THERMODYNAMICS

3

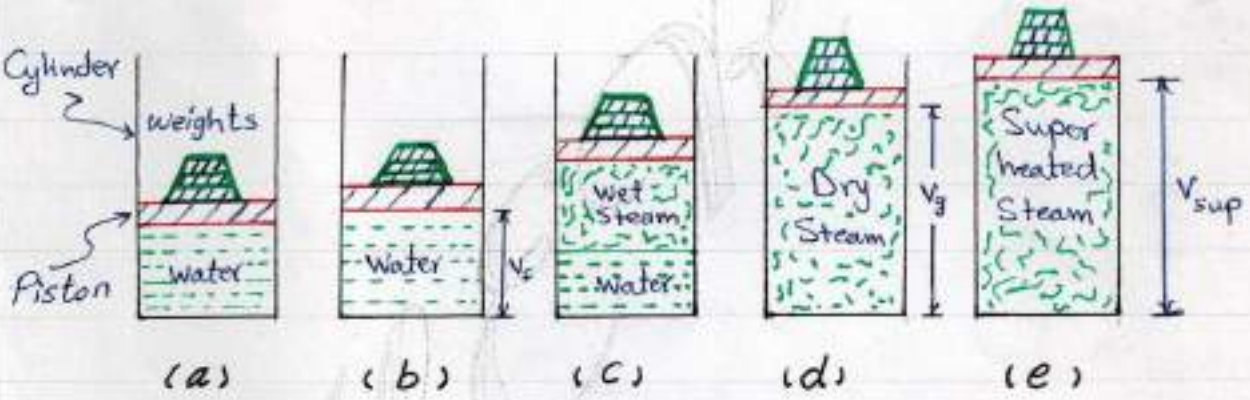
CHAPTER THREE

Steam and Two-Phase System

(Steam and Two-Phase System)

- **Steam**: is a vapour of water, and is invisible when pure and dry. It is used as the working substance in the operation of steam engines and Steam turbines. Steam does not obey laws of perfect gases, until it is perfectly dry.

- Formation of Steam at Constant Pressure from water:



Consider 1 kg of water at 0°C contained in the piston-cylinder arrangement as shown in the figure (a).

The piston and weights maintain a constant pressure in the Cylinder. If we heat the water contained in the cylinder, it will be converted into Steam as below:

1. The volume of water will increase slightly with the increase in temperature as shown in fig (b). It will cause the piston to move slightly upwards and hence work is obtained. This increase in volume of water (or work) is generally neglected for all types of calculation.

2. On further heating, temperature reaches boiling point. The boiling point of water, at normal atmospheric pressure of 1.013 bar is 100°C, but it increases with the increase in pressure. When the boiling point is reached, the temperature remains constant and the water evaporates, thus pushing the piston up against the constant pressure. Consequently, the Specific volume of Steam increase as shown in fig (c). At this stage, the steam will have some particles of water in suspension, and is termed as «Wet Steam». This process will continue till the whole water is converted into wet Steam.

