Physics Modelling: Mathematical Equations

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Static characterization

∑ forces for dynamic characterization modelling

$$TL = KTi - fw$$

$$i = 0.2323TL$$

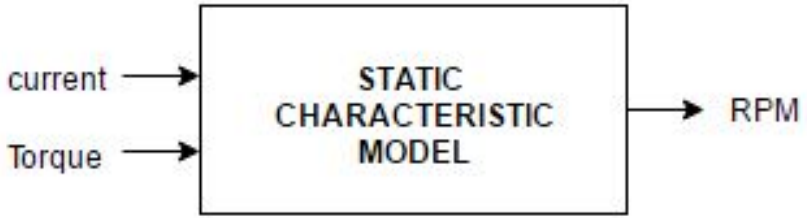
$$thus, \quad TL = KTi$$

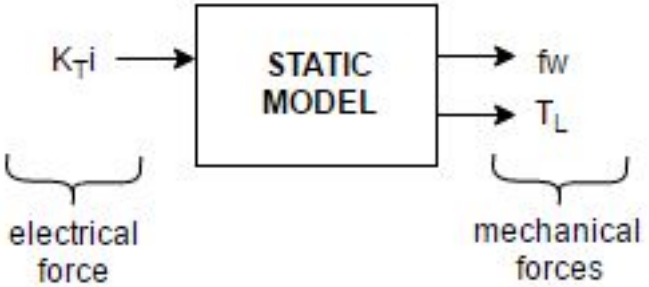
$$KT = 4.305$$

$$substitute\ in\ TL\ eqn, \quad f = \frac{KT}{w} - \frac{TL}{w}$$

$$0.0056TL = \frac{4.305i}{w} - \frac{TL}{w}$$

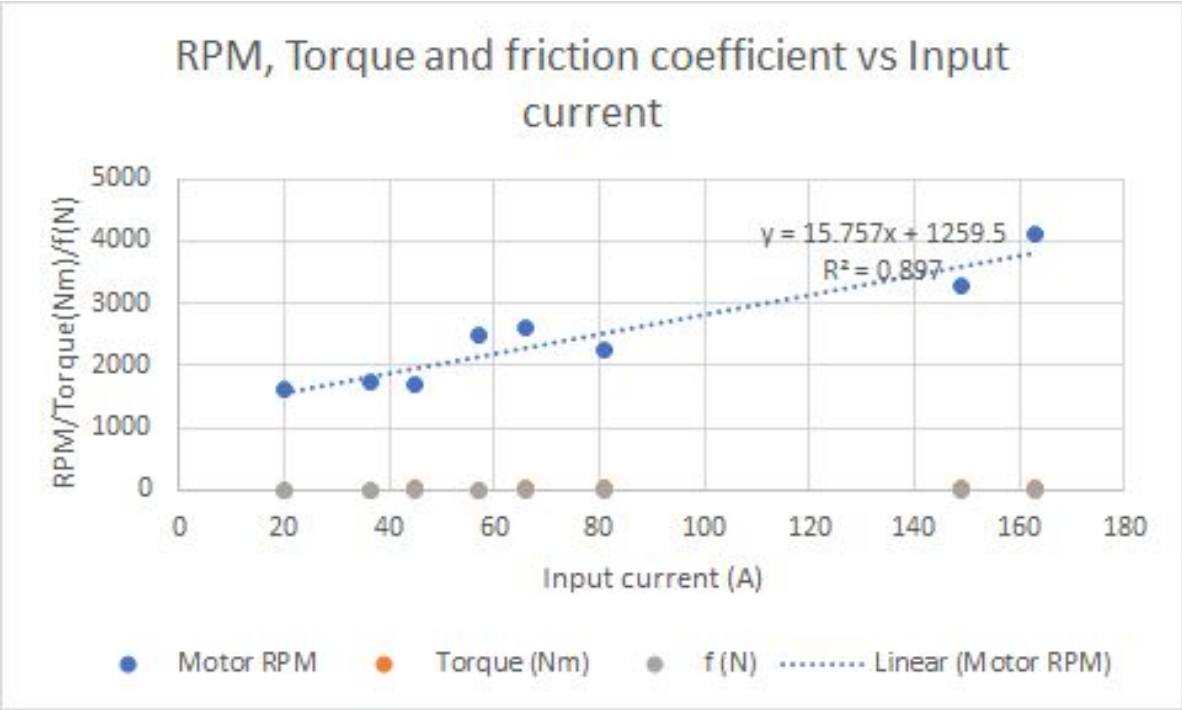
$$w = \frac{768.75i}{TL} - 178.57$$





Where
KT is torque constant, *w* is motor speed in RPM, *i* is supply current, *TL* is load torque, *f* is friction coefficient

Static model plot



With increase in input current, rpm has the biggest differential.

