Report on Usefulness of Data Collected and Plausibility of the Electric Car's Motor

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Introduction

The aim of this report is to analyze the usefulness of the experimental data collected in order to understand the plausibility of the Electric Vehicle motor operating in steady state. Data was analyzed to determine if the experimental behavior of the motor matched the theoretical[1] expectation of two linear and one hyperbolic relationships. Consistency between theoretical and experimental data behavior would suggest the Electric Vehicle motor is plausible for application in the Lafayette Formula Electric Vehicle.

Data Collection

The following experimental data was collected using the available dynamometer and sensors. All system operations are outlined and described in the Appendix. General setup for all the indexed experiment 1-3, the following steps are:

a. Hooked up all cables and checked they work
b. Booted the PC and ran Windows TeamViewer
c. Ensured Prof. Nadovich had turned HV on and E-Stop button not closed. Supply voltage was set to 91.5V.
d. Opened VirtualBox through Team viewer, then ran OpenSuse, then ran "DYNO"
e. Click "ON" on the supply tab, then went to room to look in to see voltage was present at supply
f. Minimized V.B momentarily and opened 1314-Programmer
    i. Choose data to monitor – Motor RPM, Motor Temp, Controller Temperature, Dyno Torque and Supply Current
    ii. Ran data logger at 500ms

After steps a-f, experimentation continued as follows:

Experiment 1 – constant supply current

1. Set the load setting to 0%
2. Adjust throttle setting to change supply current to reach a desired current, started at 0A with increments of 20A to 160A.
3. Recorded load%, motor speed (rpm), load torque (lb-ft) and the actual supply current (A) in a spreadsheet
4. Incremented load setting by 5% and repeat steps 2 and 3 until load setting of 50%

For this experiment, we went to only 50% load.

Experiment 2 – constant load torque

1. Set the load setting to 0%
2. Adjust throttle setting to change supply current to reach a desired load torque, started at 0 lb-ft with increments of 5 lb-ft to 40 lb-ft.

3. Recorded load%, motor speed (rpm), desired load torque (lb-ft), supply current (A) and the actual load torque (lb-ft) in a spreadsheet
4. Incremented load setting by 5% and repeat steps 2 and 3 until load setting of 35%

For this experiment, we went to only 35% load rather than the original 100% because of limitation of the motor heating up.

Experiment 3 – constant motor speed

1. Set the load setting to 0%
2. Adjust throttle setting to change supply current to reach a desired motor speed, started at 0 rpm with increments of 500 rpm to 4000 rpm.
3. Recorded load%, desired motor speed (rpm), load torque (lb-ft), supply current (A) and the actual motor speed (lb-ft) in a spreadsheet
4. Incremented load setting by 5% and repeat steps 2 and 3 until load setting of 35%

For this experiment, we went to only 35% load rather than the original 100% because of limitation of the motor heating up.

Data Analysis

Figure 1-4 are graphs plotted from data collected at a constant 91.5V supply voltage.

Constant Load Torque

Figure 1 is a linear relationship is as expected, but the range of motor speed is 762 – 3969 rpm. The range of load torque given does not show what happens at low values of motor speed. The 35 and 40 lb-ft constant load torque only have one data point each, due to limitations of heating motor.