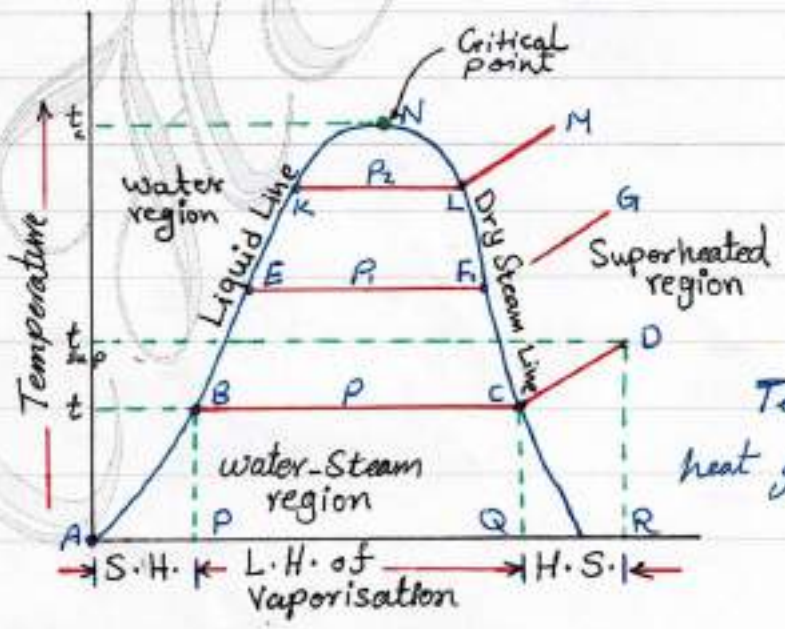
3. On further heating, the particles in suspension will be converted into Steam. The entire Steam, in such a state, is termed as **dry Steam** or Saturated Steam as shown in fig (d). Practically

the dry Steam behaves like a perfect gas.

4. On further heating, the temperature of the Steam Starts rising. The steam, in such a state is termed as Superheated Steam as Shown in fig. (e).

- Temperature vs. Total Heat Graph during Steam Formation:

The process of Steam formation may be represented on a graph, whose abscissa represents the total heat and the vertical ordinate represents the temperature. The point (A) represents the initial condition of water at 0°C and pressure p (in bars) as shown in figure below. Line ABCD shows the relation between temperature and heat at a specific pressure of p (in bars).



Temperature - total heat graph during Steam formation

During the formation of the superheated steam, from water at freezing point, the heat is absorbed in the following three stages:

1. The heating of water up to boiling temperature or saturation temperature (t) is shown by AB. The heat absorbed by the water is AP, known as Sensible heat (S.H.) or Liquid heat or total heat of water.

2. The change of state from Liquid to Steam is shown by BC. The heat absorbed during this stage is PQ, known as Latent heat (L.H.) of vaporisation.

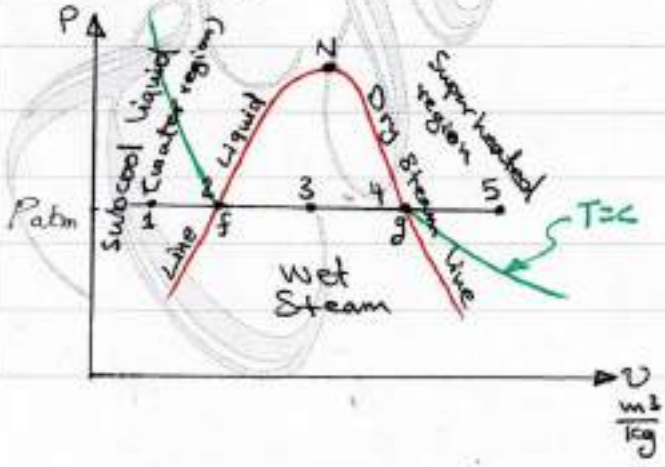
3. The Superheating process is shown by CD. The heat absorbed during this stage is QR, known as heat of Superheat (H.S.). Line AR represents the total heat of the Superheated Steam.

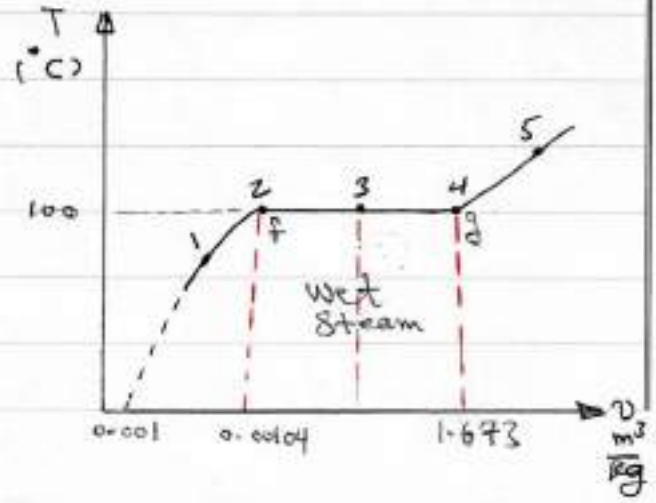
If the pressure is increased (Say P_1 bar), the boiling temperature also increas. The point (E) represents the boiling temperature or saturation temperature at pressure (P_1) and (F) is the point of dry saturated steam. Line (FG) shows the constant pressure process, in which the steam is superheated.

