Example 6–1. A 208-V, 10-hp, four-pole, 60-Hz, Y-connected induction motor has a full-load slip of 5 percent.

(a) What is the synchronous speed of this motor?
(b) What is the rotor speed of this motor at the rated load?
(c) What is the rotor frequency of this motor at the rated load?
(d) What is the shaft torque of this motor at the rated load?

Solution

(a) The synchronous speed of this motor is

$$n_{\text{sync}} = \frac{120 f_{se}}{P} \quad (6\text{–}1)$$

$$= \frac{120(60 \text{ Hz})}{4 \text{ poles}} = 1800 \text{ r/min}$$

(b) The rotor speed of the motor is given by

$$n_m = (1 - s)n_{\text{sync}} \quad (6\text{–}6)$$

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

(c) The rotor frequency of this motor is given by

$$f_{re} = sf_{se} = (0.05)(60 \text{ Hz}) = 3 \text{ Hz} \quad (6\text{–}8)$$

Alternatively, the frequency can be found from Equation (6–9):

$$f_{re} = \frac{P}{120}(n_{\text{sync}} - n_m) \quad (6\text{–}9)$$

$$= \frac{4}{120}(1800 \text{ r/min} - 1710 \text{ r/min}) = 3 \text{ Hz}$$

(d) The shaft load torque is given by

$$\tau_{\text{load}} = \frac{P_{\text{out}}}{\omega_m}$$

$$= \frac{(10 \text{ hp})(746 \text{ W/hp})}{(1710 \text{ r/min})(2\pi \text{ rad/r})(1 \text{ min}/60 \text{ s})} = 41.7 \text{ N} \cdot \text{m}$$

The shaft load torque in English units is given by Equation (1–17):

$$\tau_{\text{load}} = \frac{5252P}{n}$$

where τ is in pound-feet, P is in horsepower, and n_m is in revolutions per minute. Therefore,

$$\tau_{\text{load}} = \frac{5252(10 \text{ hp})}{1710 \text{ r/min}} = 30.7 \text{ lb} \cdot \text{ft}$$

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Example 6–2. A 480-V, 60-Hz, 50-hp, three-phase induction motor is drawing 60 A at 0.85 PF lagging. The stator copper losses are 2 kW, and the rotor copper losses are 700 W. The friction and windage losses are 600 W, the core losses are 1800 W, and the stray losses are negligible. Find the following quantities:

(a) The air-gap power P_{AG}
(b) The power converted P_{conv}
(c) The output power P_{out}
(d) The efficiency of the motor

Solution

To answer these questions, refer to the power-flow diagram for an induction motor (Figure 6–13).

(a) The air-gap power is just the input power minus the stator I^2R losses and core losses. The input power is given by

$$\begin{aligned} P_{in} &= \sqrt{3} V_T I_L \cos \theta \\ &= \sqrt{3}(480 \text{ V})(60 \text{ A})(0.85) = 42.4 \text{ kW} \end{aligned}$$

From the power-flow diagram, the air-gap power is given by

$$\begin{aligned} P_{AG} &= P_{in} - P_{SCL} - P_{core} \\ &= 42.4 \text{ kW} - 2 \text{ kW} - 1.8 \text{ kW} = 38.6 \text{ kW} \end{aligned}$$

(b) From the power-flow diagram, the power converted from electrical to mechanical form is

$$\begin{aligned} P_{conv} &= P_{AG} - P_{RCL} \\ &= 38.6 \text{ kW} - 700 \text{ W} = 37.9 \text{ kW} \end{aligned}$$

(c) From the power-flow diagram, the output power is given by

$$\begin{aligned} P_{out} &= P_{conv} - P_{F\&W} - P_{misc} \\ &= 37.9 \text{ kW} - 600 \text{ W} - 0 \text{ W} = 37.3 \text{ kW} \end{aligned}$$

or, in horsepower,

$$P_{out} = (37.3 \text{ kW}) \frac{1 \text{ hp}}{0.746 \text{ kW}} = 50 \text{ hp}$$

(d) Therefore, the induction motor's efficiency is

$$\begin{aligned} \eta &= \frac{P_{out}}{P_{in}} \times 100\% \\ &= \frac{37.3 \text{ kW}}{42.4 \text{ kW}} \times 100\% = 88\% \end{aligned}$$

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1. 7,3 kW gücünde, 380 V'lık altı kutuplu sincap kafesli asenkron motorda R_1=0,294 Ω/faz, R_2'=0,144 Ω/faz, X_{l1}=0,503 Ω/faz, X_{l2}'=0,209 Ω/faz, X_M=13,25 Ω/faz'dır. %2 kayma ile çalışan asenkron motorun;

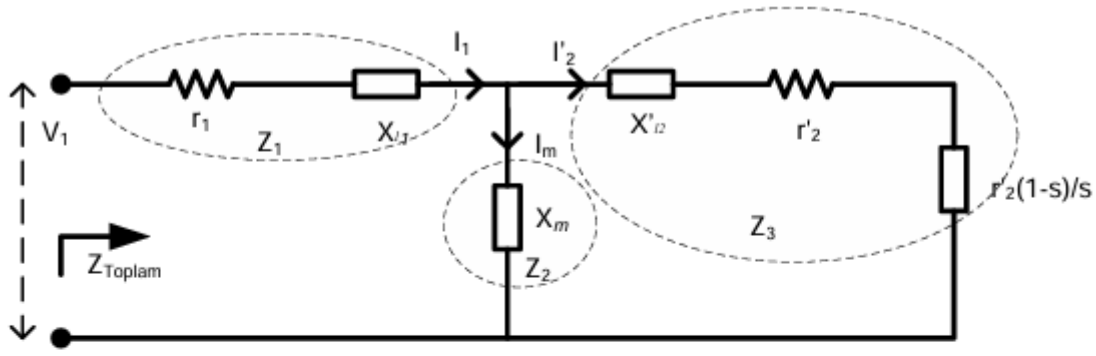
i) Eşdeğer devresini,

ii) Stator akımını,

iii) Güç Faktörünü,

iv) f_r frekansını,

v) Rotor hızını hesaplayınız.



$$\left.\begin{aligned} Z_1 &= R_1 + jX_{l1} \\ Z_2 &= jX_M \\ Z_3 &= \frac{r_2'}{s} + jX_{l2}' \end{aligned}\right\} \qquad Z_{Toplam} = Z_1 + \frac{Z_2 Z_3}{Z_2 + Z_3}$$

$$Z_{Toplam} = R_1 + jX_{l1} + \frac{jX_M\left(\frac{r_2'}{s} + jX_{l2}'\right)}{\frac{r_2'}{s} + j(X_M + X_{l2}')}$$

$$Z_{Toplam} = 0,294 + j0,503 + \frac{j13,25\left(\frac{0,144}{0,02} + j0,209\right)}{\frac{0,144}{0,02} + j(13,25 + 0,209)}$$

$$Z_{Toplam} = 5,724 + j3,61$$

$$I = \frac{380/\sqrt{3}}{5,724 + j3,61} = 32,4546\angle -32,23^o$$

$$\cos\varphi = \cos(32,23) = 0,84$$

Kutup sayısı 6 ise p=3'tür. $\Rightarrow f_r = f_s s = 60 * 0,02 = 1,2 Hz$

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$$f_s = \frac{n_s p}{60} \Rightarrow n_s = \frac{60*60}{3} = 1200 \quad d/dk$$

$$s = \frac{n_s - n}{n_s} \Rightarrow n = n_s(1-s) = 1200*(1-0,02) = 1176 \quad d/dk$$

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