**33.30 An airline refueling pump supplies $1000gpm$ of aviation fuel against a head of $400ft$. The specific heat capacity of aviation fuel is $0.51\frac{Btu}{lb\cdot{}^\circ F}$. The pump has an efficiency of 60%. What is the expected temperature increase of the fuel as it passes through the pump? Assume only the losses contribute to heating the fuel.**

A. $0.4^\circ F$

B. $0.7^\circ F$

C. $1.0^\circ F$

D. $1.4^\circ F$

Start with the most general formula for Pump Power. Replace volume flow rate, $Q$, times specific weight, $\gamma$, with mass flow rate, $\dot{m}$. Choose the efficiency as the mechanical efficiency of the pump only, ignoring motor efficiency which is not given.

$$\dot{W} = \frac{Q\gamma h}{\eta}$$

$$BHP = \frac{\dot{m}h}{\eta_p}$$

Since only the losses drive an increase in temperature, find the difference between the brake horsepower and the hydraulic horsepower supplied to the fuel.

$$BHP_{loss} = BHP - WHP = \frac{\dot{m}h}{\eta_p} - \dot{m}h = \dot{m}h\left(\frac{1}{\eta_p} - 1\right) = \dot{m}h\left(\frac{1}{0.6} - 1\right) = 0.67\dot{m}h$$

Express the heat gained by the fuel using the mass flow rate and specific heat capacity.

$$\dot{Q}_{gained} = \dot{m}c_p\Delta T$$

Set the BHP losses equal to the the heat gained by the fuel. Notice the mass flow rate cancels on both sides. The key insight is that the temperature rise is independent of the flow rate, and is a function only of the efficiency and the pressure added by the pump. Solve for $\Delta T$. Refer to Measurement Relationships for the conversion from $Btu$ to $ft \cdot lb$.

$$BHP_{loss} = \dot{Q}_{gained}$$

$$0.67\dot{m}h = \dot{m}c_p\Delta T$$

$$\Delta T = \frac{0.67h}{c_p}$$

$$\Delta T = \frac{0.67\,(400ft)}{0.51\frac{Btu}{lb\cdot{}^\circ F}}\left(\frac{1Btu}{778ft\cdot lb}\right) = 0.67^\circ F$$

**Answer B**