Dynamic characterization

∑ forces for dynamic characterization modelling

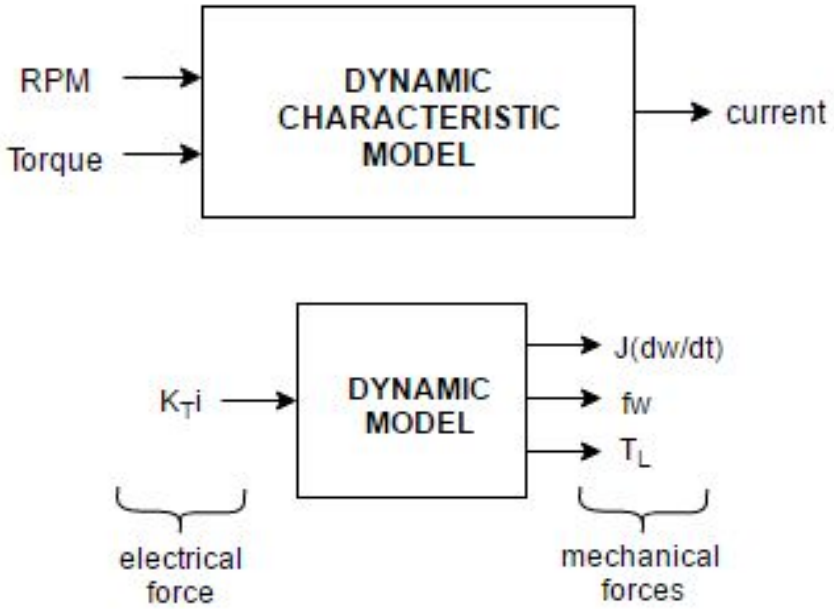
$$J\frac{dw}{dt} = KTi - TL - fw$$

$$w = \frac{768.75i}{TL} - 178.57$$

$$J\frac{dw}{dt} = \frac{768.75i}{TL} - 178.57 - w$$

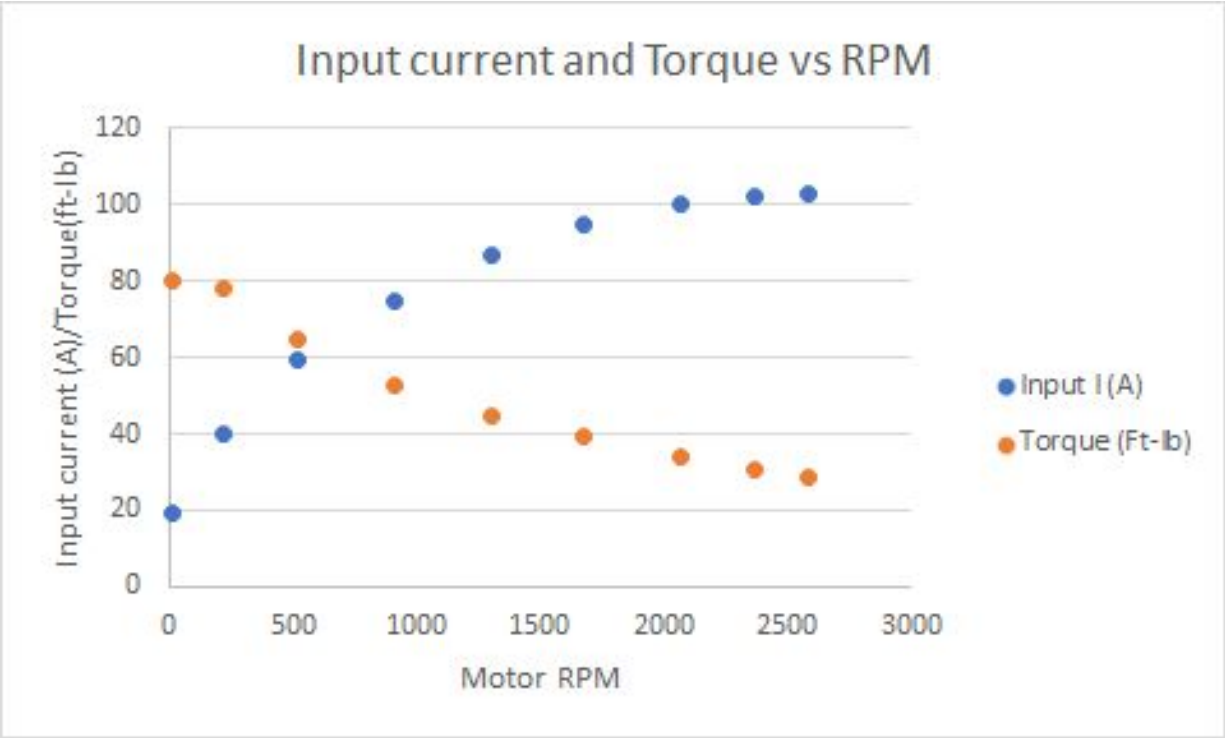
$$w = \frac{76875i - 17857TL + ce^{\left(-\frac{500t}{3}\right)}}{100TL}$$

