

Given:

A piston cylinder device contains 25 g of saturated water vapor that is maintained at a constant pressure of 300 kPa. A resistance heater running of 0.2 A and 120 V is used to heat the vapor for 5 minutes. At the same time, the system experiences a heat loss of 3.7 kJ.

$$m := 25 \text{ g} \quad P_1 := 300 \text{ kPa} \quad I_s := 0.2 \text{ A} \quad V_s := 120 \text{ V}$$

$$\Delta t := 5 \text{ min} \quad Q_{out} := 3.7 \text{ kJ}$$

Required:

Determine the final temperature.

Solution:

Since the water initially a saturated vapor, the quality is

$$x_1 := 1$$

The total heat supplied by the heat is

$$Q_{in} := V_s \cdot I_s \cdot \Delta t = 7.2 \text{ kJ}$$

1st Law for closed system with no KE or PE

$$\Delta E_{sys} = \Sigma E_{in} - \Sigma E_{out}$$

$$\Delta U + \Delta KE + \Delta PE = Q_{in} - Q_{out} - W_b$$

$$\Delta U + W_b = \Delta H = Q_{in} - Q_{out}$$

$$m \cdot \Delta h = Q_{in} - Q_{out}$$

Going to Table A-5 @ $P := P_1 = 300 \text{ kPa}$ and $x := x_1 = 1$ shows

$$h_1 := 2724.9 \frac{\text{kJ}}{\text{kg}}$$

Rearranging the **1st Law** equation, the enthalpy at state may be found

$$m \cdot (h_2 - h_1) = Q_{in} - Q_{out}$$

$$h_2 := \frac{Q_{in} - Q_{out}}{m} + h_1 = 2865 \frac{\text{kJ}}{\text{kg}}$$

Going to Table A-5 @ $P := P_1 = 300 \text{ kPa}$ shows

$$h_g := 2724.9 \frac{\text{kJ}}{\text{kg}}$$

Since $h_2 > h_g$, state 2 is superheated. Going to Table A-6 @ $P := P_1 = 0.3 \text{ MPa}$ and $h := h_2 = 2865 \frac{\text{kJ}}{\text{kg}}$ shows that interpolating is needed.

$$T_a := 150 \text{ } ^\circ\text{C} \quad T_b := 200 \text{ } ^\circ\text{C}$$

$$h_a := 2761.2 \frac{\text{kJ}}{\text{kg}} \quad h_b := 2865.9 \frac{\text{kJ}}{\text{kg}}$$

$$T_2 := \frac{h_2 - h_a}{h_b - h_a} \cdot (T_b - T_a) + T_a = 472.7 \text{ K}$$

$$T_2 = 199.5 \text{ } ^\circ\text{C}$$

