40.2 A pump delivers $200gpm$ of water at $130ft$ of total dynamic head, operating from 7am-7pm Monday through Friday. The pump is 80% efficient and the motor is 93% efficient. What is the annual cost of operation at $0.13 per kWh?

A. $2670

B. $3490

C. $3750

D. $5030

The cost is a function of electrical power and time, and electrical power is a function of hydraulic horsepower (aka water horsepower i.e. whp) and efficiency. Start by calculating the water horsepower based on volume flow rate and feet of head provided by the pump:

$$whp = \frac{Q\Delta h}{3960} = \frac{(200)(130)}{3960} = 6.566hp$$

Note the volume and head units must be in GPM and feet, respectively, to use this "rule of thumb" equation. Therefore units need not be shown, provided they are confirmed to be correct prior to use.

Recall that brake horsepower, bhp, depends on water horsepower, whp, and the efficiency of the pump, η_p. Similarly, the electrical power, P_{elec},depends on brake horsepower, bhp, and motor efficiency, η_m.

$$bhp = \frac{whp}{\eta_p}$$

$$P_{elec} = \frac{bhp}{\eta_m}$$

Put these together, substitute, solve, and convert to KW:

$$P_{elec} = \frac{whp}{\eta_p \eta_m} = \frac{6.566hp}{(.8)(.93)}\left(\frac{.746KW}{1hp}\right) = 6.58KW$$

To find the annual cost, multiply by time and the unit rate of electricity:

$$Cost = (6.58KW)\left(\frac{12hrs}{day}\right)\left(\frac{5days}{wk}\right)\left(\frac{52wks}{yr}\right)\left(\frac{\$0.13}{KWH}\right) = \$2669\,per\,year$$

Answer A

40.3 **$900gpm$ of water flows through an $8in$ pipe with a relative roughness of 0.0004 and a Reynolds number of $400,000$. What is the pressure loss per hundred feet of pipe?**

A. $0.1ft$

B. $0.2ft$

C. $1.2ft$

D. $1.4ft$

Pressure loss can be calculated using the Darcy equation:

$$h_f = \frac{fLv^2}{2Dg}$$

where f is the friction factor, L is the length of pipe, v is the velocity, D is the inside diameter, and g is acceleration due to gravity.

Start by looking up the diameter for a nominal 8 inch pipe in the reference handbook using the steel pipe friction tables. For convenience, convert from inches to feet:

$$D = \frac{7.981in}{12\frac{in}{ft}} = .6651ft$$

The velocity may also be looked up from the same table for a given GPM and pipe size. If the flow or size are non-standard, it may be necessary to calculate the velocity using $v = \frac{Q}{A}$, but that is not required in this case.

$$v = 5.77\frac{ft}{s}$$

Use the Moody Diagram to look up the friction factor which is a function of the Reynolds number, Re, and the relative roughness, $\frac{\varepsilon}{D}$. Both the Reynolds number and relative roughness were given.

$$f = f\left(Re, \frac{\varepsilon}{D}\right) \approx .0175$$

Substitute into the Darcy Equation and solve for the friction loss:

$$h_f = \frac{fLv^2}{2Dg} = \frac{(.0175)(100ft)\left(5.77\frac{ft}{s}\right)^2}{2(.6651ft)\left(32.2\frac{ft}{s^2}\right)} = 1.36ft$$

Answer D