The line passing through the points A, B, E, K is known as «Saturated Liquid Line» which forms boundary line between water and steam. Similarly, a line passing through dry steam points L, F, C is known as «dry Saturated Steam Line» which forms boundary line between wet and superheated steam.

It may also be noted from the figure, that when the pressure and saturation temperature increases, the latent heat of vaporisation decreases. It becomes zero at point «N» where liquid and dry steam lines meet.

This point «N» is known as the critical point and at this point, the liquid and vapour phases merge. The temperature corresponding to critical point «N» is known as critical temperature and the pressure is known as critical pressure. For steam, the critical temperature is 374.15 °C and critical pressure is 221.2 bar.





Important Terms for Steam :

1. **Wet Steam :** When the steam contains moisture or particles of water in suspension, it is said to be **wet Steam**. It means that the evaporation of water is not complete, and the whole of the latent heat has not been absorbed.

2. **Dry Saturated Steam :** When the wet steam is further heated, and it does not contain any suspended particles of water, it is known as **dry saturated Steam**. The dry saturated steam has absorbed its full latent heat and behaves practically, in the same way as a perfect gas.

3. **Superheated Steam :** When the dry steam is further heated at a constant pressure, thus raising its temperature, it is said to be **superheated Steam**. Since the pressure is constant, therefore the volume of superheated Steam increases.

4. **Dryness fraction or quality of wet Steam :**
It is the ratio of the mass of actual dry Steam to the mass of same quantity of wet Steam, and generally denoted by 'x'.

Mathematically. $x = \frac{m_g}{m_g + m_f} = \frac{m_g}{m}$

m_g = Mass of actual dry steam.
m_f = Mass of water in suspension, and
m = Mass of wet Steam.

5. **Sensible heat of water:** It is the amount of heat absorbed by 1 kg of water, when heated at a constant pressure, from the freezing point (0) to the temperature of formation of steam. The Sensible heat is also known as liquid heat.

The specific heat of water at constant pressure is usually taken as 4.2 kJ/kg.K.

$$Q_{sensible} = \text{mass} * \text{Specific heat} * \text{Rise in temp.}$$
$$= m C_p (T_2 - T_1)$$
$$= m(h_2 - h_1)$$
$$= H_2 - H_1$$

h_2, h_1 ≡ Enthalpy of fluid (water), denoted by h_f

6. **Latent heat of vaporisation:** It is the amount of heat absorbed to evaporate 1 kg of water, at its boiling point or saturation temperature without change of temperature. It is denoted by h_{fg} and its value depends upon the pressure.

The heat of vaporisation of water or latent heat of Steam is 2257 kJ/kg at atmospheric pressure.

It has been experimentally found that the value of h_{fg} decreases as the pressure increases and it is **zero** at critical pressure.

If the Steam is wet with a dryness fraction x, then the heat absorbed by it during evaporation is $x h_{fg}$.

7. Enthalpy or total heat of Steam:

It is amount of heat absorbed by water from freezing point to saturation temperature **plus** the heat absorbed during evaporation.

