Experiment B3: Motor and Gear Box

MECHENG 2BA3

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L03 – 2BA3

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Objective

The objective of this lab is to observe the behaviour of an electrical motor and gearbox system.

Theory

As seen in instructions

Procedure

1) Set up the power supply for the brake: Turn on the power supply for the brake. The voltage of the brake should be set to 24V.
2) Set up the power supply for the motor: Turn on the power supply for the motor. The voltage for the first test should be set to 7.5V and this should correspond to a speed of 500rpm on the input shaft. Adjust the display switch to the current setting. Turn the knob for the current all the way to the right so that the power supply will provide whatever current is required to drive the load. The current displayed on the power supply is the actual current supplied to the motor and should stop changing.
3) Perform initial test to determine when the motor will stall: As the braking load is increased the motor will eventually stall or the motor will reach its maximum current for continuous operation, which is 4A in this case. Slowly increase the current supplied to the brake until the motor stalls or the current to the motor reaches 4A. Record the current that must be supplied to the brake to either stall the motor or have the motor reach its maximum current.
4) Determine the step size for the measurements: You will want to perform a series of measurements at this speed to examine how the performance of the system changes as the load changes. Ideally, 5-6 measurements should be performed, including a minimum point and the maximum point where the motor stalls or the 4A limit for the motor is reached. Use the result from the previous step to determine reasonable values for the brake current to use in this series of tests.
5) Characterise the motor and transmission system for a given speed: For each braking current determined in step 4), adjust the current to the desired value. Wait until the system has reached steady state operation. Then record:
a. The voltage and current from the power supply to the motor. The voltage should be fixed but you can check this by toggling the display switch.
b. The force on the load cell at the motor and the speed of the motor shaft.
c. The speed of the shaft out of the gear box that corresponds to the speed of the brake shaft and the torque required to hold the brake in place.
6) Characterise the performance of the motor at different speeds: Repeat the above steps, changing the voltage to the motor in each case to adjust the speed of the motor. Perform measurements for motor input voltages of 10V, 15V, 20V, and 25V. These should roughly correspond to speeds of 1000 – 3000rpm in steps of 500rpm.
7) Calculate power and efficiency: For each measurement point in your data table, calculate motor electrical power, motor mechanical power, brake mechanical power, motor efficiency and brake efficiency.

Results

Reaches 4A (A)

7.5 V 0.197

	Motor Amp	Break amp	break volt	osciloscope (HZ)	motor rpm	motor w	break load cell	motor load cell
0.0394	1.34	0.039	2	34	511	53.511795	1.39	1.08
0.0788	1.44	0.079	4	33	497	52.045718	10.65	1.19
0.1182	1.98	0.118	6.1	28	420	43.982297	50	1.7
0.1576	2.7	0.158	8.2	19	295	30.892328	103	2.5
0.197	4.13	0.197	10.2	4.81	63	6.5973446	187	3.8

10 V

	Motor Amp	Break amp	break volt	osscilloscope (HZ)	motor rpm	motor w	break load cell	motor load cell
0.0394	1.47	0.039	2	50	752	78.749256	2.7	1.16
0.0788	1.53	0.079	4	50	746	78.120937	10.9	1.25
0.1182	1.9	0.118	6.1	46	687	71.942472	37	1.6
0.1576	2.73	0.158	8.2	36	543	56.862827	97	2.4
0.197	4.1	0.186	9.6	20	310	32.463124	164	3.5

15 V 0.183

	Motor Amp	Break amp	break volt	osciloscope (HZ)	motor rpm	motor w	break load cell	motor load cell
0.0366	1.56	0.036	1.8	83	1235	129.3289	1	1.2
0.0732	1.64	0.072	3.7	82	1222	127.96754	8.5	1.3
0.1098	1.96	0.11	5.7	77	1168	122.31267	34	1.8
0.1464	2.6	0.145	7.5	71	1058	110.7935	78	2.2
0.183	3.72	0.183	9.5	58	860	90.058989	152	3.3