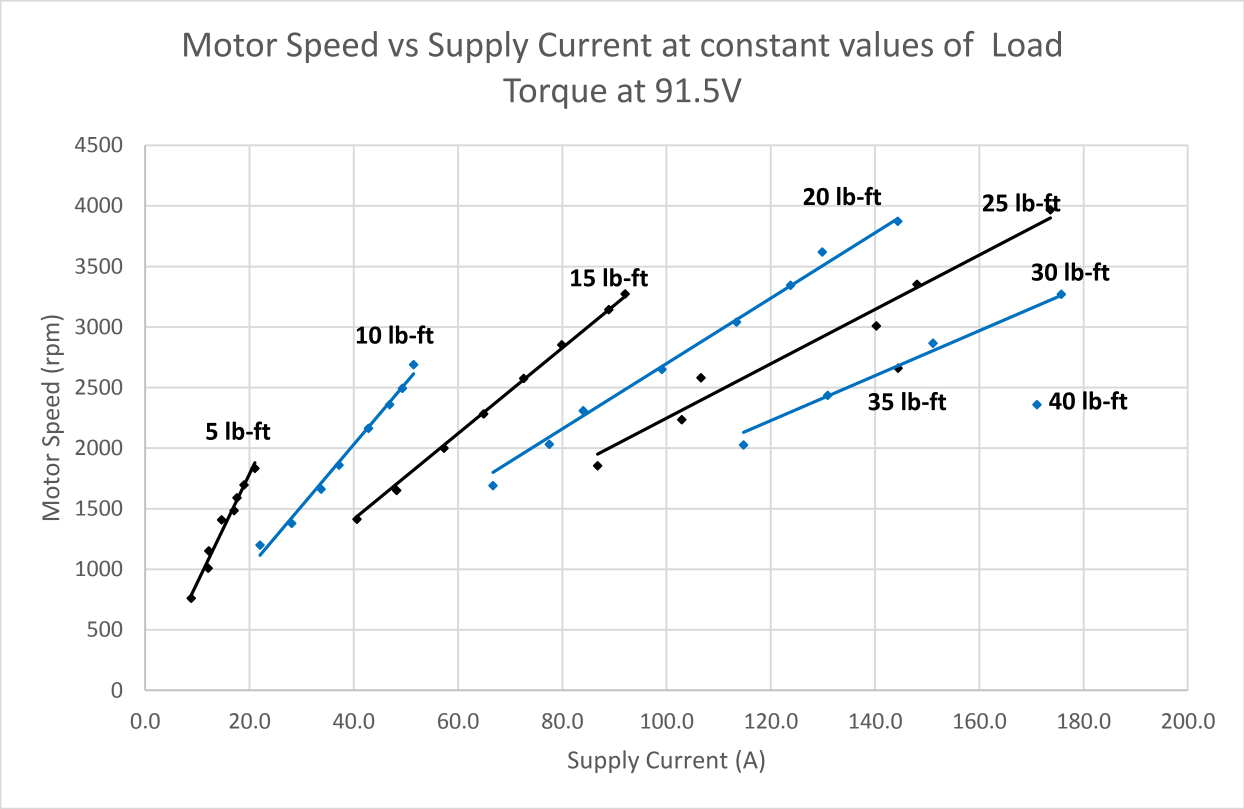

Figure 1 Motor speed at constant load torque

Constant Motor Speed

Figure 2 and 3 are a linear relationship is as expected, but the plot has been divided into constant low and high motor speed. Low motor speeds like 250 and 500 rpm correspond to very small values of torque. An optimum constant motor speed of 2500 rpm corresponds to the highest load torque of 42.2 lb-ft. Low and high motor speeds have been divided into their separate graphs because the low motor speed relation has very small ranges of supply current and load torque resulting them appearing like a smudge on a combined plot.

