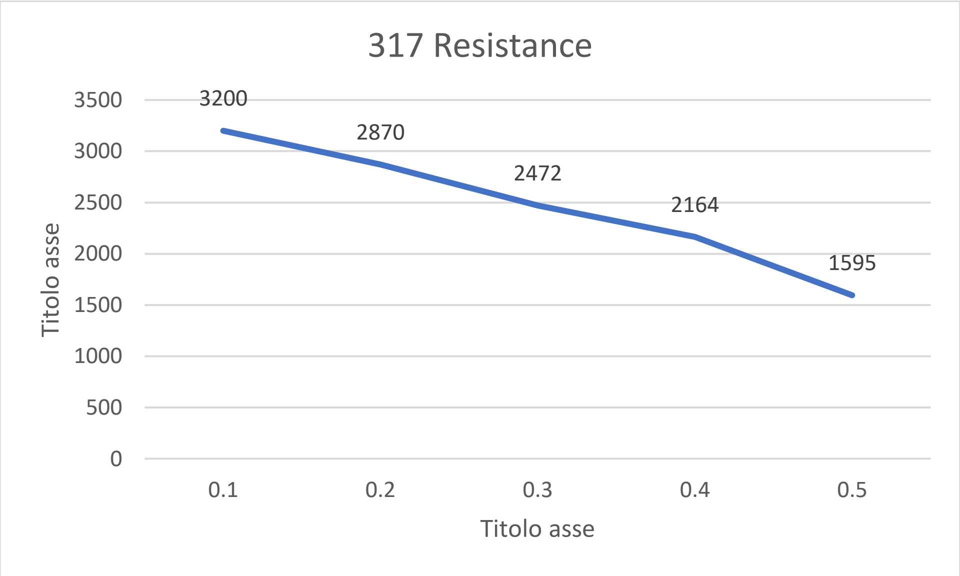

Figure 4: shows the DC motor with 317 load

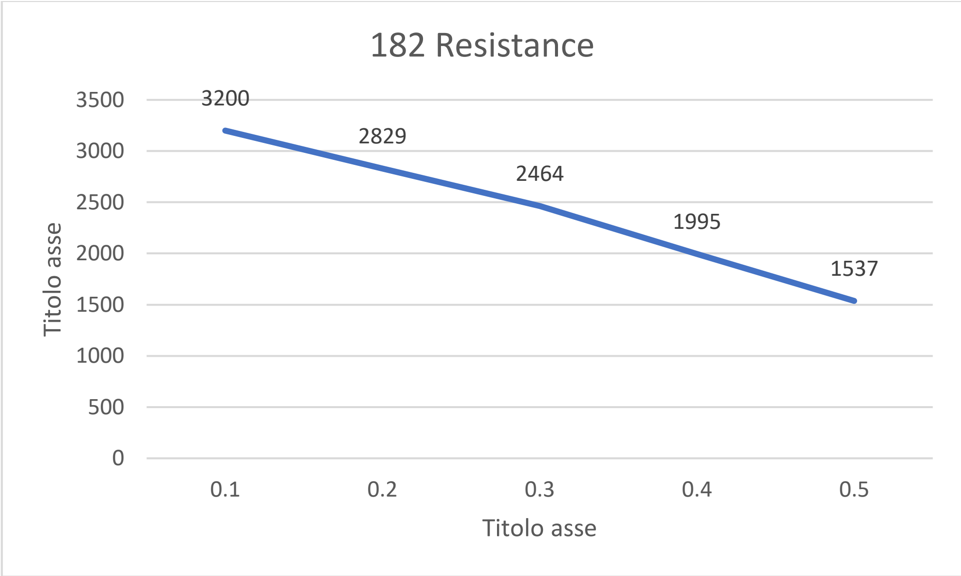

Figure 5: shows the DC motor with 182 load

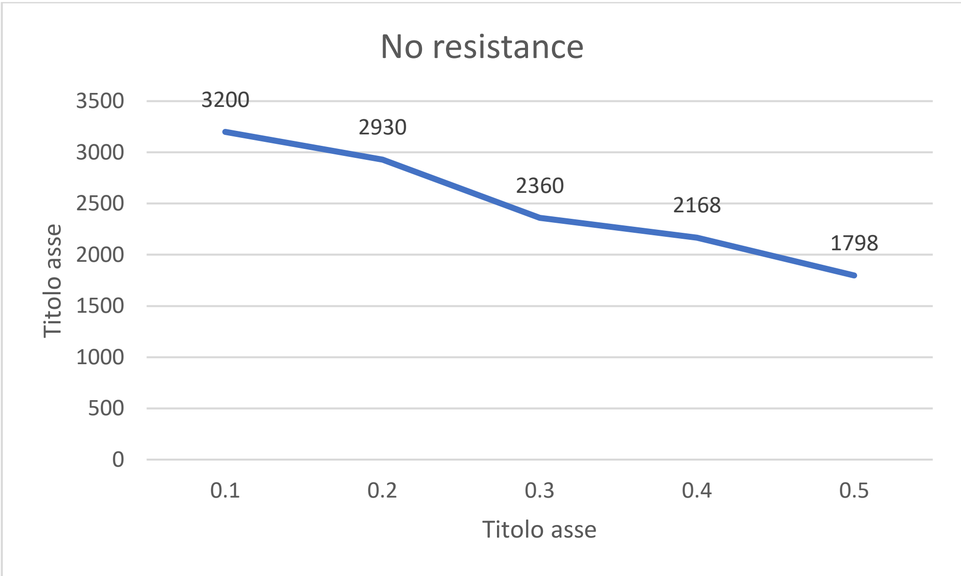

Figure 6: shows the DC motor with 0 load

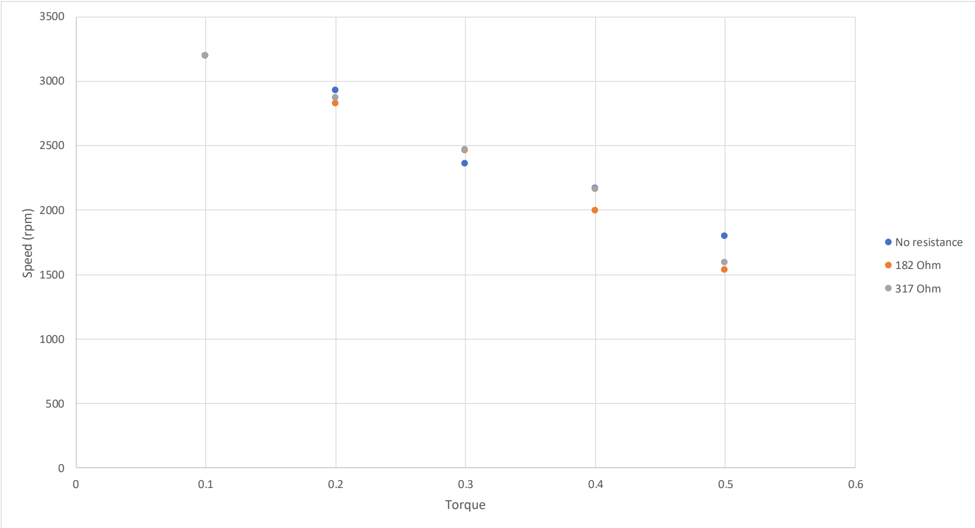

Figure 7:show all the graph to compare them

Analysis

For the analysis of the experimental results, a series of graphs were made from figure 1 to7, all the data collected for the first task were placed in table 1 and 2. In figure 1 the graph shows the correlation between current and torque. It can be noted that current and the torque are proportionally related. As torque increases, current increases, this is expected because the theory states that $\mathrm{T} = \mathrm{K_t}\ \Phi\ \mathrm{I_a}$ .This formula shows the relationship between current and torque. figure 2 portrays how torque and speed interact in relation to each other.It can be observed that with the increase in torque, the speed linearly decreases, this is what is expected by the theory which states that with an increase of torque in the DC motor there is an increase in armature current and a decrease in speed. Figure 3 shows efficiency vs torque. It is evident that efficiency increases as the torque increases, it then drops midway into the experiment. This is expected, it is called an efficiency curve and it is caused by power losses due to the increases of torque in the DC motor. In part 2, the DC motor is connected to three different loads 0Ω, 182Ω, and 317Ω. The speed vs torque results were compared in figure form to 4 to 6. Figure 7 shows all the graphs compared.It is evident that results are similar for the torque values 0.1 to 0.5.

Task 2

The practical experimentation in task 2 allows for the understanding of the single-phase transformer by investigating their performance at different loading conditions in particular in open and short circuit conditions. It allows for the analysis of the transformer by using a theoretical equivalent circuit with the practical results.

