A 208-V four-pole 60-Hz Y-connected wound-rotor induction motor is rated at 30 hp. Its equivalent circuit components are

$R_1 = 0.100\ \Omega$ $R_2 = 0.070\ \Omega$ $X_M = 10.0\ \Omega$

$X_1 = 0.210\ \Omega$ $X_2 = 0.210\ \Omega$

$P_{\text{mech}} = 500\ \text{W}$ $P_{\text{misc}} \approx 0$ $P_{\text{core}} = 400\ \text{W}$

For a slip of 0.05, find

(a) The line current I_L

(b) The stator copper losses P_{SCL}

(c) The air-gap power P_{AG}

(d) The power converted from electrical to mechanical form P_{conv}

(e) The induced torque τ_{ind}

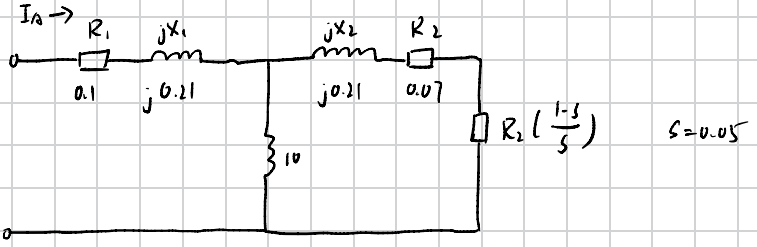
(f) The load torque τ_{load}

(g) The overall machine efficiency

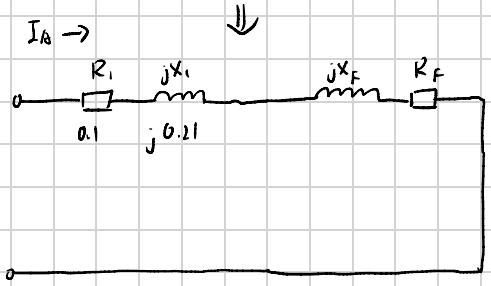
(h) The motor speed in revolutions per minute and radians per second

Homework 13

Equivalent circuit :



(a)



$$Z_F = \frac{1}{\frac{1}{jX_M} + \frac{1}{Z_2}} = \frac{1}{\frac{1}{j10} + \frac{1}{1.4+j0.21}} = 1.374\angle 16.34^\circ = 1.318 + j0.3864$$

$$I_L = I_A = \frac{V_\phi}{Z_1 + Z_F} = \frac{\frac{208}{\sqrt{3}}}{0.1+j0.21 + 1.318+j0.3864} = 78.07\angle -22.81^\circ \text{ A}$$

(b) $$P_{scL} = 3I_A^2 R_1 = 3 \times 78.07^2 \times 0.1 = 1828 \text{ W}$$

(c) $$P_{AG} = 3I_2^2 \frac{R_1}{s} = 3I_A^2 R_F = 3 \times 78.07^2 \times 1.318 = 24099 \text{ W}$$

(d) $$P_{conv} = (1-s) P_{AG} = (1-0.05) \times 24099 = 22894 \text{ W}$$

(e) $$n = \frac{120f}{P} = \frac{120 \times 60}{4} = 1800 \text{ r/min}$$

$$T_{ind} = \frac{P_{AG}}{w} = \frac{24099}{1800 \times \frac{2\pi}{60}} = 127.4 \text{ N·m}$$

(f) $$P_{out} = P_{conv} - P_{mech} - P_{misc} - P_{core} = 22894 - 500 - 0 - 400 = 21994 \text{ W}$$

$$n_m = (1-s)n = (1-0.05) \times 1800 = 1710 \text{ r/min}$$

$$T_{load} = \frac{P_{out}}{w} = \frac{21994}{1710 \times \frac{2\pi}{60}} = 122.8 \text{ N·m}$$

(g) $\eta = \frac{P_{out}}{P_{IN}} \times 100\% = \frac{P_{out}}{3\sqrt{\phi}\, I_A \cos\theta} \times 100\%$

$= \frac{21994}{3 \times \frac{208}{\sqrt{3}} \times 78.07 \times \cos 22.61^\circ} \times 100\%$

$= 84.83\%$

(h) $\omega_m = 1710 \times \frac{2\pi}{60} = 179 \text{ rad/s}$