Answer on Question #83797 – Engineering | Mechanical Engineering

Four kg of water is placed in an enclosed volume of 1m^3. Heat is added until the temperature is 150°C. Find (a) the pressure, (b)the mass of vapor, and (c) the volume of the vapor.

Answer:

NOTE: Steam table is available at:

https://www.nist.gov/sites/default/files/documents/srd/NISTIR5078-Tab1.pdf

The density of the saturated steam at 150°C is ρ_V = 2.5481 kg/m^3. Thus, 4 kg of the saturated steam at 150°C occupies volume of

$$\frac{4\ \text{kg}}{2.5481\ \text{kg/m}^3} = 1.57\ \text{m}^3,$$

which is more than 1 m^3. It shows that, the final state is the saturated water-steam mixture.

The pressure is equal to the saturation pressure 4.7616 bar.

The density of the saturated water ρ_L = 917.01 kg/m^3. Noting the mass of the water and steam in the mixture by m_L and m_v, respectively, we can define the total mass M and volume V of the mixture by following equations

$$M = m_L + m_V,$$
$$V = \frac{m_L}{\rho_L} + \frac{m_V}{\rho_V}.$$

Considering these equations together, yields

$$m_L = M - m_V,$$
$$V = \frac{M - m_V}{\rho_L} + \frac{m_V}{\rho_V},$$
$$m_V = \frac{V\rho_L - M}{\frac{\rho_L}{\rho_V} - 1}.$$

Substitute to define the mass of the steam

$$m_V = \frac{1 \cdot 917.01 - 4}{\frac{917.01}{2.5481} - 1} = 2.544\ \text{kg}.$$

The volume V_V of the steam equals to

$$V_V = \frac{m_V}{\rho_V} = \frac{2.544}{2.5481} = 0.998\ \text{m}^3.$$