Methodology

For the practical in task 2 the single-phase transformer panel(61-105) was used. The transformer was first set by following the instructions in the assignment handout. It was connected to the monitor and an oscilloscope. The hysteresis of the transformer should have been recorded but due to faults in the transformer, the waveform was not displayed successfully. The experimentation proceeded by measuring the primary voltage and current when the transformer is connected in an open and short circuit. Due to faults in the transformer the short circuit current of the secondary was not able to be recorded.

Calculations

In these calculations, the equivalent circuit of this transformer is calculated by first calculating the impedance angle and then impedance and admittance of the primary.

Short circuit

$$\theta_{sc} = \cos^{-1}\left(\frac{P_{sc}}{V_{sc} \times I_{sc}}\right) = \cos^{-1}\left(\frac{17}{238 \times 0.1}\right) = 44.42°$$

Equation 4:shows the formula for the impedance angle

$$Z_{sc} = \frac{V_{sc}}{I_{sc}} < \theta_{sc} = \frac{238}{0.1} < 44.42° = 2380 \ < 44.42°$$

$$R_{eq} = 1699.86 \quad X_{eq} = j\ 1665.79$$

Open circuit

$$\theta_{oc} = \cos^{-1}\left(\frac{P_{oc}}{V_{oc} \times I_{oc}}\right) = \cos^{-1}\left(\frac{19}{239 \times 0.1}\right) = 37.35°$$

Equation 5: shows the formula for the impedance angle

$$y_{oc} = \frac{I_{oc}}{V_{oc}} < -37.35° = \frac{0.1}{239} < -37.35° = 418 \times 10^{-6} < -37.35°$$

$$R_c = \frac{1}{0.000333} = 3003\Omega \quad X_m = \frac{1}{0.000252} = j3968.25\Omega$$

Rated power

$$S_{rated} = V_{oc} \times I_{sc} = 239 \times 0.1 = 23.9W$$

Equation 6:show the formula for the transformer rated power

Results

Table 3:shows the results of the transformer

Open-Circuit Test			Short-Circuit Test		
primary voltage Voc	current Ioc	power Poc	primary voltage Vsc	current Isc	power Psc
239 V	0.1 A	19 W	238 V	0.1 A	17 W

Equivalent circuit

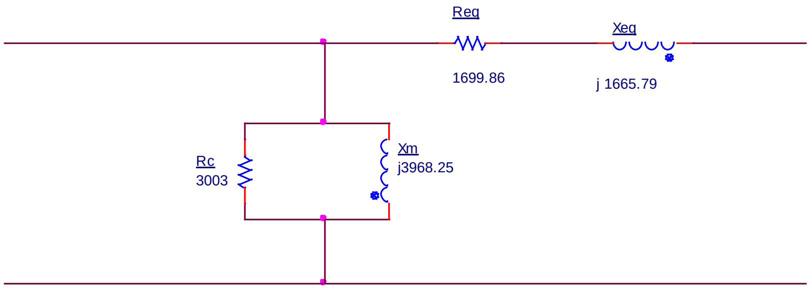

Figure 8:shows the equivalent circuit

Analysis

During the experimentation of task 2, a series of problems were encountered in the first part of the assignment, while measuring the hysteresis of the transformer, due to faults in the secondary of the transformer, the expected values were not recorded. Therefore,the oscilloscope, even if set up correctly by following the instructions given in the handout and double-checking it with the technician, did not display the expected loop. For the second part, the field current was not recorded due to the faults in the transformer. The expected high current in the short circuit test was not recorded. In the end, using the parameters that were able to be collected, their equivalent circuit made was derived using the collected parameters. The results were as expected in comparison to theory, for which the rated power of the transformer was also calculated in equation 6, giving the performance of this transformer.

Conclusion

In conclusion, all the tasks were covered with explanations, calculations and results. In task 1, the input and output powers and efficiency were calculated. Graphs using the data acquired were made to analyze the performance of the DC motor used in the experiment. In figure 1, it was explained that it is expected that the current will increase as the torque increases. In figure 2, the theory states that as torque increases, the speed drops, for figure 3,the efficiency curve is caused by power losses. For task 2, due to the fault in secondary of the transformer, the hysteresis loop, and short circuit current could not be recorded. However, the equivalent circuit was calculated allowing the calculation of its power rating and theanalysis of its performance.