

Given: $\text{kJ} := 1000\text{J}$

A rigid tank contains 5 kg of R-134a initially at 20°C and 140 kPa. The R-134a is now cooled while being stirred until its pressure drops to 100 kPa.

Required:

Determine the entropy change of the R-134a during this process.

Solution:

The mass of the R-134a is defined as

$$m_{\text{R134a}} := 5\text{kg}$$

The initial conditions are defined as

$$T_1 := 20^\circ\text{C} = 293.15\text{ K} \quad P_1 := 140\text{kPa}$$

The final pressure is defined as

$$P_2 := 100\text{kPa}$$

Going to Table A-11 @ $T_1 = 20^\circ\text{C}$ shows

$$P_{\text{sat}} := 572.07\text{kPa}$$

Since $P_{\text{sat}} > P_1$ the state is superheated. Going to Table A-13 @ $T_1 = 20^\circ\text{C}$ and $P_1 = 0.14\text{MPa}$ shows

$$\nu_1 := 0.16544 \frac{\text{m}^3}{\text{kg}} \quad s_1 := 1.0624 \frac{\text{kJ}}{\text{kg}\cdot\text{K}}$$

Since the control volume is a closed system and the tank is rigid,

$$\nu_2 := \nu_1 = 0.16544 \frac{\text{m}^3}{\text{kg}}$$

Going to Table A-12 @ $P_2 = 100\text{kPa}$ shows

$$\nu_f := 0.0007259 \frac{\text{m}^3}{\text{kg}} \quad \nu_g := 0.19254 \frac{\text{m}^3}{\text{kg}} \quad s_f := 0.07188 \frac{\text{kJ}}{\text{kg}\cdot\text{K}} \quad s_g := 0.95183 \frac{\text{kJ}}{\text{kg}\cdot\text{K}}$$

Since $\nu_f < \nu_2 < \nu_g$ the state is in the two phase region so

$$x_2 := \frac{\nu_2 - \nu_f}{\nu_g - \nu_f} = 0.859$$

The specific entropy at state 2 is then

$$s_2 := s_f + x_2 \cdot (s_g - s_f) = 0.828 \frac{\text{kJ}}{\text{kg}\cdot\text{K}}$$

The entropy change for the process is then

$$\Delta S := m_{\text{R134a}} \cdot (s_2 - s_1) = -1.174 \frac{\text{kJ}}{\text{K}}$$

