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

46.25 A steam boiler uses $50\frac{lb}{hr}$ of $40psia$ saturated steam to heat $10gpm$ of water. What is the expected increase in temperature for the water?

A. $7°F$

B. $8°F$

C. $9°F$

D. $10°F$

There is no mention of any losses in the problem statement, so assume the heat exchange process is 100% efficient. Set the heat provided by the steam equal to the heat gained by the water. Ensuring both sides of the equation have units of $\frac{Btu}{hr}$, it is valid to use the sensible heating rule of thumb for water on the right side.

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

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

The change in enthalpy for the steam may be assumed as the latent heat of vaporization for steam at 40psia. Since no quality or leaving enthalpy was given, it is reasonable to assume the steam condenses fully and gives up all of its latent heat in the process.

$$\dot{m}_{steam}h_{fg} = 500gpm\Delta T$$

Use the Properties of Saturated Water and Steam table to obtain the latent heat of vaporization.

$$P = 40psia$$

$$h_{fg} = 933.68\frac{Btu}{lb}$$

Solve the left side of the equation and confirm the units are $\frac{Btu}{hr}$.

$$\dot{m}_{steam}h_{fg} = \left(50\frac{lb}{hr}\right)\left(933.68\frac{Btu}{lb}\right) = 46,684\frac{Btu}{hr}$$

Since the units are confirmed and the right side of the equation is a "rule of thumb," it is implied that the change in temperature will be in degrees Farenheit, as desired. Solve for ΔT.

$$46,684 = (500)(10)\Delta T$$

$$\Delta T = \frac{46,684}{(500)(10)} = 9.3°F$$

Answer C