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Chemical Engineering Thermodynamics

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Q. No 1

System

The part of universe under consideration or observation is called system.

Surroundings

Everything in universe except system is called surrounding of that system.

Adiabatic Process

A process which occur without transfering the heat and and mass between system and surrounding is called Adiabatic process

Isolated System

In this type of system both mass and energy can not enter or leave the system.

Extensive Property

It depend on extent/mass/size of the system. It is an additive property. If we divide the system the properties of the system will be change. It is denoted by capital letters.

Q. No 2

$\hat{V} = ?$ $\hat{U} = ?$

$P = 7\,bar$ $\hat{H} = 2600\,kJ/kg$

Solution

$$\hat{h} = h_f + x h_{fg}$$

$$2600 = 697.1 + x(2064.9)$$

$2600 - 697.1 = x(2064.9)$

$1902.9 = x(2064.9)$

$\frac{1902.9}{2064.9} = x$

$\boxed{x = 0.921}$

$\hat{V} = x V_g$

$= (0.921)(0.2728)$

$\boxed{\hat{V} = 0.2512 \, m^3/kg}$

$\hat{U} = U_f + x U_{fg}$

$= 696.3 + (0.921)(2571.1 - 696.3)$

$= 696.3 + (0.921)(1874.8)$

$= 696.3 + 1726.6908$

$\boxed{\hat{U} = 2420 \, kJ/kg}$

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Q No 3

$m = 10\,kg$

$P_1 = 20\,bar$

$V_1 = 1\,m^3$

$P_2 = 100\,bar$

$PV^{1.5} = \text{Constant}$

$$P_1 = \frac{20\,\cancel{bar}}{} \left| \frac{100\,\cancel{kPa}}{1\,\cancel{bar}} \right| \frac{1\,MPa}{1000\,\cancel{kPa}}$$

$P_1 = 2\,MPa$

$$\hat{V}_1 = \frac{1.0\,m^3}{10\,kg}$$

$\hat{V}_1 = 0.1\,m^3 kg.$

$$P_2 = \frac{100\,\cancel{bar}}{} \left| \frac{\cancel{100\,kPa}}{1\,\cancel{bar}} \right| \frac{1\,MPa}{\cancel{1000}\,kPa}$$

$P_2 = 10\,M$

$\hat{V}_2 = ?$

$$P_1 \hat{V}_1^{1.5} = P_2 \hat{V}_2^{1.5}$$

$$\hat{V}_2^{1.5} = \frac{P_1 \hat{V}_1^{1.5}}{P_2}$$

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$$\hat{V}_2 = \left(\frac{P_1 \hat{V}_1^{1.5}}{P_2}\right)^{1/1.5}$$

$$\hat{V}_2 = \left[\frac{2\,MPa}{} \Big| \frac{(0.1\,m^3)^{1.5}}{(kg)^{1.5}} \Big| \frac{1}{10\,MPa}\right]^{1/1.5}$$

$$\hat{V}_2 = (0.2 \times (0.1)^{1.5})^{1/1.5} \; m^3/kg$$

$$= (0.2 \times 0.0316)^{1/1.5} = (0.2 \times 0.0516)^{0.667}$$

$$\hat{V}_2 = 0.034\,m^3/kg$$

$$\hat{W} = ?$$

$$\hat{W} = -\int_{0.1}^{0.0342} P\,d\hat{V}$$

$$\hat{W} = -\int_{0.1}^{0.0342} \frac{P_1 \hat{V}_1^{1.5}}{\hat{V}^{1.5}}\,d\hat{V}$$

$$\hat{W} = 2 P_1 V_1^{1.5} \left[\frac{1}{\hat{V}_2^{0.5}} - \frac{1}{\hat{V}_1^{0.5}}\right]_{0.1}^{0.0342}$$

$$\boxed{\hat{W} = 204\,kJ/kg}$$

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$\hat{q} = ?$

$$\Delta \hat{U} = \hat{q} + \hat{\omega}$$

$\Delta \hat{U} = ?$

At state 1.

$P_1 = 2Mpa$, $T_1 = 213.6^\circ C$

$U_1 (kJ/kg)$	$T (^\circ C)$
2600.3	212.4
U_1	213.6
2620.3	225

$U_1 = 2602.97\ kJ/kg$

At State 2

$P_2 = 10\ 2MPa$, $\hat{V}_2 = 0.0342\ m^3/kg$.

$U_2 (kJ/kg)$	$\hat{V}_2 (m^3/kg)$
3045.8	0.0328
$\hat{U}_2$	0.0342
3144.5	0.0356

$U_2 = 3095.15\ kJ/kg$

From steam table. (E)

at 2Mpa.

$\hat{V}_l = 0.0012$

$\hat{V}_v = 0.0996$.

Steam is superheated.

$T (^\circ C)$	$\hat{V} (m^3/kg)$
212.4	0.0996
T	0.1
225	0.1038

$$y = \left\{ (y_2 - y_1) \left(\frac{x - x_1}{x_2 - x_1} \right) \right\} + y_1$$

$$T = (225 - 212.4) \left(\frac{0.1 - 0.0996}{0.1038 - 0.0996} \right) + 212.4^\circ C$$

$T_1 = 213.6^\circ C$

$$\Delta \hat{U} = \hat{U}_2 - \hat{U}_1$$

$$= (3095.15 - 2602.97)\ kJ/kg.$$

$$\Delta \hat{U} = 492.18\ kJ/kg.$$

$$\Delta U = \hat{q} + \hat{w}$$

$$\hat{q} = \Delta U - \hat{w}$$

$$\hat{q} = (492.18 - 203.8)\ kJ/kg$$

$$\boxed{\hat{q} = 288.38\ kJ/kg}$$