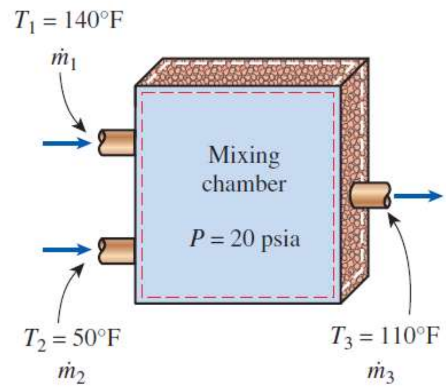
Given:

In an ordinary shower, hot water at 140°F is mixed with cold water at 50°F. The desired temperature of the water stream leaving the show head is 110°F.

$T_1 := 140\,°F$

$T_2 := 50\,°F$ $\quad P := 20psi$

$T_3 := 110\,°F$



Required:

Assuming there is no heat loss and the mixing place is at a pressure of 20 psia, determine the mass flow ratio of hot to cold water.

Solution:

Mass Conservation (for a steady flow device)

$$\frac{d}{dt}m_{sys} = \Sigma m'_{in} - \Sigma m'_{out}$$

$$0 = \Sigma m'_{in} - \Sigma m'_{out}$$

$$0 = m'_1 + m'_2 - m'_3$$

1st Law (for adiabatic, rigid, steady flow device with no changes in kinetic and potential energy)

$$\frac{d}{dt}E_{sys} = \Sigma E'_{in} - \Sigma E'_{out}$$

$$0 = \Sigma E'_{in} - \Sigma E'_{out}$$

$$0 = m'_1 \cdot h_1 + m'_2 \cdot h_2 - m'_3 \cdot h_3$$

Dividing both the mass conservation and first law by m'_2 yields

$$0 = \frac{m'_1}{m'_2} + \frac{m'_2}{m'_2} - \frac{m'_3}{m'_2}$$

$$0 = \frac{m'_1}{m'_2} + 1 - \frac{m'_3}{m'_2}$$

$$0 = \frac{m'_1}{m'_2} \cdot h_1 + \frac{m'_2}{m'_2} \cdot h_2 - \frac{m'_3}{m'_2} \cdot h_3$$

$$0 = \frac{m'_1}{m'_2} \cdot h_1 + h_2 - \frac{m'_3}{m'_2} \cdot h_3$$

Solution (cont.)

Solving for the ratio of the mass flow rate of the hot to cold water (i.e. $\frac{m'_1}{m'_2}$)

$$\frac{m'_1}{m'_2} = \frac{h_3 - h_2}{h_1 - h_3}$$

Going to Table A-4E @ $T_1 = 140 \cdot °F$ shows that the state is a compressed liquid. However, the compress liquid table (A-7E) does not have the necessary pressure values so the state will be approximated by the saturated liquid value of Table A-4E. This is shown below.

$$h_1 := 107.99 \frac{Btu}{lbm}$$

Going to Table A-4E @ $T_2 = 50 \cdot °F$ shows that the state is a compressed liquid. However, the compress liquid table (A-7E) does not have the necessary pressure values so the state will be approximated by the saturated liquid value of Table A-4E. This is shown below.

$$h_2 := 18.07 \frac{Btu}{lbm}$$

Going to Table A-4E @ $T_3 = 110 \cdot °F$ shows that the state is a compressed liquid. However, the compress liquid table (A-7E) does not have the necessary pressure values so the state will be approximated by the saturated liquid value of Table A-4E. This is shown below.

$$h_3 := 78.02 \frac{Btu}{lbm}$$

The ratio of the mass flow rate of the hot to cold water is then

$$\boxed{r_{hc} := \frac{h_3 - h_2}{h_1 - h_3} = 2}$$