∴ Enthalpy or total heat of Steam

= Sensible heat + Latent heat

It is denoted by **h_g** and its value for the dry Saturated Steam may be read directly from the Steam tables. The expressions for the enthalpy of wet Steam, dry Steam and superheated Steam are as follows:

i. Wet steam: the enthalpy of wet Steam is given by:

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

$h_f = u_f + p v_f$

ii. **Dry Steam:** We know that in case of dry Steam, $x = 1$

$$\therefore \quad h = h_f + 1 * h_{fg}$$

$$= h_f + (h_g - h_f)$$

$$\boxed{h = h_g}$$

iii. **Superheated Steam:** If we further add heat to the dry Steam, its temperature increases while pressure remaining constant. This increase in temperature shows the superheat stage of the Steam. Thus, the total heat required for the Steam to be Superheated is:

$$h_{sup} = \text{Total heat for dry Steam} + \text{Heat for Superheated Steam}$$

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

Where:

C_p = Specific heat at constant pressure for Superheated Steam.

t_{sup} = Temperature of the Superheated Steam.

t = Saturation temperature at the given constant pressure.

Notes:

1. The difference $(t_{sup} - t)$ is known as degree of Superheated
2. The value of C_p for Steam lies between 1.67 kJ/kg.K to 2.5 kJ/kg.K.

8. **Specific volume of Steam:** It is the volume occupied by the Steam per unit mass at a given temperature and pressure, and is expressed in m^3/kg. It is the reciprocal of density of Steam in kg/m^3.

The value of Specific volume decreases with the increase in pressure.

The expressions for the volumes occupied by Steam are as follows:

i. **Wet steam:** Consider 1kg of wet Steam of dryness fraction x. When know that this Steam will have x kg of dry Steam and $(1-x)$ kg of water. Let v_f be the volume of 1 kg of water, then

Volume of one kg of wet Steam $= x v_g + (1-x) v_f$

Since v_f is very small as compared to v_g, therefore the expression $(1-x) v_f$ may be neglected

$\therefore$ Volume of one kg of wet steam $= x \cdot v_g \quad m^3$

or Specific volume of wet Steam, $\quad v = x \cdot v_g \quad m^3/kg$

ii. Dry Steam: We know that in case of dry steam, the mass of water in suspension is zero and dryness fraction is unity. Therefore Specific volume of dry Steam $= v_g$ m^3/kg

iii. Superheated Steam: We have already discussed that when the dry saturated Steam is further heated under a constant pressure, there is an increase in volume with the rise in temperature. The superheated Steam behaves more or Less Like a perfect gas. Therefore, according to Charles' law.

$$\frac{v_{sup}}{T_{sup}} = \frac{v_g}{T} \quad \text{or} \quad \boxed{v_{sup} = \frac{v_g * T_{sup}}{T}}$$

Where:

v_{sup} = Specific volume of Superheated Steam.
v_g = Specific volume of dry Steam at the pressure of Steam formation.
$T_{sup.}$ = Absolute temperature of Superheated Steam
T = " Saturation temperature at the pressure of Steam formation.

Ex: Calculate the enthalpy of 1 kg of Steam at a pressure of 8 bar and dryness fraction of 0.8. How much heat would be required to raise 2 kg of this Steam from water at 20°c?

Sol: From Steam tables, at $P = 8$ bar

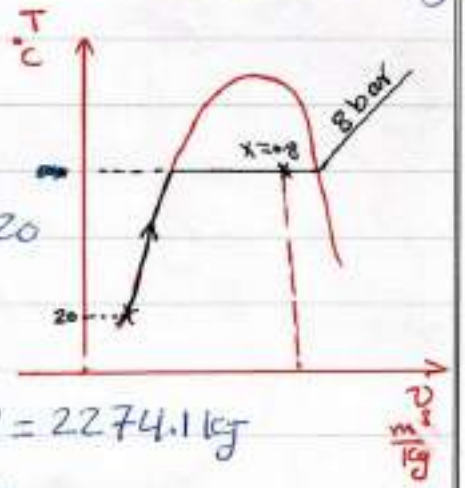
$h_f = 720.9$ kJ/kg , $h_{fg} = 2046.5$ kJ/kg

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

$= 720.9 + 0.8 * 2046.5 = 2358.1$ kJ

Heat required to raise 2kg of this Steam from water at 20°c.

