1

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Thermodynamic-I

QNo:- 3.

Consider a piston-cylinder containing 10.0 kg of water. The gas has a pressure of 20.0 bar. It occupies a volume of $1.0\,m^3$. The system undergoes a reversible process in which is is compressed to 100 bar. The $PV^{1.5}$ = constant.
calculate work done and heat transfer during this process.

Solution:-

$P_1 = 20\,bar$
$V_1 = 1.0\,m^3$
$m = 10.0\,kg$
$P_2 = 100\,bar$

$PV^{1.5} = constant$

a) T = ?

$$P_1 = \frac{20\,bar \mid 100\,kPa}{\mid 1\,bar}$$

$= 2000\,kPa$
$= 2\,MPa$

②

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$$\hat{V}_1 = \frac{1.0\, m^3}{10\, kg} = 0.1\, m^3/kg$$

From steam table
at 2MPa pressure

$\hat{V}_l = 0.0012$

$\hat{V}_v = 0.996$

$P = 2MPa$

The steam is superheated because $\hat{V}_1 > \hat{V}_v$

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

$$P_2 = \frac{100\, bar \,|\, 100\, kPa}{1\, bar} = \underline{10\, MPa}$$

$$P_1 V_1^{1.5} = P_2 V_2^{1.5} \Rightarrow V_2^{1.5} = \frac{P_1 V_1^{1.5}}{P_2}$$

$$\hat{V}_2 = \left(\frac{(P_1 V_1)^{1.5}}{P_2}\right)^{1/1.5} = \frac{P^{1.5}\hat{V}_1}{P_2^{1/1.5}}$$

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

$$\hat{V}_2 = \underline{0.0342\, m^3/kg}$$

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3

Workdone $= \hat{W} = ?\ N/m^2$

$P_1 = \dfrac{20\,bar}{} \Big| \dfrac{100\,kPa}{1\,bar} = 2000\,kPa = 2\,MPa.$

$P_2 = \dfrac{100\,bar}{} \Big| \dfrac{100\,kPa}{1\,bar} = 10\,MPa.$

$V_2 = ?\quad P_1 \hat{V}_1^{1.5} = P_2 \hat{V}_2^{1.5} = \quad V_2 = \left(\dfrac{P_1 V_1^{1.5}}{P_2}\right)^{1.5}$

From previous page we already find it.

$\hat{V}_2 = 0.03342\,m^3/kg.$

$\hat{W} = -\int_{0.1}^{0.0342} PEd\hat{V} = -\int_{0.1}^{0.0342} PdV.$

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

$P = \dfrac{P_1 V_1^{1.5}}{V^{1.5}}$

$\hat{W} = -\int_{0.1}^{0.0342} \dfrac{P_1 V_1^{1.5}}{V^{1.5}} = -\int_{0.1}^{0.0342} V^{-1.5} dV.$

$P_1 V_1^{1.5} \left| \dfrac{V^{-0.5}}{-0.5} \right|_{0.1}^{0.0342}$

$\hat{W} = \dfrac{P_1 V_1^{1.5}}{0.5}\left[\dfrac{1}{0.0342^{0.5}} - \dfrac{1}{0.1^{0.5}}\right]$

$\hat{W} = 283.8\,kJ/kg.$

$\dfrac{0.2830\,MPa\,m^3}{kg} \Big| \dfrac{1000\,kPa}{1\,MPa} \Big| \dfrac{kN}{kPa \cdot m^2}$

$= \therefore Nm = J.$

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(c) $\Delta \hat{U} = \hat{q} + \hat{w}$

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

$\hat{U}_1 = (kJ/kg)$	$T(C)$
2600.3	212.4
$\hat{U}_1$	213.6
2625.3	225

By interpolation method.

$\hat{U}_1 = 2602.97 kJ/kg$.

At state 2

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

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

By linear interpolation b/w $\hat{U}$ & $\hat{V}$

$\hat{U}_2 = 3095.15 kJ/kg$

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Now heat
$\hat{q} = ?$
$\Delta\hat{U} = q + \hat{W}$
$q = \Delta U - \hat{W}$ — (2)
$\Delta\hat{U} = \hat{U}_2 - \hat{U}_1$

At state 1:-

$P_1 = 2mPa.$

Find temp. at T_1 is by linear interpolation at 2mpa.

$V_l = 0.0012 m^3/kg$, $V_g = 0.0996 m^3/kg.$

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

$\Delta\hat{U} = \hat{U}_2 - \hat{U}_1$
$= (3095.15 - 2602.97)$ kJ/kg

$\Delta\hat{U} = 42918.$ kJ/kg

put value of $\Delta\hat{U}$ & $\hat{W}$ in eq (2)

$\hat{q} = \Delta\hat{U} + \hat{W}.$
$= (492.18 - 283.8)$ kJ/kg

$\hat{q} = 20538$ kJ/kg.

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6

Q:- 1

1- **System:-**

A system is the set of substances and energy that is being studied. If for examples, reactions are accuring in a jars everything inside the jar, is the system and except of jar (which is under consideration) everything is surrounding.

2. **Sorroudings:-**

Everything in the universe surrounded by a thermodynamic system. The surronded is everything except of system that is else not defined.

3. **Adiabatic process:-**

In thermodynamic, an adiabatic process is a type of thermodynamic process which occurs without transferring heat or mass betwen the system and it's surrounding.

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Isolated:-

In isolated system is either of following.
A physical system so far removed from other system that it doesn't interact with them.

e.g A thermal flask is the best example of Isolated system.

Question :- 2

given data:-

Pressure = P = 7 bar.

from steam table:-

specific enthalpy of liquid = $\hat{h}_f$ = 697 kJ/kg.
Change in sp. enthalpy = $\Delta \hat{h}_{fg}$ = 2067 kJ/kg
specific enthalpy of steam given = $\hat{h}$ = 2600 kJ/kg.

for ~~of~~ dryness fraction.

$$x = \frac{\hat{h} - \hat{h}_f}{\hat{h}_{fg}} = \frac{2600 - 697}{2067} = 0.921.$$

dryness fraction $x = 0.921$.

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8

specific volume = ?

$$\hat{V} = (1-x)\hat{V}_f + x\hat{V}_g$$

$$= (1-0.921)697 + (0.921)(25.73)$$

$$= 55.06 + 2369$$

$$\hat{V} = 2424.79 \text{ kJ/kg}$$