Question #79070

A cylinder has a volume of 0.4 m^3 holds 2.0 kg of a mixture of liquid water and water vapor. The mixture is in equilibrium at a pressure of 0.6 MPa.

Calculate:

a. Mass of liquid

b. Mass of Vapor

Answer:

The mass of the steam and water mixture is given by the sum of the steam mass m_s and the water mass m_w:

$$m_s + m_w = 2.0 \text{ kg}. \quad (1)$$

The volume of the mixture is given by the sum of the steam volume V_s and the water volume V_w:

$$V_s + V_w = 0.4 \text{ m}^3,$$

$$\frac{m_s}{\rho_s} + \frac{m_w}{\rho_w} = 0.4 \text{ m}^3, \quad (2)$$

where ρ_s and ρ_w are the density of the steam and the water, respectively.

Since the mixture is in equilibrium, the steam and the water are saturated. From the saturated steam and water table, we can determine the density of the steam and the water at 0.6MPa (see https://www.nist.gov/sites/default/files/documents/srd/NISTIR5078-Tab2.pdf):

$$\rho_s = 3.1687 \text{ kg/m}^3, \qquad \rho_w = 908.59 \text{ kg/m}^3.$$

From (2):

$$m_s = \rho_s \left(0.4 - \frac{m_w}{\rho_w}\right). \quad (3)$$

Substitute (3) in (1):

$$\rho_s \left(0.4 - \frac{m_w}{\rho_w}\right) + m_w = 2.0,$$

$$m_w = \frac{2.0 - 0.4\rho_s}{1 - \frac{\rho_s}{\rho_w}} = \frac{2.0 - 0.4 \cdot 3.1687}{1 - \frac{3.1687}{908.59}} = 0.735 \text{ kg} - \text{the mass of liquid.}$$

Substitute into (3):

$$m_s = 3.1687 \cdot \left(0.4 - \frac{0.735}{908.59}\right) = 1.265 \text{ kg} - \text{the mass of vapor.}$$