Can find I_A from total developed power Thursday, April 7 2016

$$P_{dev} = I_A E_A$$

$$I_A = \frac{7460\ W}{250} = 29.84$$

→ In this case, note that another way to calculate I_A is by

$$T_{dev} = K\phi I_A$$

$$\text{so} \quad I_A = \frac{T_{dev}}{K\phi} = \frac{47.49}{1.59}$$

$$= 29.84\ A.$$

The applied voltage V_T by KVL:

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

$$\text{so} \quad V_T = E_A + I_A R_A$$

$$V_T = 250 + (29.84)(0.3)$$

$$= 258.95$$

Total developed power in the armature (10 HP), $P_{dev} = 7460\ W$

Total input power includes power supplied by V_T and field losses.

$$P_{in} = V_T I_A + I_F^2 R_F$$

$$= (258.95)(29.84) + (3)^2(50)$$

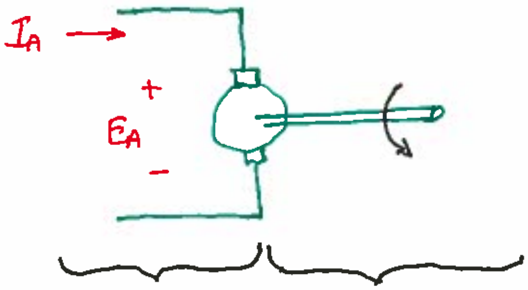
$$= 8177.1\ W.$$

Efficiency: $$\eta = \frac{P_{dev}}{P_{in}} \times 100\% = \frac{7460}{8177.1} \times 100\%$$

$$= 91.2\%.$$

Power and torque: "developed" vs. "output"

At the mechanical output of the motor



Electrical power $P = I_A E_A$

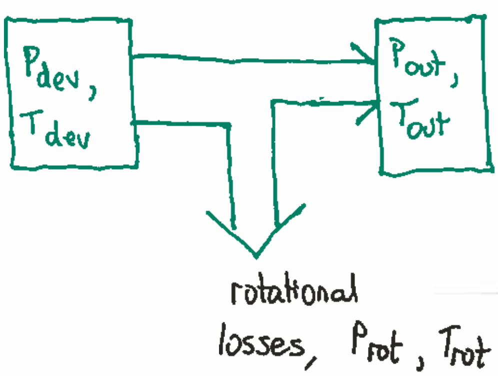
Developed mechanical power $P_{dev} = P = I_A E_A$

and $T_{dev} = \dfrac{P_{dev}}{\omega_m} = K\phi I_A$

Developed power and torque do not take into account rotational losses, such as

- friction (bearings)
- windage (wind resistance)

In a practical motor, we have

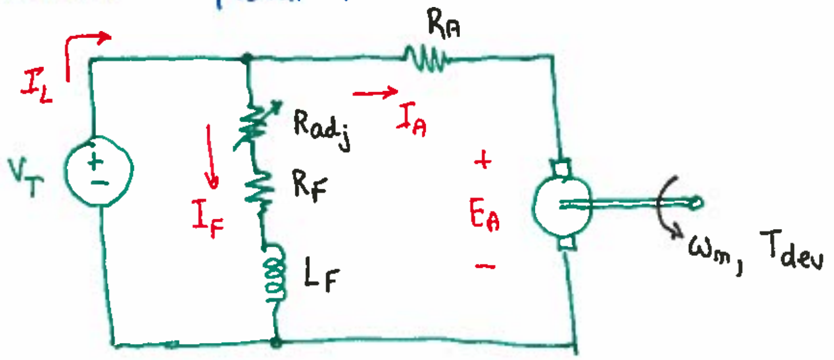


$$P_{out} = P_{dev} - P_{rot}$$
$$T_{out} = T_{dev} - T_{rot}.$$

If there are no rotational losses, then $P_{out} = P_{dev}$, $T_{out} = T_{dev}$.

Shunt - connected DC machines

In this machine configuration, the field and armature circuits are connected in parallel.



The variable resistor R_{adj} is available to adjust the torque-speed characteristic. The total input power is

$$P_{in} = V_T I_L \quad \text{total "line current"}$$

Some of this creates the field. Power absorbed by the field is dissipated as heat

$$P_F = I_F^2 (R_{adj} + R_F)$$
$$= \frac{V_T^2}{R_F + R_{adj}}$$

Armature resistance similarly dissipates power as heat.

$$P_A = I_A^2 R_A$$
$$= \frac{(V_T - E_A)^2}{R_A}$$

The remaining power is developed power P_{dev}.

$$P_{dev} = E_A I_A$$

$$\text{and} \quad T_{dev} = \frac{P_{dev}}{\omega_m} = \frac{E_A I_A}{\omega_m}$$

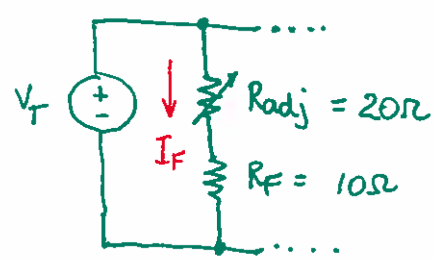
Example: Consider a shunt-connected DC machine with

$$V_T = 300\ \text{v}$$
$$\left.\begin{array}{l} R_F = 10\Omega \\ R_{adj} = 20\Omega \end{array}\right\} \text{combined } R_F = 30\Omega$$
$$R_A = 0.065\,\Omega$$

- The machine also has rotational losses (friction) represented by constant Torque : $T_{rot} = 12$ Nm (rotational power loss proportional to speed $P_{rot} = T_{rot}\,\omega_m$)
- From prior tests on this machine, when $I_F = 10$ A and $n_m = 1200$ rpm, $E_A = 300$ v.
- Total required torque by the mechanical load is $T_{out} = 200$ Nm.

Find motor speed and efficiency.

Solution: In the field, for DC,



$$I_F = \frac{300}{20+10} = 10\ \text{A}$$

From information given at $n_m = 1200$ rpm for $I_F = 10$ A, $E_A = 300$ v.
Basic machine equations again

$$T_{dev} = K\phi I_A \quad , \quad E_A = K\phi\,\omega_m$$