$$\dot{m} = \rho Q = \left(1\frac{kg}{L}\right)\left(500,000\frac{L}{s}\right) = 500,000\frac{kg}{s}$$

Substitute and solve for power.

$$\dot{W} = \dot{m}gh = \left(500,000\frac{kg}{s}\right)\left(9.81\frac{m}{s^2}\right)(30m) = 1.47 \times 10^8 \frac{kg \cdot m^2}{s^3}$$

To get the final answer in MW, use the following unit conversions.

$$1N = 1\frac{kg \cdot m}{s^2}$$

$$1J = 1N \cdot m = 1\frac{kg \cdot m^2}{s^2}$$

$$1W = 1\frac{J}{s} = 1\frac{kg \cdot m^2}{s^3}$$

$$1MW = 10^6 W = 10^6 \frac{kg \cdot m^2}{s^3}$$

Finally, solve for power, $\dot{W}$, in MW.

$$\dot{W} = \left(1.47 \times 10^8 \frac{kg \cdot m^2}{s^3}\right)\left(\frac{1MW}{10^6 \frac{kg \cdot m^2}{s^3}}\right) = 147MW$$

Answer B

47.37 An air handling unit uses a hot water coil to produce $20,000cfm$ of $120°F$ supply air. The entering air is composed of $5000cfm$ of $25°F$ outside air and $15,000cfm$ of $75°F$ return air. The hot water supply and return temperatures to and from the coil are $135°F$ and $105°F$, respectively. What volume flow rate of hot water is required?

A. $14gpm$

B. $83gpm$

C. $119gpm$

D. $345gpm$

Use the sensible heating rule of thumb for air to quantify the amount of heat added to the air.

$$\dot{Q}_{s,air} = 1.08cfm\Delta T$$

The discharge air temperature is given, but the entering air is a mixture of outside air and return air. Perform a mixing calculation to find the temperature of the air entering the coil. For convenience, use the known volume flow rates as the states are not fully defined and it will be implausible to determine the mass flow rates.

$$T_{MA} = \frac{(5000cfm)\,(25^{\circ}F) + (15,000cfm)\,(75^{\circ}F)}{20,000cfm} = 62.5^{\circ}F$$

Calculate the sensible heating of the air.

$$\dot{Q}_{s,air} = 1.08\,(20,000)\,(120 - 62.5) = 1,242,000\frac{Btu}{hr}$$

Equate the quantity of heat added to the air with the quantity of heat given up by the hot water flowing through the coil. The hot water undergoes an equal amount of sensible cooling. Use the sensible heating/cooling rule of thumb for water to solve for the volume flow rate of hot water. The temperature range is given.

$$\dot{Q}_{s,water} = \dot{Q}_{s,air}$$

$$500gpm\Delta T = 1,242,000\frac{Btu}{hr}$$

$$gpm = \frac{1,242,000}{(500)\,(135 - 105)} = 82.8gpm$$

Answer B

47.38 A radiator is designed for $100^{\circ}F$ entering air and $150^{\circ}F$ leaving air. The inlet water is expected to enter at $212^{\circ}F$ and leave at $195^{\circ}F$. The radiator may be treated as a counterflow heat exchanger with a heat transfer surface area of $10ft^2$ and an overall coeffieient of heat transfer of $11\frac{Btu}{hr\cdot ft^2\cdot{}^{\circ}F}$. What is the rate of heat transfer?

A. $5000\frac{Btu}{hr}$

B. $8100\frac{Btu}{hr}$

C. $8500\frac{Btu}{hr}$

D. $10,500\frac{Btu}{hr}$

Calculate the log mean temperature difference for the radiator modeled as a Counterflow heat exchanger. Draw the heat exchanger and label the temperatures.

$$Hot\,Fluid:\ 212^{\circ}F \longrightarrow 195^{\circ}F$$

$$Cold\,Fluid:\ 150^{\circ}F \longleftarrow 100^{\circ}F$$

Define one *physical* side of the heat exchanger as 'A' and the other side as 'B' and determine the respective temperature differences.