We have calculated above the enthalpy or total heat required to raise 1kg of Steam from water at 0°C. Since the water, in this case, is already at 20°c, therefore



Heat already in water $= m C_p T$

$= 1 * 4.2 * 20$

$= 84$ kJ

Heat required per 1 kg of Steam

$= 2358.1 - 84 = 2274.1$ kJ

and Heat required for 2kg of Steam

$= 2 * 2274.1$

$= 4548.2$ kJ

Ex:- Determine the quantity of heat required to produce 1kg of steam at a pressure of 6 bar at a temperature of 25°C, under the following conditions:

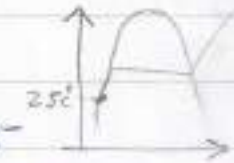
1. When the steam is wet having a dryness fraction 0.9
2. When the steam is dry saturated.
3. When it is superheated at a constant pressure at 250°C assuming the mean specific heat of superheated steam to be 2.3 kJ/kg.K.

Sol:- From Steam tables, at $p = 6$ bar

$h_f = 670.4$ kJ/kg.K , $h_{fg} = 2085$ kJ/kg.K

$t = 158.8°C$

1. When the Steam is wet:



$h = h_f + x h_{fg} = 670.4 + 0.9 * 2085$

$= 2546.9$ kJ (for 1 kg)

Since the water is at a temperature of 25°C, therefore enthalpy or Heat already in water $= m C_p T$

$= 1 * 4.2 * 25 = 105$ kJ

$\therefore$ Heat actually required $= 2546.9 - 105$

$= 2441.9$ kJ

2. When the Steam is dry saturated: $h = h_g$, $x = 1$

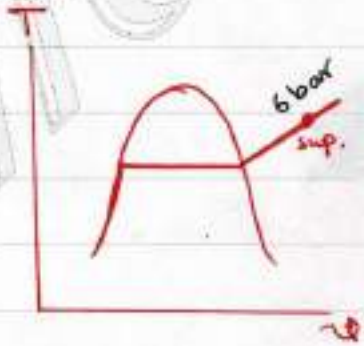
enthalpy or total heat of 1kg of dry saturated Steam, $h = h_f + 1 * h_{fg}$

$\Rightarrow h_g = 670.4 + 2085 = 2755.4$ kJ

Heat actually required = 2755.4 - 105
= 2650.4 kJ

3. When the Steam is superheated,
enthalpy or total heat of 1 kg of Superheated Steam,

$$h_{sup} = h_g + C_p(t_{sup} - t)$$
$$= 2755.4 + 2.3(250 - 158.8)$$
$$= 2965.16 \text{ kJ}$$



Heat actually required = 2965.16 - 105
= 2860.16 kJ

Ex: Determine the condition of Steam in the following cases:

1. At a pressure of 10 bar and temperature 200°C.
2. " " " " " " volume 0.175 m³/kg.

Sol:

1. From Steam tables, at $P = 10$ bar

$v_g = 0.194$ m³/kg , $h_f = 762.6$ kJ/kg.

