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Question: A mixture of 60% methane and 40% propane, by volume, is c...

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A mixture of 60% methane and 40% propane, by volume, is compressed in an adiabatic compressor from 40°C, 0.4 x 10^6 N/m^2 to 1.2 x 10^6 N/m^2. Determine the minimum work required per unit mass, the final temperature of the mixture, and the entropy change for each gas, assuming ideal gas behavior with constant specific heats. Explain the entropy changes determined for each gas and the total entropy change for the process.

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Expert Answer

sundeep answered this
284 answers

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Given

initial temperature $(T_1) = 40^\circ c = 313K$

initial pressure $(P_1) = 0.4 \times 10^6 \ N/m^2$

$= 0.4 MPa = 400 KPa$

final pressure $(P_2) = 1.2 \times 10^6 \ N/m^2 = 1.2 MPa = 1200 KPa$.

specific heat ratio (r) for methane (CH_4) $= 1.304$.

specific heat ratio (r) for propane $= 1.13$.

equivalent specific heat ratio $= 0.6(1.304) + 0.4(1.13)$

$$\boxed{r_{mixture} = 1.234}$$

from Ideal gas equation.

$PV = mRT$ [treating mass = 1 kg]

$PV = RT$

$$V = \frac{RT}{P}$$

$$v_1 = \frac{0.287 \times 313}{400}$$

$$\boxed{V_1 = 0.2245 \ m^3}$$

for Adiabatic process $PV^r = constant$.

$$P_1 V_1^r = P_2 V_2^r$$

$$V_2^r = \frac{P_1 V_1^r}{P_2}$$

$$V_2 = V_1 \cdot \left(\frac{P_1}{P_2}\right)^{1/r}$$

$$= 0.2245 \times \left(\frac{400}{1200}\right)^{1/1.234}$$

$$\boxed{V_2 = 0.092 \ m^3}$$

work done in an Adiabatic process is given by

$$w = \frac{P_1 V_1 - P_2 V_2}{r - 1}$$

$400 \times 0.2245 - 1200 \times 0.092$

$$\boxed{\dot{W} = -88.034 \text{ KJ}}$$

The minimum work required per unit mass is 88.034 KJ.

here '-ve' sign indicates work is done on the system

change in Entropy of an ideal gas is given by

$$\Delta S_{sym} = C_v \ln\left(\frac{P_2}{P_1}\right) + C_p \ln\left(\frac{V_2}{V_1}\right)$$

Specific heat at constant volume $C_v = 0.45$ (methane)

Specific heat at constant volume $C_v = 0.34$ (propane)

Specific heat at constant volume of the mixure.

$$= 0.6\,(0.45) + 0.4\,(0.34)$$

$$\boxed{C_{v_{mix}} = 0.406 \ \frac{KJ}{Kg\,K}}$$

$$\frac{C_p}{C_v} = r.$$

$$C_p = r \cdot C_v.$$

$$C_p = 1.234 \times 0.406.$$

$$\boxed{C_{p_{mix}} = 0.501 \ \frac{KJ}{Kg \cdot K}.}$$

$$\Delta S_{sys} = 0.406 \times \ln\left(\frac{1200}{400}\right) + 0.501 \ln\left(\frac{0.092}{0.2245}\right).$$

$$\boxed{\Delta S_{sym} = -8.99 \times 10^{-4} \ \frac{KJ}{Kg\,K}.}$$

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Q: 3 Entropy of Radiation The equation of state of radiation is PV = U/3. Stefan's law U/V = σT4, with σ= 72k4/(15ħ°c). Find the entropy of radiation as a function of V and T. 4 Thermodynamics relations KT (a) The TdS equations remain valid when dS = 0. Exploiting this fact, express Cy and Cp in terms of adiabatic derivatives, and show CP Cy Ks (b) Equate the right side of the first...

grams of krypton. What is the partial pressure of each gas in the mixture? PN2 = mm Hg PKr = mm Hg 2) A mixture of hydrogen and nitrogen gases contains hydrogen at a partial pressure of 219mm Hg and nitrogen at a partial pressure of 685 mm Hg. What...

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