$$\dot{W}_{comp} = \frac{\left(10,000\frac{ft^3}{min}\right)\left(14.7\frac{lb_f}{in^2}\right)(1.4)\left(\frac{144in^2}{ft^2}\right)}{(1.4-1)(0.7)}\left[\left(\frac{40psia}{14.7psia}\right)^{1-\frac{1}{1.4}}-1\right] = 3.5\times10^7\frac{ft\cdot lb_f}{min}$$

$$\dot{W}_{comp} = 3.5\times10^7\frac{ft\cdot lb_f}{min}\left(\frac{1min}{60s}\right)\left(\frac{1hp}{550\frac{ft\cdot lb_f}{s}}\right) = 1062hp$$

Answer D

46.22 A $1.5hp$ motor drives a re-circulation fan serving a room with a $7500ft^3$volume of room temperature air. The fan and fan motor are located in an adjacent mechanical room which is a return plenum for the conditioned space. What is the maximum possible increase in the room air temperature if the fan is left to run for 30 minutes?

A. $1°F$

B. $3°F$

C. $8°F$

D. $14°F$

In a worst-case scenario, assume all of the motor's energy heats the air. This drives the maximum possible increase in the room air temperature. Determine the amount of energy produced by the motor during a half hour.

$$(1.5hp)\left(\frac{0.7457KW}{hp}\right)(0.5hr)\left(3412\frac{\frac{Btu}{hr}}{KW}\right) = 1908Btu$$

Assume a typical density for air of $0.075\frac{lb_m}{ft^3}$ and find the mass of air based on the volume given.

$$m = \rho V = \left(0.075\frac{lb_m}{ft^3}\right)\left(7500ft^3\right) = 562.5lb_m$$

Find ΔT based on the heat transfer, mass, and specific heat capacity of air.

$$Q = mc_p\Delta T$$

$$\Delta T = \frac{Q}{mc_p} = \frac{(1908Btu)}{(562.5lb_m)\left(0.24\frac{Btu}{lb_m\,°F}\right)} = 14.1°F$$

Answer D

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.

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

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