ELG2331: DGD on Induction Machines

P17.49: Draw the equivalent circuit. It should be similar to the circuit shown in Figure 17.40. The value of $R_s / S = 0.08 / 0.02 = 4$

$$V_s = \frac{440}{\sqrt{3}} = 254\angle 0^o \text{ V}$$

$$Z_{in} = 0.06 + j0.3 + \frac{j5(4 + j0.3)}{4 + j5.3} = 2.328 + j2.294 = 3.268\angle 44.59^o\,\Omega$$

$$I_s = 77.7\angle -44.59 \text{ A (This is phase current)}$$

$$P_{in} = 3 \times 254 \times 77.7 \cos(-44.59^o) = 42.16 \text{ kW (This is the input power)}$$

$$I_2 = \frac{j5}{4 + j5.3} Is = 58.51\angle -7.55^o \text{ A}$$

The developed torque means the torque developed in the rotor. We need to find first the power developed in the rotor

Developed power in the rotor = Input power - Copper losses in the stator

$$P_{\text{dev}} = 42.16 - 3 \times (77.7)^2 \times 0.06 = 40.25 \text{ kW}$$

In order to find the developed torque, we need to find the mechanical speed in rad/s

$$n_s = 1800 \text{ rpm}$$

$$\omega_s = 1800 \times \frac{2\pi}{60} = 188.5 \text{ rad/s}$$

$$\omega_m = (1 - s)\omega_s = 0.98 \times 188.5 = 184.7 \text{ rad/s}$$

We can find the developed torque by applying the following relationship

$$T_{dev} = \frac{P_m}{\omega_m} = \frac{40.25\,\text{kW}}{184.7} = 218\ \text{Nm}$$

In order to find the shaft torque, first we have to find the rotational power and rotational torque

$$P_{rotational} = 3240 - 3 \times 45^2 \times 0.06 = 2875.5\ \text{W}$$
$$T_{rotional} = \frac{2875.5\ \text{W}}{184.7} = 15.56\ \text{Nm}$$

The shaft torque is

$$T_{Shaft} = 218 - 15.56 = 202.4\ \text{Nm}$$

The efficiency is

$$\eta = \frac{P_{out}}{P_{in}} = \frac{202.4 \times 184.7}{42.16 \times 10^3} = 88.7\%$$

P17.50: Draw the equivalent circuit

$$s = \frac{1800 - 1755}{1800} = 0.025$$

$$\frac{R_s}{s} = 4$$

$$Z_m = 0.2 + j0.5 + \frac{j20(4 + j0.2)}{4 + j20.2} = 3.972 + j1.444 = 4.226\angle 19.98^o$$

$$V_s = \frac{400}{\sqrt{3}} = 231\,\text{V}$$

$$I_s = \frac{V_s}{Z_m} = \frac{231}{4.226\angle 19.98^o} = 54.65\angle -19.98^o\ A$$

$$P_{in} = 3 \times 54.6 \times 231\cos(-19.98^o) = 35.6\,\text{kW}$$

The developed torque means the torque developed in the rotor. We need to find first the power developed in the rotor

Developed power in the rotor = Input power - Copper losses in the stator

$$P_{\text{dev}} = 35.6 - 3 \times (54.65)^2 \times 0.2 = 33.81\,\text{kW}$$

The mechanical power developed is equal to

$$P_m = (1\text{-}s)P_{dev} = (1 - 0.025) \times 33.81 = 32.97\,\text{kW}$$

$$P_{shaft} = P_{out} = P_m - 800 = 32.97 - 800 = 32.17\,\text{kW}$$

$$\omega_m = 183.8\,\text{rad/s}$$

$$T_{shaft} = \frac{32.17\,\text{kW}}{183.8} = 175\,\text{Nm}$$

$$\eta = \frac{32.17}{35.6} = 90.4\%$$