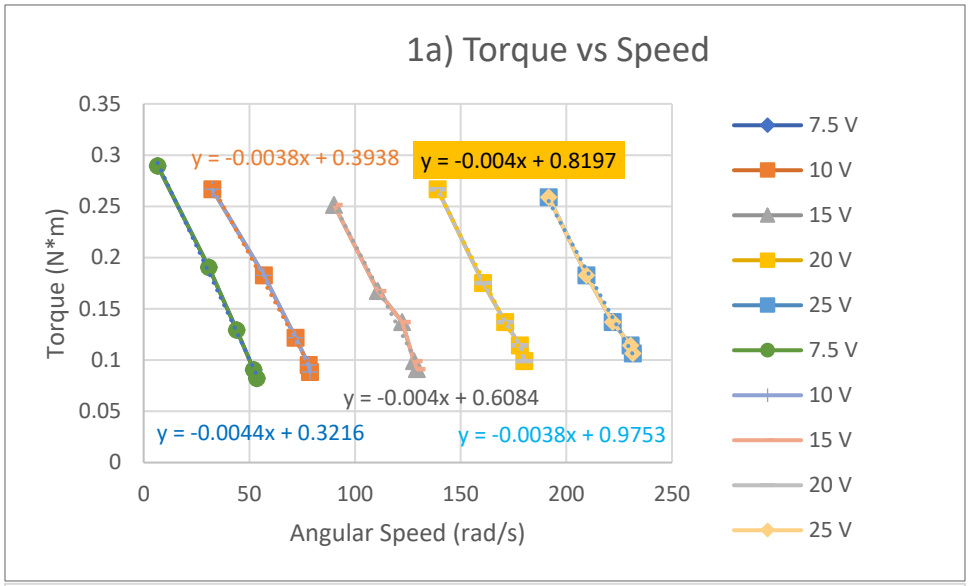
20 V 0.183

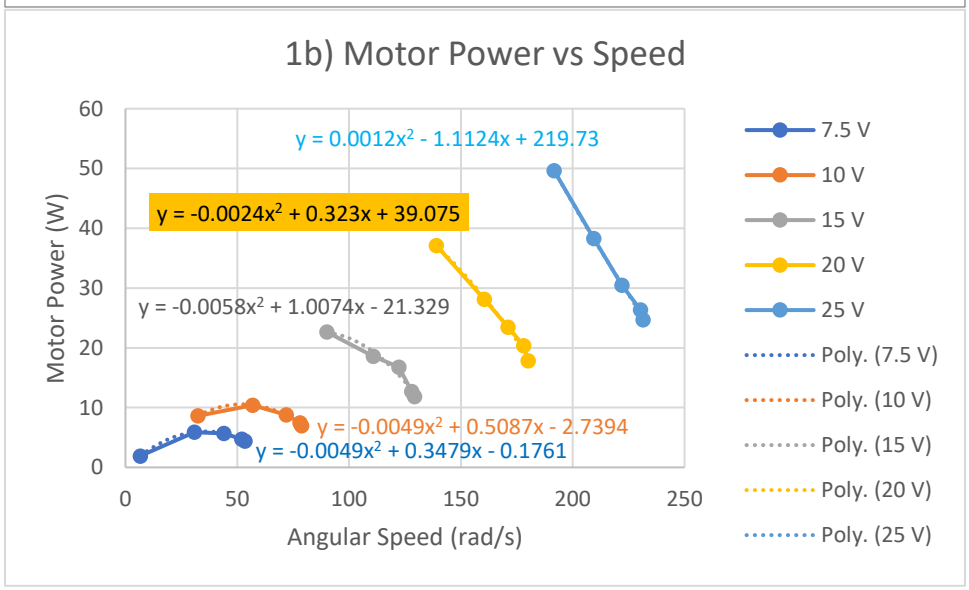
	Motor Amp	Break amp	break volt	osciloscope (HZ)	motor rpm	motor w	break load cell	motor load cell
0.0366	1.7	0.036	1.8	114	1720	180.11798	1.3	1.3
0.0732	1.8	0.073	3.7	114	1700	178.02358	11	1.5
0.1098	2.16	0.11	5.7	109	1633	171.00736	39	1.8
0.1464	2.7	0.146	7.6	102	1533	160.53538	79	2.3
0.183	3.9	0.182	9.5	88	1328	139.06783	159	3.5

