31.27 **$30\frac{lb}{hr}$ of $30psia$ saturated steam enters a steam heat exchanger and leaves as a saturated mixture after heating $1000\frac{lb}{hr}$ of water by $25°F$. What is the quality of the leaving steam?**

A. 0.12

B. 0.26

C. 0.74

D. 0.88

On the steam side of the heat exchanger, consider the entering steam as State 1 and the leaving saturated mixture as State 2.

The heat added to the water is quivalent to the heat given up by the steam.

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

Use the mass flow rate, specific heat capacity, and temperature differential to calculate the heat gained by the water.

$$\dot{Q}_{water} = \dot{m}_{water} c_p \Delta T = \left(1000\frac{lb}{hr}\right)\left(1\frac{Btu}{lb°F}\right)(25°F) = 25,000\frac{Btu}{hr}$$

Use the Properties of Saturated Water and Steam table to look up the enthalpy at State 1.

$$P_1 = 30psia\,(saturated)$$

$$h_1 = 1164.13\frac{Btu}{lb}$$

Write an expression for the heat provided by the steam and set equal the to heat added to the water. Solve for the enthalpy at State 2.

$$\dot{Q}_{steam} = \dot{m}_{steam}\,(h_1 - h_2) = \dot{Q}_{water}$$

$$h_2 = h_1 - \frac{\dot{Q}_{water}}{\dot{m}_{steam}} = 1164.13\frac{Btu}{lb} - \frac{25,000\frac{Btu}{hr}}{30\frac{lb}{hr}} = 330.8\frac{Btu}{lb}$$

Return to the steam table to obtain enthalpy values at $30psia$.

$$P_2 = 30psia$$

$$h_f = 218.92\frac{Btu}{lb}$$

$$h_{fg} = 945.21\frac{Btu}{lb}$$

Determine the quality at State 2.

$$\chi_2 = \frac{h_2 - h_f}{h_{fg}} = \frac{330.8 \frac{Btu}{lb} - 218.92 \frac{Btu}{lb}}{945.21 \frac{Btu}{lb}} = 0.118$$

Answer A