

6.5) $V_L = 2300V$, 3 ϕ , 60 Hz, $p = 20$, $X_s = 2 \Omega$
motor

$$P_{3\phi} = 800 \text{ kW}$$

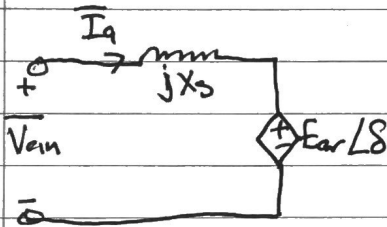
$$PF = 1$$

$$\omega_m = \left(\frac{2}{p}\right) \omega_s \Rightarrow \omega_m = \left(\frac{2}{20}\right) (2\pi 60)$$

$$\omega_m = 37.70 \text{ rad/s}$$

$$\omega_m = 360 \text{ rpm}$$

$$T^e = \frac{P}{\omega_m} = \frac{800 \times 10^3}{37.70} \Rightarrow T^e = 21,220 \text{ Nm}$$



$$\bar{V}_{an} = jX_s \bar{I}_a + E_{ar} L_s$$

$$\bar{V}_{an} - jX_s \bar{I}_a = E_{ar} L_s$$

$$\bar{S}_{3\phi} = \frac{P_{3\phi}}{PF} \angle \cos^{-1}(PF) = \bar{S}_{3\phi} = 800 \angle 0^\circ \text{ kVA}$$

$$800 \angle 0^\circ = 3 \bar{V}_{an} \bar{I}_a^* \Rightarrow \bar{I}_a = \frac{800 \angle 0^\circ \text{ kVA}}{3 \left(\frac{2300}{\sqrt{3}}\right) \angle 0^\circ} \Rightarrow \bar{I}_a = 200.82 \angle 0^\circ \text{ A}$$

$$\frac{2300}{\sqrt{3}} \angle 0^\circ - 2(200.82) \angle 90^\circ = E_{ar} L_s$$

$$E_{ar} L_s = 1327.91 - j401.64$$

$$E_{ar} L_s = 1387.32 \angle -16.83^\circ$$

6.6) $V_L = 6600\text{V}$, 3 ϕ , 10 pde, 60Hz
motor

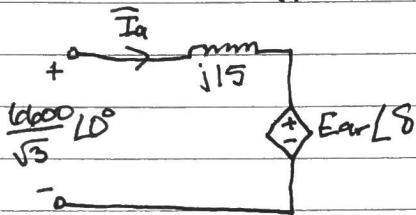
$$X_s = 15\Omega$$

$$I_s = 95\text{A}, \text{PF} = 0.8 \text{ lead}$$

a) $P = 3V_{\text{lin}} I_s (\text{PF})$

$$P = 868,796.69\text{ W}$$

$$T^e = \frac{P}{\left(\frac{2}{p}\right)\omega_s} \Rightarrow T^e = 11,523\text{ Nm}$$



$$\bar{I}_a = 95 \angle 36.87^\circ$$

$$\bar{V}_{\text{an}} = jX_s \bar{I}_a + E_{\text{ar}}/8$$

$$\frac{6600}{\sqrt{3}} - j15(95 \angle 36.87^\circ) = E_{\text{ar}}/8$$

$$E_{\text{ar}}/8 = 4665.5 - j1139.998\text{ V}$$

$$E_{\text{ar}}/8 = 4802.76 \angle -13.73^\circ$$

$$\theta = -13.73^\circ$$

b) $S_{3\phi} = \frac{P}{\text{PF}} \Rightarrow S_{3\phi} = 1,085,995.863\text{ VA}$

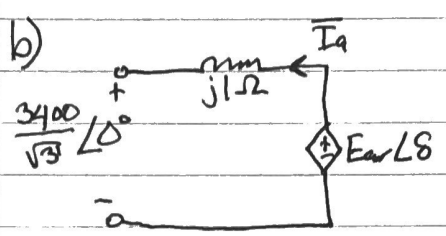
$$\bar{S}_{3\phi} = S_{3\phi} \angle \theta = P + jQ$$

$$Q = -651.6\text{ kVAR}$$

b.8) 3 ϕ , 60 Hz, ~~3400V~~, $V_L = 3400V$, 24 pole, max power = 11,000 kVA
 $P = 8,000 kW$, PF = 1 generator
 $X_s = 1 \Omega$

a) $\omega_m = \left(\frac{2}{p}\right)\omega_s \Rightarrow \omega_m = 31.42 \text{ rad/s}$
 $\omega_m = 300 \text{ rpm}$

$T^e = \frac{P}{\omega_m} \Rightarrow T^e = 254.61 \text{ kNm}$



$E_{ar} \angle \delta = \frac{3400}{\sqrt{3}} \angle 0^\circ + j1 \bar{I}_a$

$\bar{I}_a = \left(\frac{8000 \angle 0^\circ \text{ kVA}}{3 \left(\frac{3400}{\sqrt{3}} \right) \angle 0^\circ} \right)^* \Rightarrow \bar{I}_a = 1358.47 \angle 0^\circ$

$E_{ar} \angle \delta = \frac{3400}{\sqrt{3}} \angle 0^\circ + 1358.47 \angle 90^\circ \Rightarrow E_{ar} \angle \delta = 1962.99 + j1358.47$
 $E_{ar} \angle \delta = 2387.2 \angle 34.68^\circ$

c) $\frac{\omega_s M I_r}{\sqrt{2}} = 2387.2 V$ $\frac{\omega_s M (1.2) I_r}{\sqrt{2}} = 1.2 \left(\frac{\omega_s M I_r}{\sqrt{2}} \right) = 2864.64$

