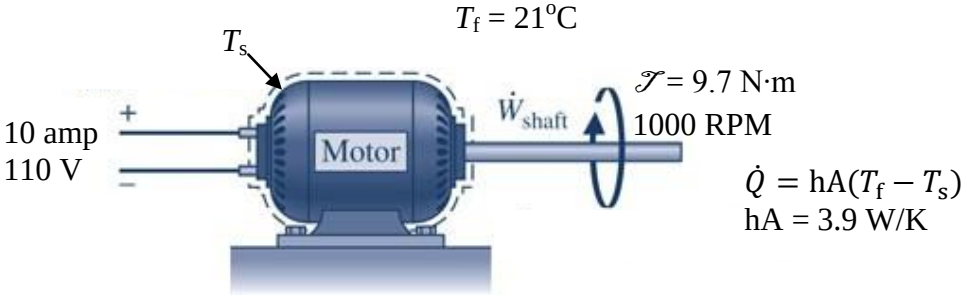
Problem 2.62

An electric motor draws a current of 10 amp with a voltage of 110 V, as shown in Fig. P2.62. The output shaft develops a torque of 9.7 N·m and a rotational speed of 1000 RPM. For operation at steady state, determine for the motor
(a) the electric power required, in kW.
(b) the power developed by the output shaft, in kW.
(c) the average surface temperature, T_s, in ^oC, if heat transfer occurs by convection to the surroundings at $T_f = 21^oC$.

KNOWN: Operating data are provided for an electric motor at steady state.

FIND: Determine (a) the electric power required, (b) the power developed by the output shaft, and (c) average the surface temperature.



ENGINEERING MODEL: (1) The motor is the closed system. (2) The system is at steady state.

ANALYSIS: (a) Using Eq. 2.21

$$\dot{W}_{electric} = \text{- (voltage) (current)} = \text{- (110 V)(10 amp)}\left|\frac{1\ \text{W/amp}}{1\ \text{V}}\right|\left|\frac{1\ \text{kW}}{10^3\text{W}}\right| = \text{-1.1 kW (in)} \leftarrow$$

(b) Using Eq. 2.20

$$\dot{W}_{shaft} = \text{(torque) (angular velocity)}$$

$$= (9.7\ \text{N}\cdot\text{m})\left(1000\ \frac{\text{rev}}{\text{min}}\right)\left|\frac{2\pi\ \text{rad}}{\text{rev}}\right|\left|\frac{1\ \text{min}}{60\ \text{s}}\right|\left|\frac{1\ \text{kW}}{10^3\text{N}\cdot\text{m/s}}\right| = 1.016\ \text{kW (out)} \leftarrow$$

(c) To determine the surface temperature, first find the rate of energy transfer by heat using the energy balance

$$\cancel{\frac{dE}{dt}}^{\,0} = \dot{Q} - \dot{W} = \dot{Q} - (\dot{W}_{electric} + \dot{W}_{shaft})$$

$$\dot{Q} = (\dot{W}_{electric} + \dot{W}_{shaft}) = \text{(-1.1 kW) + (1.016 kW) = -0.084 kW}$$

The surface temperature of the motor is

Problem 2.62 (Continued)

$$T_s = \left(\dot{Q}/\text{hA}\right) + T_f = (-0.084\ \text{kW})/(3.9\ \text{W/K})\left|\frac{10^3\ \text{W}}{1\ \text{kW}}\right| + 294\ \text{K}$$

$$= 315.5\ \text{K} = 42.5\ ^{\text{o}}\text{C} \longleftarrow$$

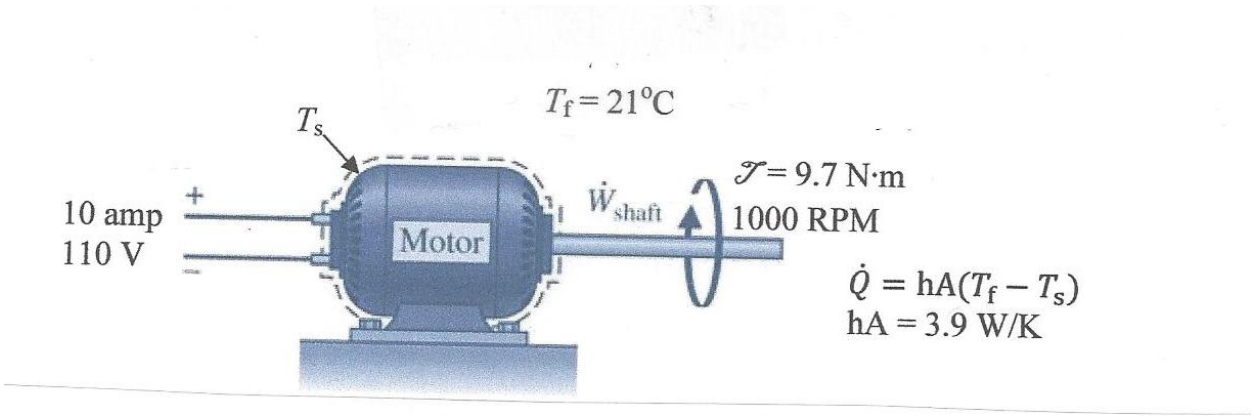


Fig. P2.62 – 8e

Pick-up motor graphic from Fig. E2.6 – 7e