Homework Problem 8
DC Machines

A dc motor is to be used to drive the main rotation axis of an industrial robot through a gear box. The motor selected has the following parameters and ratings:

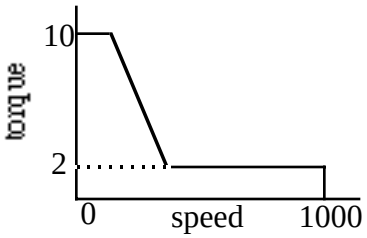
Rated torque - 10 n-m Rated speed - 1000 rpm

R = 3.0 ohm K_t = 1.0 n-m/A K_v = 0.105 V/rpm at full flux

The operating requirements are:

Speed 0 to 1000 rpm continuously variable

Torque stall (zero speed) 10 n-m, dropping to 2.0 n-m at full speed as shown in the figure



a) Find the required armature power supply ratings (rated current, voltage and power) if the motor is always operated with full flux and the speed variation is obtained entirely by varying the armature voltage.

Basic Equations $T_e = K_t I_a$ $V_a = I_a R_a + K_v \omega$

At Stall

$$I_a = \frac{10\ \text{Nm}}{1.0\ \text{Nm/A}} = 10\ \text{A}$$

$$V_a = (10\text{A})(3\Omega) + 0 = 30\ \text{V}$$

At 1000 rpm

$$I_a = \frac{2\ \text{Nm}}{1.0\ \text{Nm/A}} = 2\ \text{A}$$

$$V_a = (2\text{A})(3\Omega) + \left(0.105\ \frac{\text{V}}{\text{rpm}}\right)(1000\ \text{rpm}) = 111\ \text{V}$$

Rated Power: $V_{max}\ I_{max}$ = (111V)(10V) = 1110 W (even though V_{max} and I_{max} are never used simultaneously)

b) Find the required armature power supply ratings if the field flux is reduced by one half to obtain the full speed operating point and full flux is used at low speeds.

At Stall

(Same as above)

I_a = 10 A

V_a = 30 V

At 1000 rpm

$$K_t = 0.5\ \frac{\text{Nm}}{\text{A}} \Rightarrow K_v = 0.0525\ \frac{\text{V}}{\text{rpm}}$$

$$I_a = \frac{2\ \text{Nm}}{0.5\ \text{Nm/A}} = 4\ \text{A}$$

$$V_a = (4\text{A})(3\Omega) + \left(0.0525\ \frac{\text{V}}{\text{rpm}}\right)(1000\ \text{rpm}) = 64.5\ \text{V}$$

Rated Power = V_{max} x I_{max} = (64.5V)(10A) = 645
Note: Voltage rating is decreased by field weakening at high speeds