

Given:

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

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

The initial conditions are defined as

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

The final pressure is defined as

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

Going to Table A-11 @ $T_1 = 20.00 \text{ }^{\circ}\text{C}$ shows

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

Since $P_{sat} > P_1$, the state is superheated. Going to Table A-13 @ $T_1 = 20.00 \text{ }^{\circ}\text{C}$ and $P_1 = 0.1400 \text{ MPa}$ shows

$$v_1 := 0.16544 \frac{\text{m}^3}{\text{kg}} \quad s_1 := 1.0624 \frac{\text{kJ}}{\text{kg K}}$$

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

$$v_2 := v_1 = 0.1654 \frac{\text{m}^3}{\text{kg}}$$

Going to Table A-12 @ $P_2 = 100.0 \text{ kPa}$ shows

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

Since $v_f < v_2$ and $v_2 < v_g$, the state is in the two phase region so

$$x_2 := \frac{v_2 - v_f}{v_g - v_f} = 0.8587$$

The specific entropy at state 2 is then

$$s_2 := s_f + x_2 \cdot (s_g - s_f) = 0.8275 \frac{\text{kJ}}{\text{kg K}}$$

The entropy change for the process is then

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