$t_{sat} = 179.9°C \equiv t_{saturation}$

$\therefore t > t_{sat} \Rightarrow$ the Steam is Superheated

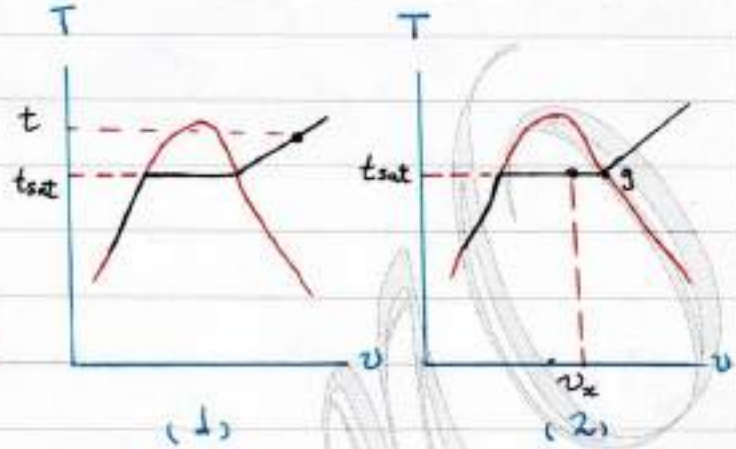
$\therefore$ the degree of Superheated $= t - t_{sat}$

$= 200 - 179.9 = 20.1°C$

2. $\because v < v_g$

$\therefore$ the Steam is wet

$$x = \frac{v}{v_g} = \frac{0.175}{0.194} = 0.902$$



Ex: Steam enters on engine at a pressure of 12 bar with a 67 °C of Superheated. It is exhausted at a pressure of 0.16 bar and 0.95 dry. Find the drop in enthalpy of the Steam. Take $C_{p_{sup}} = 2$ kJ/kg.K

Sol: from Steam tables, at 12 bar

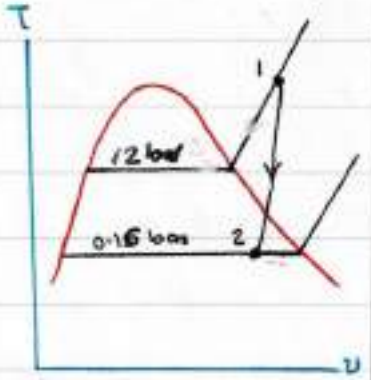
$h_f = 798$ kJ/kg. , $h_{fg} = 1986$ kJ/kg.

$$h_{sup} = h_f + h_{fg} + C_p(t_{sup} - t_{sat})$$
$$= 798 + 1986 + 2 * 67 = 2918 \text{ kJ/kg}$$

from Steam tables at 0.16 bar

$h_f = 232$ kJ/kg , $h_{fg} = 2369$ kJ/kg

$$h = h_f + x\, h_{fg} = 232 + 0.95 * 2369$$
$$= 2482.55 \text{ kJ/kg}$$



Drop in enthalpy of the steam

$$= h_{sup} - h = 2918 - 2482.55$$
$$= 435.45 \text{ kJ/kg}$$

* Interpolation :-

Ex:- When $P = 133$ bar Compute (t_{sat}, h_f, h_g, v_g, u_f)

Sol:- from Steam tables.

P [bar]	t_{sat} [°C]	v_g [m³/kg]	u_f [kJ/kg]	h_f [kJ/kg]	h_g [kJ/kg]
130	330.8	0.01278	1511	1531	2662
133	t_s ?	v_g ?	u_f ?	h_f ?	h_g ?
135	333.8	0.01211	1530	1551	2650

$$\frac{133-130}{135-130} = \frac{t_s - 330.8}{333.8-330.8} = \frac{v_g - 0.01278}{0.01211-0.01278} = \frac{u_f - 1511}{1530-1511}$$

$$= \frac{h_f - 1531}{1551-1531} = \frac{h_g - 2662}{2650-2662}$$

$$\therefore t_s = 330.8 + \frac{133-130}{135-130}(333.8-330.8) = 332.6\ °C$$

$$v_g = 0.01278 + \frac{3}{5}(0.01211-0.01278) = 0.017398\ \frac{m^3}{kg}$$

$$u_f = 1511 + \frac{3}{5}(1530-1511) = 1522.4\ kJ/kg$$

$$h_f = \quad + \frac{\quad}{\quad}(\quad - \quad) = 1543\ kJ/kg$$

$$h_g = \quad + \frac{\quad}{\quad}(\quad - \quad) = 2654.8\ \frac{kJ}{kg}$$

$$h_{fg} = \quad + \frac{\quad}{\quad}(\quad - \quad) = 1111.8\ \frac{kJ}{kg}$$

Ex: If $P = 12$ bar & $t = 255°C$, find (h) ?

