33.22 **$500kPa$ saturated steam is mixed in a chamber with $30°C$ saturated liquid water. $1\frac{kg}{s}$ of the mixture exits the chamber as a $200kPa$ saturated vapor. What is the mass flow rate of water entering the mixing chamber?**

A. $15\frac{kg}{hr}$

B. $30\frac{kg}{hr}$

C. $45\frac{kg}{hr}$

D. $60\frac{kg}{hr}$

Consider the entering saturated steam as State 1, the entering saturated liquid water as State 2, and the exiting saturated vapor as State 3. All states are fully defined as either the temperature or pressure is given as well as the thermodynamic state. Use the Properties of Saturated Water and Steam tables by temperature or pressure to obtain the enthalpies.

$$P_1 = 500kPa\ (saturated\,vapor)$$

$$h_1 = 2748.1\frac{kJ}{kg}$$

$$T_2 = 30°C\ (saturated\,liquid)$$

$$h_2 = 125.7\frac{kJ}{kg}$$

$$P_3 = 200kPa\ (saturated\,vapor)$$

$$h_3 = 2706.2\frac{kJ}{kg}$$

Write the energy and mass balance for a Steady-Flow System.

$$\dot{m}_1 h_1 + \dot{m}_2 h_2 = \dot{m}_3 h_3$$

$$\dot{m}_1 + \dot{m}_2 = \dot{m}_3$$

Since the mass flow rate of State 3 is known, make the substitution, then rearrange the equation for the mass flow rate of State 1, which can then be substituted into the energy balance equation. Substitution is one method of solving two equations with two unknowns, $\dot{m}_1$ and $\dot{m}_2$. Also substitute the known enthalpy values. Distribute, collect like terms, and solve for $\dot{m}_2$.

$$\dot{m}_1 + \dot{m}_2 = 1\frac{kg}{s}$$

$$\dot{m}_1 = 1\frac{kg}{s} - \dot{m}_2$$

$$\left(1\frac{kg}{s} - \dot{m}_2\right)\left(2748.1\frac{kJ}{kg}\right) + \dot{m}_2\left(125.7\frac{kJ}{kg}\right) = \left(1\frac{kg}{s}\right)\left(2706.2\frac{kJ}{kg}\right)$$

$$\dot{m}_2 = 0.016\frac{kg}{s}$$

Convert units to $\frac{kg}{hr}$.

$$\dot{m}_2 = 0.016\frac{kg}{s}\left(\frac{3600s}{hr}\right) = 57.5\frac{kg}{hr}$$

Answer D