8-5

(a) $n_s = \frac{n}{1-s} = \frac{855}{(1-0.05)} = 900$ rpm

(b) $p = \frac{120f}{n_s} = \frac{(120)(60)}{900} = 8$ poles

(c) $f_r = sf = (0.05)(60) = 3$ Hz

8-11 Refer to Fig. 8-8

(a) $n_s = \frac{120f}{p} = \frac{(120)(60)}{4} = 1800$ rpm

$n = (1-s)n_s = (1-0.05)(1800) = 1710$ rpm

(b) $V_1 = \frac{220}{\sqrt{3}} \angle 0^\circ = 127 \angle 0^\circ$

$I_2 = \frac{V_1}{(R_1 + \frac{R_2}{s}) + j(X_1 + X_2)} = \frac{127 \angle 0^\circ}{(0.3 + \frac{0.2}{0.05}) + j(0.5+0.5)} = 28.77 \angle -13.1^\circ$ A

$I_m = \frac{V_1}{jX_m} = \frac{127 \angle 0^\circ}{j15} = 8.47 \angle -90^\circ$ A

$I_1 = I_2 + I_m = 28.77 \angle -13.1^\circ + 8.47 \angle -90^\circ = 31.78 \angle -28.1^\circ$ A

(c) $PF_1 = \cos\theta = \cos 28.1^\circ = 0.882$ lagging

(d) $P_{in} = 3V_1 I_1 \cos\theta = (3)(127)(31.78)\cos 28.1^\circ = 10,680$ W

$P_{ag} = 3I_2^2 \frac{R_2}{s} = (3)(28.77)^2\left(\frac{0.2}{0.05}\right) = 9932.6$ W

$P_{dev} = (1-s)P_{ag} = (1-0.05)(9932.6) = 9435.9$ W

$P_{out} = P_{dev} - P_{rot} = 9435.9 - 500 = 8935.9$ W

$\omega_m = \frac{2\pi n}{60} = \frac{2\pi(1710)}{60} = 179.1$ rad/s

$T_{out} = T_{shaft} = \frac{P_{out}}{\omega_m} = \frac{8935.9}{179.1} = 49.9$ N-m

(e) $\eta = \frac{P_{out}}{P_{in}} = \frac{8935.9}{10,680} 100\% = 83.7\%$

8-17

$$R_1 = \frac{1}{2}\left(\frac{V_{DC}}{I_{DC}}\right) = \frac{1}{2}\left(\frac{8}{50}\right) = 0.08\ \Omega$$

$$R_{nl} = \frac{P_{nl}}{3I_{nl}^2} = \frac{3800}{(3)(38)^2} = 0.877\ \Omega$$

$$Z_{nl} = \frac{V_{nL}}{\sqrt{3}\,I_{nl}} = \frac{440}{\sqrt{3}\,(38)} = 6.685\ \Omega$$

$$X_{nl} = \sqrt{Z_{nl}^2 - R_{nl}^2} = \sqrt{(6.685)^2 - (0.877)^2} = 6.627\ \Omega$$

$$R_{bl} = \frac{P_{bl}}{3I_{bl}^2} = \frac{4800}{(3)(110)^2} = 0.132\ \Omega$$

$$Z_{bl} = \frac{V_{bl}}{\sqrt{3}\,I_{bl}} = \frac{80}{\sqrt{3}\,(110)} = 0.42\ \Omega$$

$$X_{bl,test} = \sqrt{Z_{bl}^2 - R_{bl}^2} = \sqrt{(0.42)^2 - (0.132)^2} = 0.40\ \Omega$$

$$X_{bl} = \left(\frac{f_{rated}}{f_{test}}\right) X_{bl,test} = \left(\frac{60}{15}\right)(0.40) = 1.60\ \Omega$$

$$X_1 = X_2 = \frac{1}{2} X_{bl} = \frac{1}{2}(1.60) = 0.80\ \Omega$$

$$X_m = X_{nl} - X_1 = 6.627 - 0.80 = 5.827\ \Omega$$

$$R_2 = R_{bl} - R_1 = 0.132 - 0.08 = 0.052\ \Omega$$

8-23 Refer to Fig. 8-8 : $V_1 = \frac{440}{\sqrt{3}} \angle 0^\circ = 254 \angle 0^\circ$ V

(a) $$I_2 = \frac{V_1}{R_1 + \frac{R_2}{s} + j(X_1 + X_2)} = \frac{254 \angle 0^\circ}{0.12 + \frac{0.10}{0.035} + j(0.25 + 0.2)} = 84.36 \angle -8.6^\circ\ A$$

$$I_m = \frac{V_1}{jX_m} = \frac{254 \angle 0^\circ}{j15} = 16.93 \angle -90^\circ$$

$$I_1 = I_2 + I_m = 84.36 \angle -8.6^\circ + 16.93 \angle -90^\circ = 88.5 \angle -19.5^\circ\ A$$

$$PF_1 = \cos 19.5^\circ = 0.943 \text{ lagging}$$

(b) $$P_{ag} = 3I_2^2 \frac{R_2}{s} = (3)(84.36)^2\left(\frac{0.10}{0.035}\right) = 61{,}000\ W$$

(c) $$P_{conv} = P_{dev} = (1-s)P_{ag} = (1-0.035)(61{,}000) = 58{,}865\ W$$

8-29

(a) $P_{out} = 20\ kW$

$P_{dev} = P_{out} + P_{rotational} = 20 + 1.5 = 21.5\ kW$

$P_{ag} = \frac{P_{dev}}{1-s} = \frac{21.5}{1-0.045} = 22.5\ kW$

(b) $n_s = \frac{120f}{P} = \frac{(120)(60)}{6} = 1200\ rpm$

$n = (1-s)\,n_s = (1-0.045)(1200) = 1146\ rpm$

$\omega_m = \frac{2\pi n}{60} = \frac{2\pi(1146)}{60} = 120\ rad/s$

$T_{out} = \frac{P_{out}}{\omega_m} = \frac{20{,}000}{120} = 166.7\ N\text{-}m$

(c) $T_{dev} = \frac{P_{dev}}{\omega_m} = \frac{21{,}500}{120} = 179.2\ N\text{-}m$