Sol: at $P = 12$ bar from Steam tables

$t_{sat} = 188°C$ $\therefore t > t_{sat} \Rightarrow$ the Steam is Superheated

from Superheated Steam table:

	250 °C	(255°C)	300 °C
10 bar	2944	h_1	3052
(12)	h_1 ?	h_{sup}	h_2 ?
15 bar	2925	h_2	3039

$$h_1 = 2944 + \frac{12-10}{15-10}(2925-2944) = 2936.4 \text{ kJ/kg}$$

$$h_2 = 3052 + \frac{12-10}{15-10}(3039-3052) = 3046.8 \text{ kJ/kg}$$

$$h_{sup} = h_1 + \frac{255-250}{300-250}(h_2 - h_1)$$

$$= 2936.4 + \frac{255-250}{300-250}(3046.8 - 2936.4)$$

$$= 2947.44 \text{ kJ/kg}$$

It is called double Interpolation.

H.W: find for the same case (u, v)

Ex: Find the missing properties of water and given the phase of it:

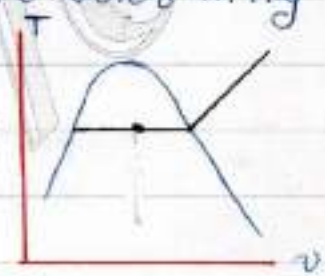
a. $T = 120^\circ C$, $v = 0.5\ m^3/kg$, u, P, X?

b. $T = 100^\circ C$, $P = 10\ Mpa$, u, X, v?

Sol: a. Saturation Condition of H_2O at $120^\circ C$ from Steam tables, $v_g = 0.8908$

$v_f = 0.00108\ m^3/kg$

Since $v < v_g \Rightarrow$ wet Steam



$v = v_f + x(v_g - v_f)$

$0.5 = 0.00108 + x(0.8908 - 0.00108)$

$\therefore x = 0.56$, $P = 198.5\ kpa = 1.985\ bar$

$u = u_f + x(u_g - u_f)$, By Interpolation

$= 503.48 + 0.56(2529.24 - 503.48)$

$u = 1639.7\ kJ/kg$

b. $T = 100^\circ C$ $P = 10\ Mpa$

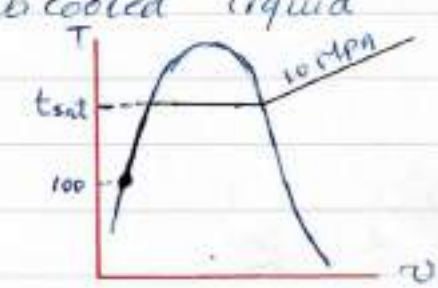
from Steam tables at $P = 10\ Mpa$

$t_{sat} = 311.06$ $\therefore t < t_{sat} \Rightarrow$ Subcooled liquid

$\therefore x = 0$

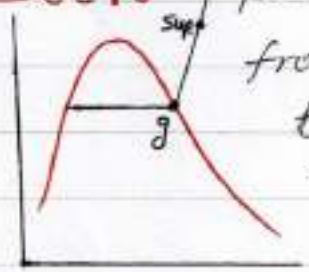
$u = u_f = 418.91\ kJ/kg$

$v = v_f = 0.00104\ m^3/kg$



Ex: Determine the volume of 1 kg of superheated Steam at a pressure of 20 bar and a temperature of 300 °C. (using charles's law)