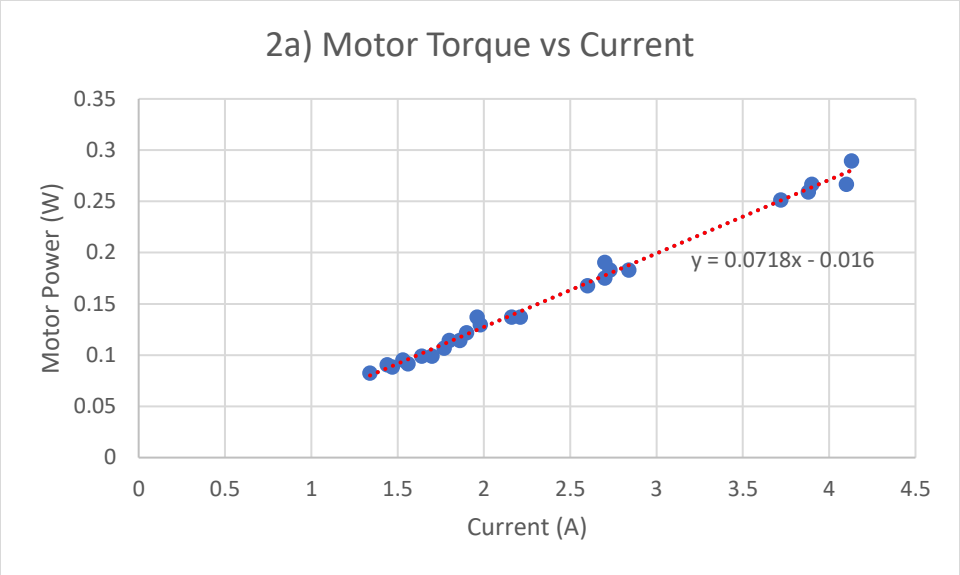
25 V 0.183

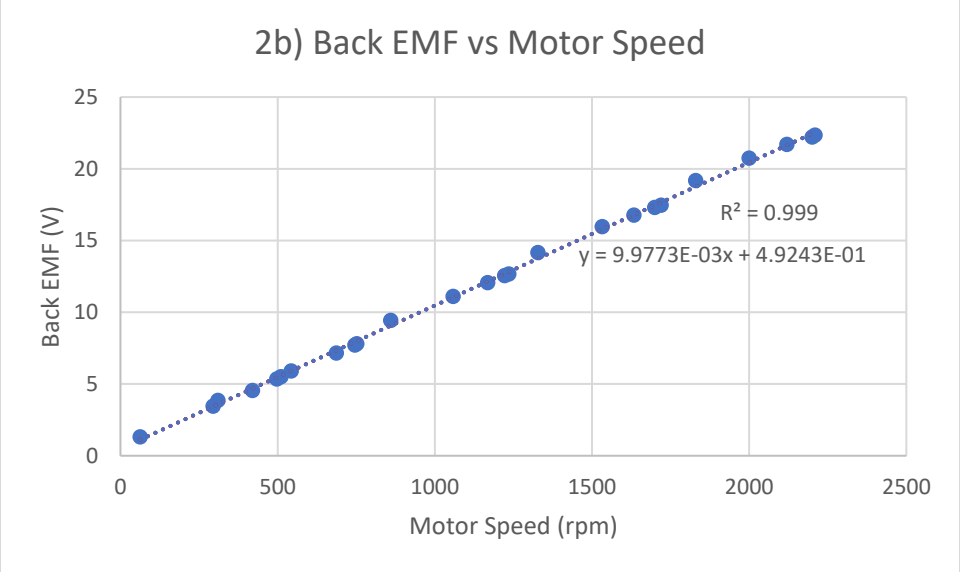
	Motor Amp	Break amp	break volt	osciloscope (HZ)	motor rpm	motor w	break load cell	motor load cell
0.0366	1.77	0.037	1.9	152	2210	231.43066	1.6	1.4
0.0732	1.86	0.072	3.7	147	2200	230.38346	10	1.5
0.1098	2.21	0.11	5.7	139	2120	222.00588	37	1.8
0.1464	2.84	0.146	7.7	135	2000	209.43951	83	2.4
0.183	3.88	0.183	9.6	122	1830	191.63715	153	3.4

Discussion


1a) Torque vs Speed
Torque (N*m)
Angular Speed (rad/s)
y = -0.0038x + 0.3938
y = -0.004x + 0.8197
y = -0.004x + 0.6084
y = -0.0044x + 0.3216
y = -0.0038x + 0.9753
7.5 V
10 V
15 V
20 V
25 V
7.5 V
10 V
15 V
20 V
25 V


1b) Motor Power vs Speed
Motor Power (W)
Angular Speed (rad/s)
y = 0.0012x² - 1.1124x + 219.73
y = -0.0024x² + 0.323x + 39.075
y = -0.0058x² + 1.0074x - 21.329
y = -0.0049x² + 0.5087x - 2.7394
y = -0.0049x² + 0.3479x - 0.1761
7.5 V
10 V
15 V
20 V
25 V
Poly. (7.5 V)
Poly. (10 V)
Poly. (15 V)
Poly. (20 V)
Poly. (25 V)





The motor speed constant Kv is 9.98E-3 V/RPM. This fit is reliable since the r^2 value is almost exactly equal to 1. This shows that the linear relationship between Back EMF and motor speed are accurately represented by the sample data.

Conclusion

In this lab, the aim was to observe the properties and behaviour of an electric motor and gearbox, extracting and analyzing various properties such as back emf, mechanical power, and observing the difference between brake and motor load cells.