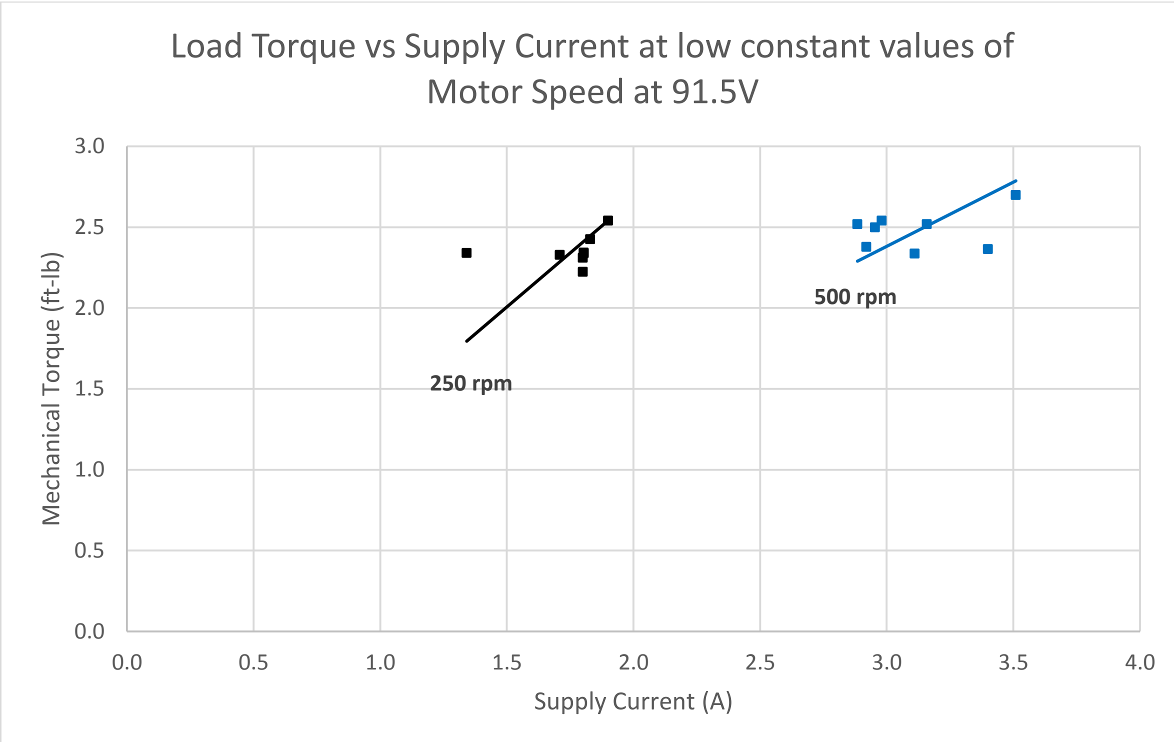

Figure 2 Load torque at constant low motor speed

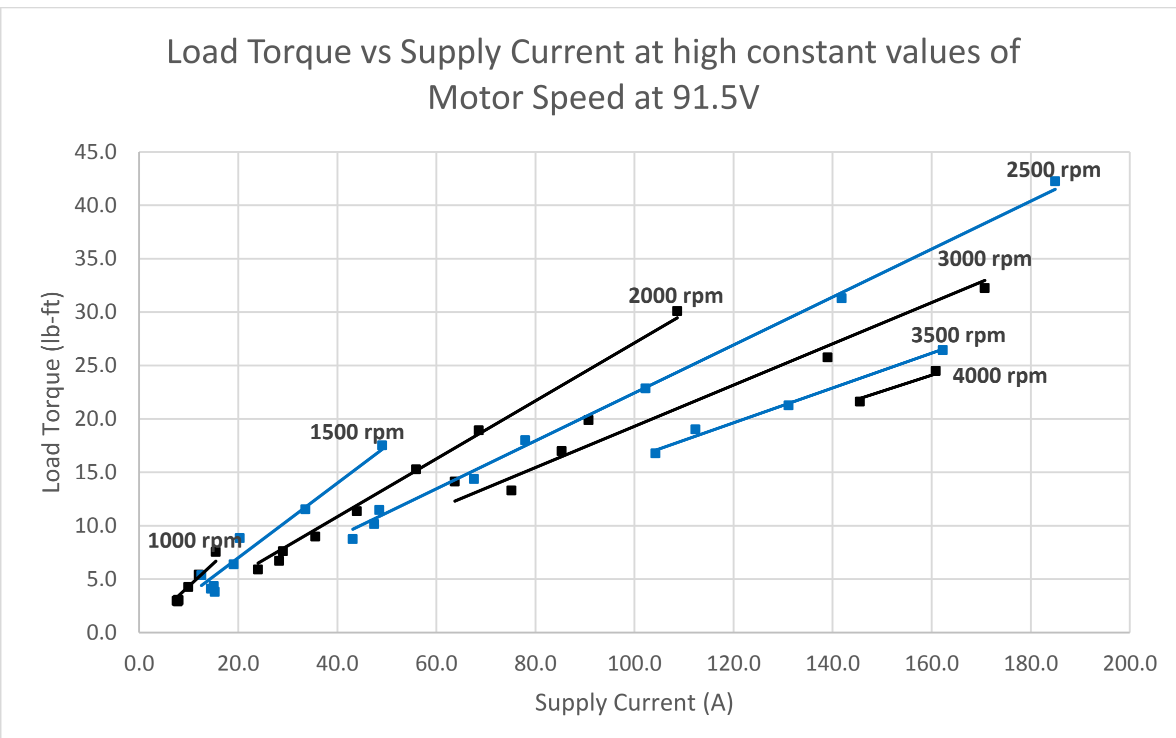

Figure 3 Load torque at constant high motor speed

Constant Supply Current

Figure 4 is a hyperbolic relationship is as expected. The range of load torque given does not show what happens at low values of motor speed. The load torque self-adjusts to meet the given power that is proportional to the constant current, resulting in the expected hyperbolic relationship shown. . 62.2 lb-ft was the highest load torque recorded for this entire experiment, giving a load torque range of 0-62.2 lb-ft.