$$i = \frac{100TLw - ce^{-\frac{500t}{3}} + 17857TL}{76875}$$



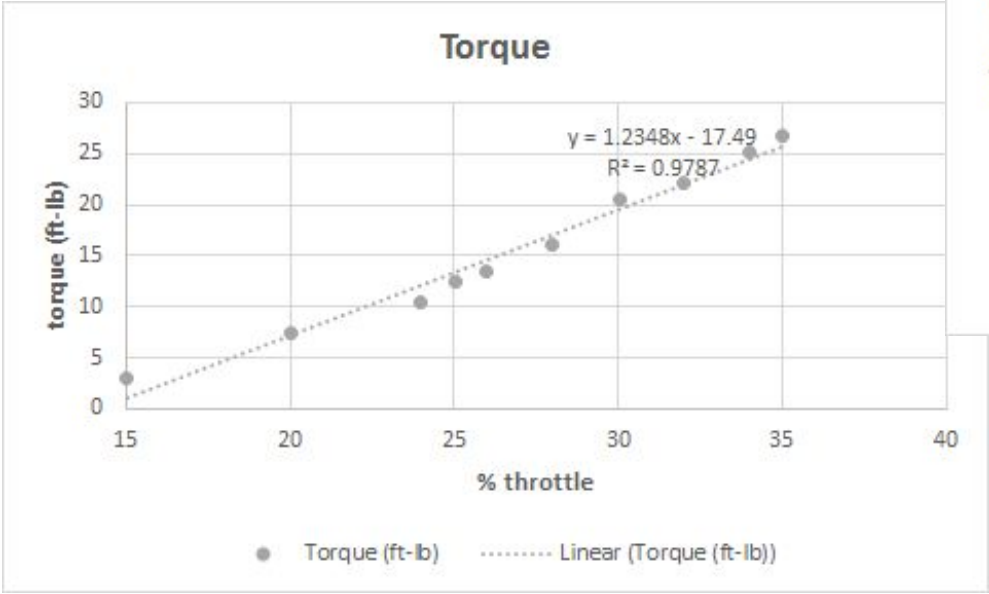
Where
J is moment of inertia - .006, *KT* is torque constant, *w* is motor speed in RPM, *i* is supply current, *TL* is load torque, *f* is friction coefficient

