Hydraulic Motors

$$\eta_v = \frac{\text{theoretical flow-rate motor should consume}}{\text{actual flow-rate consumed by motor}} = \frac{Q_T}{Q_A}$$

$$\eta_m = \frac{\text{actual torque delivered by motor}}{\text{torque motor should theoretically deliver}} = \frac{T_A}{T_T}$$

$$T_T(\text{in} \cdot \text{lb}) = \frac{V_D(\text{in}^3/\text{rev}) \times p\,(\text{psi})}{2\pi}$$

$$T_T(\text{N} \cdot \text{m}) = \frac{V_D(\text{m}^3/\text{rev}) \times p\,(\text{Pa}}{2\pi}$$

$$\eta_o = \eta_v \eta_m$$

$$\eta_o = \frac{T_A\,(\text{N} \cdot \text{m}) \times N\,(\text{rad/s})}{p\,(\text{Pa}) \times Q_A(\text{m}^3/\text{s})}$$

EXAMPLE 7-5

A hydraulic motor has a 82-cm^3 (0.082-L) volumetric displacement. If it has a pressure rating of 70 bars and it receives oil from a 0.0006-m^3/s (0.60-Lps or 36.0-Lpm) theoretical flow-rate pump, find the motor

a. Speed
b. Theoretical torque
c. Theoretical power

Solution

a. From Eq. (7-6M) we solve for the motor speed.

$$N = \frac{Q_T}{V_D} = \frac{0.0006\ \text{m}^3/\text{s}}{0.000082\ \text{m}^3/\text{rev}} = 7.32\ \text{rev/s} = 439\ \text{rpm}$$

b. Theoretical torque is found using Eq. (7-4M).

$$T_T = \frac{V_D p}{2\pi} = \frac{(0.000082\ \text{m}^3)(70 \times 10^5\ \text{N/m}^2)}{2\pi} = 91.4\ \text{N}\cdot\text{m}$$

c. Theoretical power is obtained as follows:

$$\text{theoretical power} = T_T N = (91.4\ \text{N}\cdot\text{m})(7.32 \times 2\pi\ \text{rad/s}) = 4200\ \text{W} = 4.20\ \text{kW}$$

EXAMPLE 7-6

A hydraulic motor has a displacement of 164 cm^3 and operates with a pressure of 70 bars and a speed of 2000 rpm. If the actual flow-rate consumed by the motor is 0.006 m^3/s and the actual torque delivered by the motor is 170 N · m, find

a. η_v
b. η_m
c. η_o
d. The actual kW delivered by the motor

Solution

a. To find the volumetric efficiency, we first calculate the theoretical flow-rate.

$$Q_T = V_D N = (0.000164\ \text{m}^3/\text{rev})\left(\frac{2000}{60}\text{rev/s}\right) = 0.00547\ \text{m}^3/\text{s}$$

$$\eta_v = \frac{Q_T}{Q_A} = \frac{0.00547}{0.006} = 0.912 = 91.2\%$$

b. To find η_m, we need to calculate the theoretical torque.

$$T_T = \frac{V_D p}{2\pi} = \frac{(0.000164)(70 \times 10^5)}{2\pi} = 182.8\ \text{N}\cdot\text{m}$$

$$\eta_m = \frac{T_A}{T_T} = \frac{170}{182.8} = 0.930 = 93.0\%$$

c. $$\eta_o = \eta_v \eta_m = 0.912 \times 0.930 = 0.848 = 84.8\%$$

d. $$\text{actual power} = T_A N = (170)\left(2000 \times \frac{2\pi}{60}\right) = 35{,}600\ \text{W} = 35.6\text{k W}$$