$P = \frac{3 V_{an} E_{ar} \sin(\delta)}{X_s} \Rightarrow \delta = 28.31^\circ$

$2864.64 \angle 28.31^\circ = j \bar{I}_a + \frac{3400}{\sqrt{3}} \angle 0^\circ \Rightarrow \bar{I}_a = \frac{559.02 + j1358.53}{j}$

$\bar{I}_a = 1358.53 - j559.02$
 $\bar{I}_a = 1469.05 \angle -22.37^\circ$

$\bar{S}_{3\phi} = 3 V_{an} \bar{I}_a^* \Rightarrow \bar{S}_{3\phi} = 8651.20 \angle 22.37^\circ \text{ kVA}$
 $= 8000 + j3292.5 \text{ kVA}$

$Q = 3292.5 \text{ kVAR}$

7.2) $P_{sc1} = 6 \text{ kW}$
 $f_r = 3 \text{ Hz}$
 60 Hz , 4 pole motor

$$s = \frac{f_r}{f_s} \Rightarrow s = \frac{2\pi(3)}{2\pi(60)} \Rightarrow \boxed{s = 0.05}$$

$$P_{sc1} = s P_{ag} \Rightarrow P_{ag} = \frac{P_{sc1}}{s} \Rightarrow \boxed{P_{ag} = 120 \text{ kW}}$$

$$P_m = (1-s) P_{ag} \Rightarrow \boxed{P_m = 114 \text{ kW}}$$

$$s = \omega_s - \omega_m \left(\frac{p}{2}\right) \Rightarrow s \omega_s = \omega_s - \left(\frac{p}{2}\right) \omega_m$$

$$\left(\frac{p}{2}\right) \omega_m = (1-s) \omega_s$$

$$\omega_m = \left(\frac{2}{p}\right) (1-s) \omega_s \Rightarrow \omega_m = 358.14 \text{ rad/s} \left(\frac{2}{p}\right)$$

$$\boxed{\omega_m = 179.07 \text{ rad/s}}$$

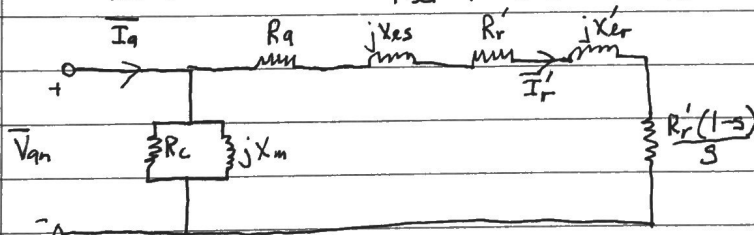
$$\boxed{= 1710 \text{ rpm}}$$

7.4) 3 ϕ , $V_L = 220 \text{ V}$, 60 Hz $I_s = 77 \text{ A}$ $\text{PF} = 0.88 \text{ lag}$ ~~_____~~

$$s = 0.05$$

$$P_{sc1} = 1033 \text{ W}$$

$$P_c = 485 \text{ W}$$



$$P_{sc1} = 3 |I_r'|^2 R_a \quad P_{ag} = 3 |I_r'|^2 \left(\frac{R_r'}{s}\right)$$

$$P_T = 3 V_{an} I_a (\text{PF}) \Rightarrow P_T = 25,820.03 \text{ W} = P_{sc1} + P_c + P_{ag}$$

$$\boxed{P_{ag} = 24,302.03 \text{ W}}$$

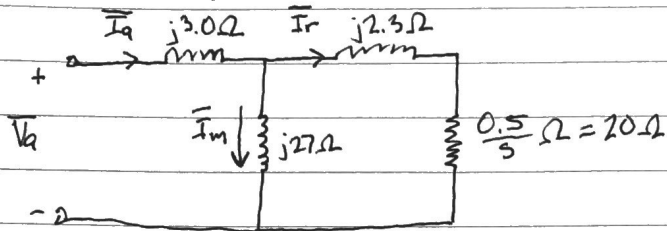
$$P_m = (1-s) P_{ag}$$

$$\boxed{P_m = 23,086.93 \text{ W}}$$

$$T^e = \frac{P_{ag}}{\left(\frac{2}{p}\right) \omega_s} \Rightarrow \boxed{T^e = 128.93 \text{ Nm}}$$

7.11) 3 ϕ , 60 Hz, 866 V, 6 pole

$$\omega_m = 1170 \text{ rpm}$$



$$s = \frac{2\pi(60) - (\frac{P}{2})\omega_m}{2\pi 60} \Rightarrow s = 0.025$$

$$Z_{eq} = 11.585 + j13.028 \Omega$$

$$\bar{I}_a = \frac{\bar{V}_a}{Z_{eq}} \Rightarrow \bar{I}_a = 28.679 \angle -48.355^\circ \text{ A}$$

$$\bar{I}_m = \frac{\bar{V}_a - j3.0 \bar{I}_a}{j27} \Rightarrow \bar{I}_m = \frac{435.692 - j57.173}{j27} \Rightarrow \bar{I}_m = -2.118 - j16.167 \text{ A}$$

$$\bar{I}_r = \bar{I}_a - \bar{I}_m \Rightarrow \bar{I}_r = 21.175 \angle -14.037^\circ \text{ A}$$

$$P_{AG} = 3 \bar{I}_r^2 \left(\frac{R_r'}{s} \right) \Rightarrow P_{AG} = 28,585.08 \text{ W}$$

$$P_m = (1-s) P_{AG} \Rightarrow P_m = 27,810.45 \text{ W}$$

$$T^c = \frac{P_m}{(\frac{P}{2})\omega_s} \Rightarrow T^c = 227.47 \text{ Nm}$$