Assignment 3

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Sub : Basic Mechanical Engg.

Sec : G.

Answer to the question no - 1.

Given, $p = 5$ bar, $x = 0.9$

from Steam table, Corresponding of a pressure of 5 bar we find that,

$h_f = 640.23$ kJ/kg , $h_{fg} = 2108.5$ kJ/kg

We know that, entropy of 1 kg wet steam,

$$h = h_f + x h_{fg}$$
$$= 640.23 + 0.9 \times 2108.5$$
$$= 2537.88 \text{ kJ/kg}.$$

Heat required to rise 5kg of this steam from water at 20°C

Heat already water $= 20 \times 4.2$
$= 84$ kJ/kg.

∴ Heat required per kg of steam
$(2537.88 - 84)$
$= 2453.88$ kJ/kg

and Heat required for 5kg $= 2453.88 \times 5$
$= 12269.4$ kJ

(Ans)

Answer to the question no-2

Given, $P = 0.5$ bar , $x = 0.9$

From Steam table, corresponding to a pressure of 0.5 bar, we find that,

$h_f = 340.49$ kJ/kg $\quad h_{fg} = 2305.4$ kJ/kg

We know that enthalpy of 1 kg of wet steam $h = h_f + x h_{fg}$

$= (340.49 + 0.9 \times 2305.4)$ kJ/kg

$= 2415.35$ kJ/kg

We know that enthalpy of 1 kg of dry saturated steam,

$h_g = h_f + h_{fg}$

$= (340.49 + 2305.4)$ kJ/kg

$= 2645.89$ kJ/kg

$\therefore$ Required Heat, $\Delta h = h_g - h$

$= (2645.89 - 2415.35)$ kJ

$= 230.54$ kJ

(Ans)

Answer to the question no-3

Given, $P = 4$ bar , $x = 0.8$

From steam table corresponding to a pressure of 4 bar, we find that,

$h_f = 604.74 kJ/kg$ $h_{fg} = 2133.8 kJ/kg$

$v_g = 0.4625$

∴ Volume of 1 kg wet steam

$$v = x v_g$$
$$= (0.8 \times 0.4625)\ m^3/kg$$
$$= 0.37\ m^3/kg$$

∴ mass of $0.5 m^3$ of wet steam is $V = \frac{0.5}{0.37} = 1.35 kg$

∴ Enthalpy of 1 kg wet steam,

$$h = h_f + x h_{fg}$$
$$= 604.74 + 0.8 \times 2133.8$$
$$= 2311.04\ kJ/kg$$

Volume of $1 m^3$ wet steam is $V = \frac{1}{0.37}$

$$= 2.70 kg$$

∴ Enthalpy of $1 m^3$ or 2.70 kg wet steam is

$$\Delta h = (2311.04 \times 2.70)\ kJ$$
$$= 6239.808\ kJ \quad (Ans)$$

Answer to the question no-4.

Given, $p = 14$ bar, $t_{sup} - t = 110^\circ C$

water initial heat, $t = 47.8^\circ C$, $c_p = 2.1 kJ/kgK$

From the Steam table,

	h_f	h_{fg}
at → 10 bar	→ 762.81	2015.3
at → 15 bar	→ 844.84	1947.3

at → 14 bar

$$\rightarrow \frac{h_f - 762.81}{844.84 - 762.81} = \frac{14 - 10}{15 - 10}$$

$$\Rightarrow h_f = 828.434 \text{ kJ/kg}$$

$$\therefore \frac{h_{fg} - 1947.3}{2015.3 - 1947.3} = \frac{14 - 10}{15 - 10}$$

$$\Rightarrow h_{fg} = 2001.7 \text{ kJ/kg}$$

We know that, enthalpy or total heat of 1 kg of Supperheated Steam,

$$h_{sup} = h_f + h_{fg} + c_p(t_{sup} - t)$$

$$= 828.434 + 2001.7 + 2.1(110)$$

$$= 3061.134 \text{ kJ/kg}$$

Since, the water is at a temperature of 47.8°C,

Therefore, Heat already in water

$= (4.2 \times 47.8)$ kJ

$= 200.76$ kJ

$\therefore$ Actually Heat required $= 3061.134 - 200.76$

$= 2860.374$ kJ

We know that, enthalpy or total heat of 1kg of Saturated Steam,

$h = hf + hfg$

$= 828.434 + 2001.7$

$= 2830.134$

Heat for dry Satured Steam $= 2830.134 - 200.76$

$= 2629.374$ kJ/kg

$\therefore$ Heat required for Superheated Steam is

$= 2860.374 - 2629.374$

$= 231$ kg. (Ans)

