

6-18

(a)

$$I_t = 38 \text{ A}$$

$$I_f = 2 \text{ A}$$

$$I_a = I_t - I_f = 38 - 2 = 36 \text{ A}$$

$$E_a = V_t - R_a I_a = 230 - (0.15)(36) = 224.6 \text{ V}$$

$$K_a = \frac{PZ}{2\pi a} = \frac{(4)(596)}{2\pi(2)} = 189.7$$

$$\omega_m = \frac{2\pi n}{60} = \frac{2\pi(1150)}{60} = 120.43 \text{ rad/sec}$$

$$\phi_p = \frac{E_a}{K_a \omega_m} = \frac{224.6}{(189.7)(120.43)} = 9.83 \text{ mWb}$$

(b)

$$T_e = \frac{P_{dev}}{\omega_m} = \frac{E_a I_a}{\omega_m} = \frac{(224.6)(36)}{120.43} = 67.1 \text{ N-m}$$

6-23

$$\textcircled{a} \quad I_f = \frac{V_t}{R_f} = \frac{120}{120} = 1 \text{ A}$$

$$I_a = I_t - I_f = 41 - 1 = 40 \text{ A}$$

$$\textcircled{b} \quad E_a = V_t - R_a I_a - V_{BD} = 120 - (0,1)(40) - 2 = 114 \text{ V}$$

$$\textcircled{c} \quad P_{dev} = E_a I_a = (114)(40) = 4560 \text{ W} = 4.56 \text{ kW}$$

$$\textcircled{d} \quad T_e = \frac{P_{dev}}{\omega_m} = \frac{4560}{200} = 22,8 \text{ N-m}$$

6-27

$$E_{a1} = V_t - (R_a + R_s) I_{a1} - V_{BD} = 230 - (0,4 + 0,2)(37) - 2 = 205,8 \text{ V}$$

$$\textcircled{a} \quad E_{a2} = 230 - (0,4 + 0,2)(20) - 2 = 216 \text{ V}$$

$$\frac{E_{a2}}{E_{a1}} = \frac{K_a \phi_2 (2\pi n_2 / 60)}{K_a \phi_1 (2\pi n_1 / 60)} = \frac{K_a' I_{a2} n_2}{K_a' I_{a1} n_1}$$

$$n_2 = \left(\frac{E_{a2}}{E_{a1}} \right) \left(\frac{I_{a1}}{I_{a2}} \right) n_1 = \left(\frac{216}{205,8} \right) \left(\frac{37}{20} \right) (1200) = 2330 \text{ rpm}$$

$$\textcircled{b} \quad E_{a3} = 230 - (0,4 + 0,2)(1) - 2 = 227,4 \text{ V}$$

$$n_3 = \left(\frac{E_{a3}}{E_{a1}} \right) \left(\frac{I_{a1}}{I_{a3}} \right) n_1 = \left(\frac{227,4}{205,8} \right) \left(\frac{37}{1} \right) (1200) = 49,060 \text{ rpm}$$

$$\textcircled{c} \quad E_{a4} = 230 - (0,4 + 0,2)(60) - 2 = 192 \text{ V}$$

$$n_4 = \left(\frac{E_{a4}}{E_{a1}} \right) \left(\frac{\phi_1}{\phi_2} \right) n_1 = \left(\frac{192}{205,8} \right) \left(\frac{1,25 \phi_1}{\phi_1} \right) (1200) = 1399 \text{ rpm}$$

6-32

$$\textcircled{a} \quad E_a = V_t - R_a I_a = 230 - (0.25)(38) = 220.5 \text{ V}$$

$$P_{dev} = E_a I_a = (220.5)(38) = 8379 \text{ W}$$

$$\omega_m = \frac{2\pi n}{60} = \frac{(2\pi)(1050)}{60} = 109.96 \text{ rad/sec}$$

$$T_e = \frac{P_{dev}}{\omega_m} = \frac{8379}{109.96} = 76.2 \text{ N-m}$$

$$\textcircled{b} \quad I_{f1} = \frac{V_t}{R_{f1}} = \frac{230}{115} = 2 \text{ A}$$

$$I_{f2} = \frac{230}{144} = 1.6 \text{ A}$$

$$E_{a1} = V_t - R_a I_{a1} = K_a \phi_1 \omega_{m1} = K_a' I_{f1} (2\pi n_1 / 60)$$

$$\begin{aligned} E_{a2} &= V_t - R_a I_{a2} = K_a \phi_2 \omega_{m2} = K_a' I_{f2} (2\pi n_2 / 60) \\ &= V_t - R_a I_{a1} \\ &= E_{a1} \end{aligned}$$

$$K_a' I_{f2} (2\pi n_2 / 60) = K_a' I_{f1} (2\pi n_1 / 60)$$

$$n_2 = \left(\frac{I_{f1}}{I_{f2}} \right) n_1 = \left(\frac{2}{1.6} \right) (1050) = 1312 \text{ rpm}$$

$$\textcircled{c} \quad P_{out} = P_{dev} - P_{rotational} = 8379 - 600 = 7779 \text{ W}$$

$$I_t = I_a + I_f = 38 + 1.6 = 39.6 \text{ A}$$

$$P_{in} = V_t I_t = (230)(39.6) = 9108 \text{ W}$$

$$\eta = \frac{P_{out}}{P_{in}} = \frac{7779}{9108} \cdot 100\% = 85.4\%$$

6-36

$$\textcircled{a} \quad P_{out} = (20)(746) = 14,920$$

$$P_{in} = \frac{P_{out}}{\eta} = \frac{14,920}{0.85} = 17,553 \text{ W}$$

$$I_{t,FL} = \frac{P_{in}}{V_t} = \frac{17,553}{220} = 79.8 \text{ A}$$

$$I_f = \frac{V_t}{R_f} = \frac{220}{110} = 2 \text{ A}$$

$$I_{a,FL} = I_{t,FL} - I_f = 79.8 - 2 = 77.8 \text{ A}$$

$$I_{t,start} = 2 I_{t,FL} = (2)(79.8) = 159.6 \text{ A}$$

$$I_{a,start} = I_{t,start} - I_f = 159.6 - 2 = 157.6 \text{ A}$$

$$(R_a + R_{a,start}) = \frac{V_t - 0}{I_{a,start}} = \frac{220}{157.6} = 1.396 \Omega$$

$$R_{a,start} = 1.396 - R_a = 1.396 - 0.15 = 1.246 \Omega$$

$$\textcircled{b} \quad E_{a,FL} = V_t - R_a I_{a,FL} = 220 - (0.15)(77.8) = 208.33 \text{ V}$$

$$P_{dev,FL} = E_{a,FL} I_{a,FL} = (208.33)(77.8) = 16,208 \text{ W}$$

$$\omega_m = \frac{2\pi n}{60} = \frac{2\pi(1150)}{60} = 120.4$$

$$T_{FL} = \frac{P_{dev,FL}}{\omega_m} = \frac{16,208}{120.4} = 134.6 \text{ N-m}$$

$$\frac{T_{start}}{T_{FL}} = \frac{K_a \phi I_{a,start}}{K_a \phi I_{a,FL}} = \frac{I_{a,start}}{I_{a,FL}} = \frac{157.6}{77.8}$$

$$T_{start} = \left(\frac{157.6}{77.8}\right) T_{FL} = \left(\frac{157.6}{77.8}\right)(134.6) = 272.7 \text{ N-m}$$