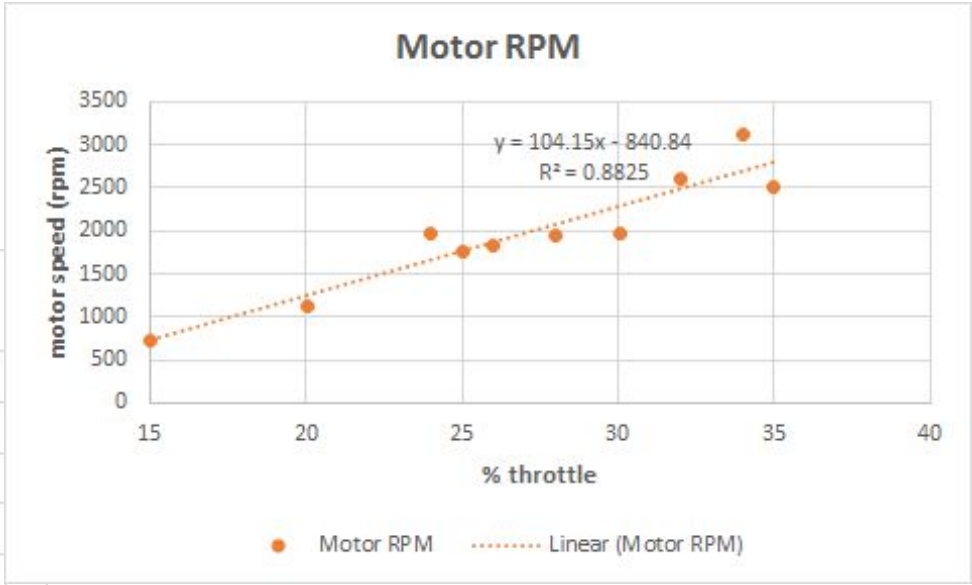
Dynamic model plot



With increase in RPM, input current and torque depict an inverse relation, but have an optimum intersection point

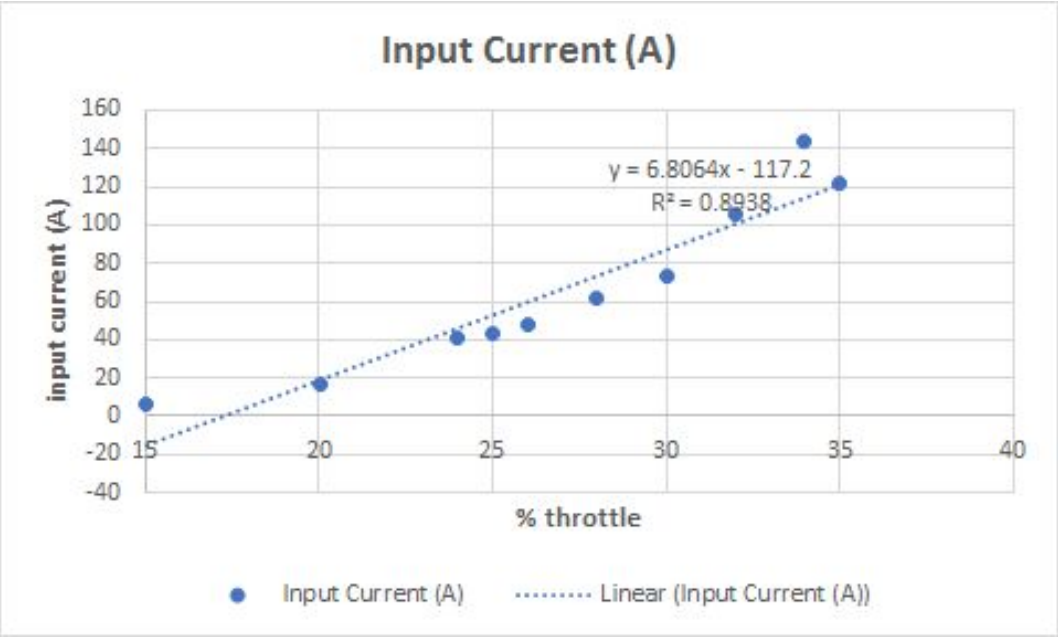
Pedal press to rpm and torque charac.





Torque and rpm parameters examined here have a direct proportionality relation with the % of max voltage. The R squared of the fits are high, supporting this result.

Pedal press to current charac.



Input current parameter examined here have a direct proportionality relation with the % of max voltage. The R squared of the fits are high, supporting this result.

Note on some model parameters

Torque in eqn:

Torque used in transient calculations for dynamic model is a theoretical value.

Collect experimental data torque in a lab setup directly from the load cell. Then compare to theoretical values used.

RPM vs % throttle:

Max motor RPM - 6500 RPM

1. Static model - 30% throttle, 90% load gives 4500 RPM
2. Dynamic model - 30% throttle, 90% load gives 3500 RPM

Note: various throttle % collected, but the above used because of max RPM at given setting of respective model

Future work on equations

- Characterization of the motor and motor controller I/O for better approximation of system input and output power, to calculate the heat loss from this MCM system.

Note: Will be done in lab tomorrow (2/16/2017)