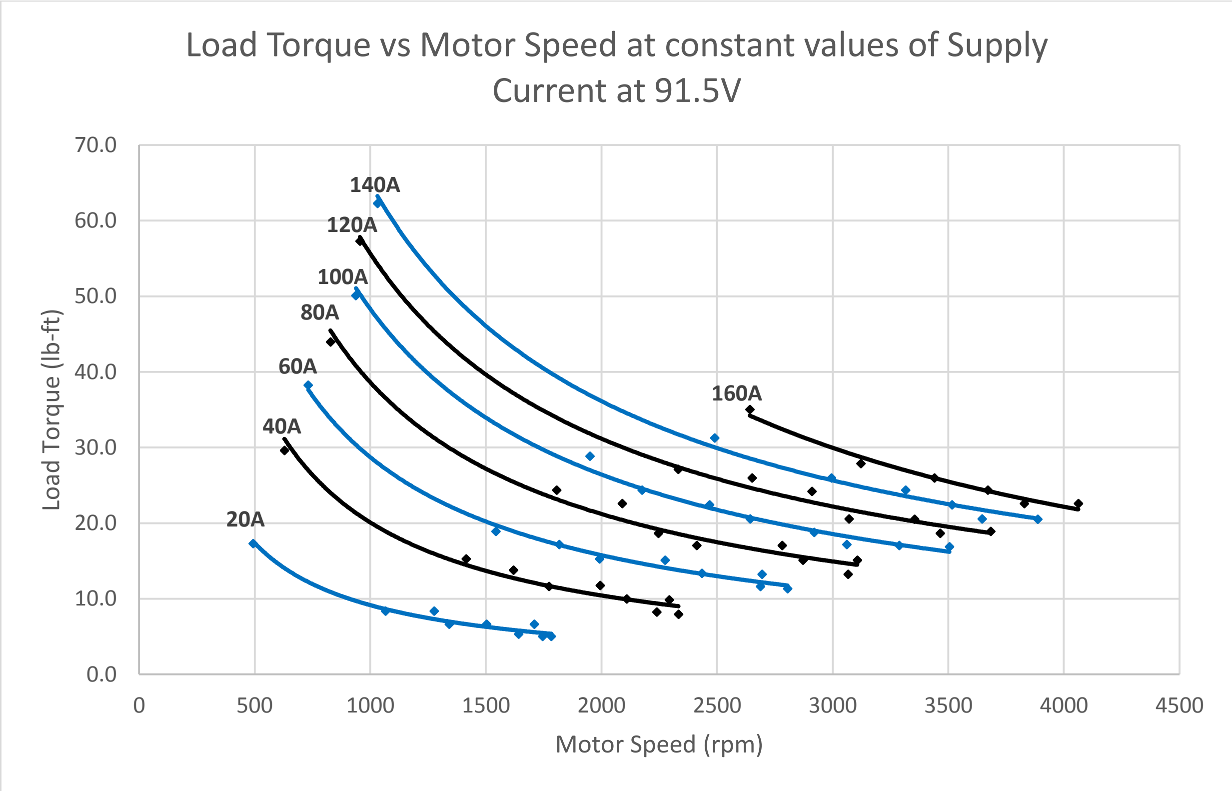

Figure 4 Load Torque at constant supply current

Results and Conclusion

The three expectations of this experiment to prove two linear relationships and one hyperbolic one. At constant current, motor speed self-adjusts at a set load torque value to meet the power which the current is proportional to, resulting in hyperbolic relationship. The two linear relationships of constant motor speed and load torque: when load torque is held constant, a set increase in motor speed results to an increase in supply current to maintain the given constant load torque. Then motor speed is held constant, at constant motor speed, a set increase in load torque results to an increase in supply current to maintain the given constant motor speed. Therefore, the experimental results are consistent with the theoretical expectations, following a mathematical model of conservation of power. The conclusion of this report is that the electric motor tested is plausible for use in the Formula Electric car.

Appendix - Dyno System Setup

Electric Vehicle Systems

- HPEVS AC50515X Motor
- Curtis Instruments 1238R7601 Controller

Battery Simulation MagnaPower(TSD 100250/208) D.C. Power Supply

- 20kW P.S. 200A max rms @ ~100 Vdc

Dynamometer System and Sensors - Huff HTH100 Dyno

- Load Adjustment
  - Oil Valve(CAT HY143200)
- Torque Sensor
  - Load Cell (LCCE250)
  - Strain Gauge Input Module (DataForth SCM5B38)
- Tachometer
  - Frequency Input Module (DataForth SCM5B45)
- Throttle
  - Voltage Output Module (DataForth SCM5B49)
- Data Acquisition Board (MCDAQUSB7204)

Data Acquisition Software

- Curtis 1314 Programming Software
  - Motor RPM data
- Dyno Software (Proprietary from Class of 2015)
  - Output Data: P.S. Current, Torque
  - Input Data: Load %, Throttle %

Computer

- Dell Precision T1700
  - Accessed through Windows TeamViewer
  - Dyno software is run using a deployment of OpenSuse in Oracle's Virtual Box

Reference

[1]Hussein, Zainab. *Theoretical relation of the Formula Electric Car Physical Parameters of Load Torque, Supply Current and Motor Speed*. March 24, 2017