46.23 In a steam heat exchanger, $750\frac{lb}{hr}$ of $500°F$ steam at atmospheric pressure is used to heat $80gpm$ of cold water initally at $50°F$. If the steam exits as a saturated liquid, what is the final temperature of the water assuming there are no losses?

A. $52°F$

B. $64°F$

C. $71°F$

D. $76°F$

Consider the entering steam as State 1 and leaving saturated liquid as State 2. Consider the entering water as State 3 and the leaving water as State 4.

Use the Properties of Superheated Steam table to obtain the enthalpy at State 1.

$$P_1 = 14.7psia$$

$$T_1 = 500°F$$

$$h_1 = 1287.3\frac{Btu}{lb}$$

Use the Properties of Saturated Water and Steam table to obtain the saturated liquid enthalpy at State 2.

$$P_2 = 14.7psia\,(saturated)$$

$$h_2 = 180.18\frac{Btu}{lb}$$

Use the mass flow rate to calculate the heat provided by the steam.

$$\dot{Q}_{steam} = \dot{m}_{steam}\,(h_1 - h_2) = 750\frac{lb}{hr}\left(1287.3\frac{Btu}{lb} - 180.18\frac{Btu}{lb}\right) = 830,340\frac{Btu}{hr}$$

The quantity of heat added to the water is equal to the quantity of heat provided by the steam. Use the sensible heat rule of thumb for water to calculate the increase in temperature, and then specify the leaving water temperature at State 4. Note $\dot{Q}$ must have units of $\frac{Btu}{hr}$ for the rule of thumb to work properly, with temperatures having units of $°F$.

$$\dot{Q}_{water} = \dot{Q}_{steam}$$

$$500gpm\Delta T = \dot{Q}_{steam}$$

$$\Delta T = T_4 - T_3 = \frac{\dot{Q}_{steam}}{500gpm} = \frac{830,340}{(500)\,(80)} = 20.8°F$$

$$T_4 = T_3 + 20.8°F = 70.8°F$$

Answer C

46.24 Air enters a compressor at $80°F$ and $14.7psia$ and exits at $180psia$. What is the change in enthalpy during the compression process?

A. $115\frac{Btu}{lb}$

B. $135\frac{Btu}{lb}$

C. $155\frac{Btu}{lb}$

D. $175\frac{Btu}{lb}$

Consider the entering conditions as State 1 and the leaving conditions as State 2. Use the Air at Low Pressure tables to obtain the enthalpy at State 1. The air tables assume that for low pressure air, enthalpy is a function of temperature only. Also obtain the relative pressure at State 1.

$$T_1 = 80°F$$

$$h_1 \approx 129\frac{Btu}{lb}$$

$$p_{r,1} = 1.386$$

Use the ratio of the pressures to find the relative pressure at State 2.

$$\frac{p_{r,2}}{p_{r,1}} = \frac{P_2}{P_1} = \frac{180psia}{14.7psia} = 12.24$$

$$p_{r,2} = (12.24)(1.386) = 16.97$$

Use the air tables again to obtain the enthalpy at State 2 using the relative pressure at State 2.

$$h_2 \approx 264\frac{Btu}{lb}$$

Calculate the change in enthalpy.

$$\Delta h = h_2 - h_1 = 264\frac{Btu}{lb} - 129\frac{Btu}{lb} = 135\frac{Btu}{lb}$$

Answer B