Answer to the question no-5

Given, $p = 8$ bar, $x = 0.8$

From steam tables, corresponding to a pressure of 8 bar, we find that,

$h_f = 721.11$ kJ/kg $\quad h_{fg} = 2048.0$ kJ/kg

$v_g = 0.2404$, $\quad t = 170.4^\circ C$

(i) We know that, external workdone during evaporation with dryness fraction wet steam,

$$W = 100 p x v_g$$
$$= (100 \times 8 \times 0.8 \times 0.2404)\ kJ$$
$$= 153.856\ kJ$$

(ii) Internal Latent heat of Steam (wet Steam)

$$h = x h_{fg} - 100 p x v_g$$
$$= 0.8 \times 2048 - 100 \times 8 \times 0.8 \times 0.2404$$
$$= (1638.4 - 153.856)\ kJ$$
$$= 1484.544\ kJ$$

(Ans)

Answer to the question no-6

Given, $P = 8$ bar, $x = 0.8$

From Steam tables, corresponding of a pressure 7 bar, we find that,

$h_f = 697.22$ kJ/kg $\quad h_{fg} = 2066.3$ kJ/kg

$v_g = 0.2729$

(i) Internal energy for 1 kg of wet Steam,

$$u = h_f + x h_{fg} - 100 p x v_g$$

$$= 697.22 + 0.8 \times 2066.3 - 100 \times 8 \times 0.8 \times 0.2729$$

$$= 2175.604 \text{ kJ/kg}$$

(ii) Internal energy for 1 kg of dry saturated steam.

$$u = h_f + h_{fg} - 100 p v_g$$

$$= 697.22 + 2066.3 - 100 \times 8 \times 0.2729$$

$$= 2545.2 \text{ kJ/kg}$$

(Ans)

Answer to the question - 7

Given, $P_1 = 10$ bar, $P_2 = 1.4$ bar, $x = 0.8$

$t_{sup} = 300°C$

From Steam tables, corresponding to a pressure of 10 bar, We find that,

$h_f = 762.81$ kJ/kg $\quad h_{fg} = 2015.3$ kJ/kg

$v_g = 0.1944$ m^3/kg $\quad t = 179.9°C$

We know internal energy for Superheated Steam,

$$u = [h_f + h_{fg} + c_p(t_{sup} - t)] - 100p\, v_{sup}$$

$$= [h_f + h_{fg} + c_p(t_{sup} - t)] - 100p \times v_g \frac{T_{sup}}{T} \quad \left[\because v_{sup} = v_g \frac{T_{sup}}{T}\right]$$

$$= [762.81 + 2015.3 + 2.1(300 - 179.9)] - 100 \times 10 \times 0.1944 \times \frac{300 + 273}{179.9 + 273}$$

$$= 2784.37 \text{ kJ/kg}$$

From Steam tables, corresponding to a pressure of 1.4 bar, we find that,

$h_f = 457.186$ kJ/kg $h_{fg} = 2251.7$ kJ/kg

$v_g = 1.6732$

We know, internal energy for wet steam.

$$u = h_f + x h_{fg} - 100 p x v_g$$

$$= 451.186 + 0.8 \times 2251.7 - 100 \times 1.4 \times 0.8 \times 1.6732$$

$$= 2065.1476 \text{ kJ/kg}$$

The change of Internal energy

$$\Delta u = (2784.37 - 2065.1476) \text{ kJ/kg}$$

$$= 719.2224 \text{ kJ/kg}.$$

(Ans)

Answer to the question no-8

Given, $P = 20\ bar$, $C_p = 2.3\ kj/kg.k$.

From the Steam tables, Corresponding to a pressure of 20 bar, we find that,

$h_f = 908.79\ kj/kg$ $\quad h_{fg} = 1890.7\ kj/kg$

$t = 212.4^\circ C$ $\quad V_g = 0.1$

(i) Dryness fraction $x = 0.9$

Internal energy for wet Steam is,

$$u = h_f + x h_{fg} - 100 p x v_g$$

$$= 908.79 + 0.9 \times 1890.7 - 100 \times 20 \times 0.9 \times 0.1$$

$$= 2430.42\ kj/kg$$

(ii) Superheated for $t_{sup} = 400^\circ C$

$$\therefore V_{sup} = \frac{V_g T_{sup}}{T}$$

$$= \frac{0.1 \times (400 + 273)}{(212.4 + 273)}$$

$$= 0.1386$$

Internal energy for Superheated Steam,

$$u = [h_f + h_{fg} + c_p(t_{sup} - t)] - 100 p v_{sup}$$

$$= [908.79 + 1890.7 + 2.3(400.2 - 212.4)]$$

$$- 100 \times 20 \times 0.1386$$

$$= 2953.77 \text{ kJ/kg} \quad (\text{Ans})$$