KING FAHD UNIVERSITY OF PETROLEUM & MINERALS
ELECTRICAL ENGINEERING DEPARTMENT

EE 306

Solved-HW # 6: Induction Motors

D8-4

(a) $n_s = \frac{120f}{P} = \frac{(120)(60)}{8} = 900$ rpm

(b) $n_r = (1-s)n_s = (1-0.05)(900) = 855$ rpm

(c) slip rpm $= n_s - n_r = 900 - 855 = 45$ rpm

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

D8-8

$R_1 = \frac{1}{2}\left(\frac{V_{DC}}{I_{DC}}\right) = \frac{1}{2}\left(\frac{15}{70}\right) = 0.107\ \Omega$

$R_{nl} = \frac{P_{nl}}{3I_{nl}^2} = \frac{1400}{3(24)^2} = 0.81\ \Omega$

$Z_{nl} = \frac{V_{nl}}{\sqrt{3}\,I_{nl}} = \frac{208}{\sqrt{3}\,(24)} = 5.0\ \Omega$

$X_{nl} = \sqrt{Z_{nl}^2 - R_{nl}^2} = \sqrt{(5)^2 - (0.81)^2} = 4.934\ \Omega$

$R_{bl} = \frac{P_{bl}}{3I_{bl}^2} = \frac{2300}{3(66)^2} = 0.176\ \Omega$

$Z_{bl} = \frac{V_{bl}}{\sqrt{3}\,I_{bl}} = \frac{25}{\sqrt{3}\,(66)} = 0.219\ \Omega$

$X_{bl,test} = \sqrt{Z_{bl}^2 - R_{bl}^2} = \sqrt{(0.219)^2 - (0.176)^2} = 0.130\ \Omega$

$X_{bl} = \left(\frac{f}{f_{test}}\right) X_{bl,test} = \left(\frac{60}{15}\right)(0.13) = 0.52\ \Omega$

$X_1 = X_2 = \frac{1}{2}X_{bl} = \frac{1}{2}(0.52) = 0.26\ \Omega$

$X_m = X_{nl} - X_1 = 4.934 - 0.26 = 4.674\ \Omega$

$R_2 = R_{bl} - R_1 = 0.176 - 0.107 = 0.069\ \Omega$

D8-10

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

$s = \frac{n_s - n}{n_s} = \frac{1200 - 1152}{1200} = 0.04$

(b) $P_{a.g.} = P_{in} - SCL = 44 - 1.6 = 42.4$ kW

(c) $RCL = sP_{a.g.} = (0.04)(42.4) = 1.696$ kW

(d) $P_{dev} = P_{a.g.} - RCL = 42.4 - 1.696 = 40.7$ kW $= 54.56$ hp

$\omega_m = \frac{2\pi n}{60} = \frac{(2\pi)(1152)}{60} = 120.64$ rad/sec

$T_{dev} = \frac{P_{dev}}{\omega_m} = \frac{40.7 \times 10^3}{120.64} = 337.4$ N-m

(e) $P_{out} = P_{dev} - P_{rotational} = 40.7 - 0.5 = 40.2$ kW $= 53.89$ hp

$T_{out} = \frac{P_{out}}{\omega_m} = \frac{40.2 \times 10^3}{120.64} = 333.2$ N-m

D8-14

(a) $\frac{R_2}{s_{max}} = \sqrt{R_1^2 + (X_1 + X_2)^2} = \sqrt{(0.25)^2 + (0.5+0.5)^2} = 1.0308$

$s_{max} = \frac{R_2}{1.0308} = \frac{0.15}{1.0308} = 0.1455$

(b) $n_s = \frac{120f}{P} = \frac{(120)(60)}{4} = 1800$ rpm

$\omega_s = \frac{2\pi n}{60} = \frac{2\pi(1800)}{60} = 188.5$ rad/sec

$I_2 = \frac{V_1}{R_1 + \frac{R_2}{s_{max}} + j(X_1 + X_2)} = \frac{120\angle 0^\circ}{0.25 + \frac{0.15}{0.1455} + j(0.5+0.5)} = 73.85\angle -38^\circ$ A

$P_{ag} = 3I_2^2 (R_2/s_{max}) = 3(73.85)^2 (0.15/0.1455) = 16{,}864.8$ W

$T_{max} = \frac{P_{ag}}{\omega_s} = \frac{16{,}864.8}{188.5} = 89.5$ N-m