Friday, April 8, 2016

This gives $$K\phi = \frac{E_A}{\omega_m} = \frac{300}{1200 \times \frac{2\pi}{60}} = 2.387$$

Total torque required is $T_{out} = 200$ Nm. Add rotational losses

$$T_{dev} = T_{out} + T_{rot}$$

total developed torque

torque required by load

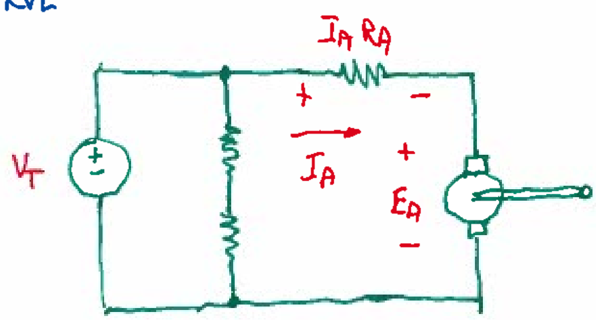
due to rotational losses

$$T_{dev} = 200 + 12 = 212 \text{ Nm}$$

Strategy: Find I_A, then E_A, then speed.

$$I_A = \frac{T_{dev}}{K\phi} = \frac{212}{2.387} = 88.8$$

From KVL



$$-V_T + I_A R_A + E_A = 0$$

$$E_A = V_T - I_A R_A$$
$$= 300 - 88.8(0.065)$$
$$= 294.2 \text{ V}$$

So $$\omega_m = \frac{E_A}{K\phi} = \frac{294.2}{2.387} = 123.6 \text{ rad/sec}$$

$$n_m = \omega_m \times \frac{60}{2\pi} = 1177 \text{ rpm}$$

And efficiency: $$P_{out} = T_{out}\,\omega_m = 200 \times 123.6$$
$$= 24,652 \text{ W}$$

$$P_{in} = V_T I_L = 300(I_F + I_A)$$
$$= 300(10 + 88.8)$$
$$= 29,640 \text{ W}.$$

$$\eta = \frac{P_{out}}{P_{in}} \times 100\% = \frac{24{,}632}{29{,}640} \times 100\%$$

$$= 83.2\%$$

<u>Example</u>: Suppose fan blades are attached to the shaft of the above motor.

- this adds 15 Nm of additional torque loss, independent of speed.

What is the new speed?

The total developed torque: $T_{dev} = \underbrace{200}_{\text{load}} + \underbrace{12 + 15}_{\text{rotational losses}} = 227 \text{ Nm}$

Armature current increases: $I_A = \frac{T_{dev}}{K\phi} = \frac{227}{2.387} \approx 95.1$.

By KVL, $E_A = V_T - I_A R_A = 300 - (95.1)(0.065)$

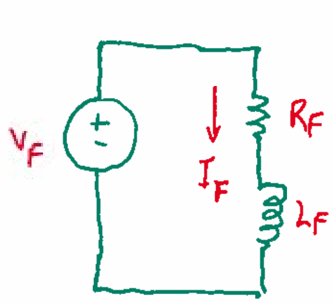
$= 293.82$

Then, $\omega_m = \frac{E_A}{K\phi} = \frac{293.82}{2.387} = 123.09 \text{ rad/sec}$

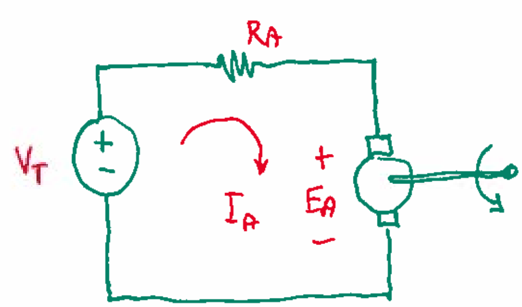
So $n_m = \omega_m \times \frac{60}{2\pi} = 1175.4 \text{ rpm}$

<u>Separately excited DC machines</u>

This configuration is similar to shunt-connected, except field and armature have separate sources.



FIELD



ARMATURE

$$\eta = \frac{P_{out}}{P_{in}} \times 100\% = \frac{24652}{29640} \times 100\%$$

$$= 83.2\%$$

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What is the new speed?

The total developed torque: $T_{dev} = \underbrace{200}_{\text{load}} + \underbrace{12 + 15}_{\text{rotational losses}} = 227 \text{ Nm}$

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By KVL, $E_A = V_T - I_A R_A = 300 - (95.1)(0.065)$

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Then, $\omega_m = \frac{E_A}{K\phi} = \frac{293.82}{2.387} = 123.09 \text{ rad/sec}$

so $n_m = \omega_m \times \frac{60}{2\pi} = 1175.4 \text{ rpm}$

<u>Separately excited DC machines</u>

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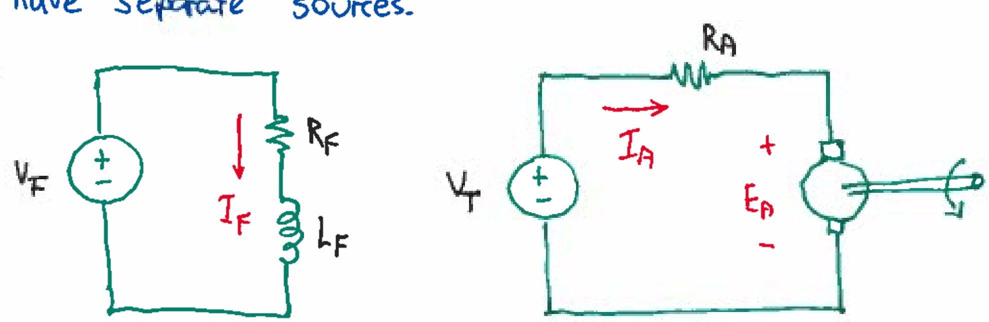


FIELD

ARMATURE

Permanent - magnet DC motors

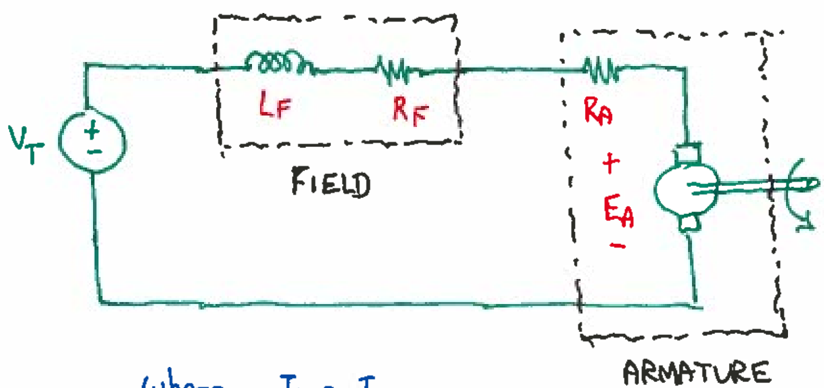
Similar to separately excited, except field is produced by permanent magnets.

Useful in fractional - horsepower applications

- Small fans
- power windows, windshield wipers
- servos

Series - connected DC motors

Field and armature connected in series



where $I_A = I_F$

Series - connected motors have high torque at low speeds.
Suitable for many applications

- electric automotive starter motors
- electric drills, screwdrivers
- handheld mixers.

Torque - speed characteristics

All motors are characterized by torque - speed characteristics.