Sol: $P = 20$ bar , $T_{sup} = 300°C = 300 + 273 = 573K$



from Steam tables, at $P = 20$ bar

$t_{sat} = 212.4°C$, $v_g = 0.09957 \ m^3/kg$

$T_{sat} = 212.4 + 273 = 485.4 \ K$

from Charles's law $\frac{v_g}{T_{sat}} = \frac{v_{sup}}{T_{sup}}$ (for 1 kg)

$\therefore v_{sup} = \frac{v_g}{T} * T_{sup} = \frac{0.09957}{485.4} * 573 = 0.1175 \ m^3$

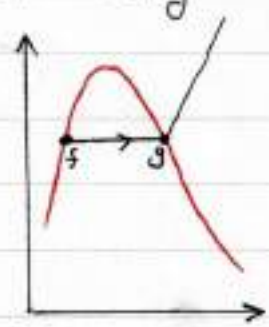
Ex: Find the external work done during evaporation per kg of Steam at a pressure of 15 bar when the Steam is (a) 90% dry (or 10% wet) (b) dry Saturated.

Sol: at $P = 15$ bar

from Steam tables, $v_g = 0.1317 \ m^3/kg$

a. $\because P = C \Rightarrow W = P(V_2 - V_1)$

$= P(V_g - V_f)$



$\because (v_f)$ very small, as compared with v_g therefore neglecting the value of v_f

$\therefore W = P * v_g$, when the steam is not completely dry, and has dryness fraction of x, the the work:

$$W = P * x v_g$$
$$= 15 * 10^2 * 0.9 * 0.1317$$
$$= 177.8 \text{ kJ/kg}$$

b. Work done when the Steam is dry Saturation

$$W = P * v_g$$
$$= 15 * 10^2 * 0.1317 = 197.5 \text{ kJ/kg}$$

Ex: A vessel having volume of 0.4 m^3 contains 2kg of a Liquid water and water vapour mixture in equilibrium of 600 kpa. Calculate the volume and mass of Liquid, the volume and mass of vapour.

Sol:

$$v = V/m = 0.4/2 = 0.2 \text{ m}^3/\text{kg}$$

at 600 kpa, from Steam tables,

$v_g = 0.3157 \text{ m}^3/\text{kg}$ since $v < v_g$

$\therefore$ wet Steam

$$v = v_f + x v_{fg}$$
$$0.2 = 0.001014 + x * 0.3146 \Rightarrow x = 0.6322$$

$$x = \frac{m_{vapour}}{m_{total}} \Rightarrow m_v = x \cdot m_t$$
$$= 0.6322 * 2$$
$$= 1.2644 \text{ kg}$$
$$m_f = m_t - m_v$$
$$= 2 - 1.2644$$
$$= 0.7356 \text{ kg} = m_{Liquid} \text{ or } m_L$$

$v_L = v_f$
$m_L = m_f$

$V = V_{Liq} + V_{vap}$

$m v = m_{Liq} \cdot v_f + m_v v_g$

$V_{Liq} = m_{Liq} * v_f$
$V_{vap} = m_v * v_g$

$$v_v = \frac{V_v}{m_v} \Rightarrow$$

$v_g = v_v$

$$V_v = m_v * v_v = 1.2644 * 0.3157$$
$$= 0.3992 \text{ m}^3$$
$$V_L = V_t - V_v = 0.4 - 0.3992 = 8.2 * 10^{-4} \text{ m}^3$$

Ex: A 200 l volume tank contain R-12 at 25°C has 10% liquid and 90% vapour by volume. Find the dryness fraction of R-12.

Sol: at 25°C, from R-12 tables.

$$v_L = 0.000763 \frac{m^3}{kg}, \quad v_g = 0.02685 \frac{m^3}{kg}$$
$$V = \frac{200}{1000} = 0.2 \text{ m}^3$$

$$V_L = 0.1 * V = 0.1 * 0.2 = 0.02 \text{ m}^3$$
$$V_g = 0.9 * V = 0.9 * 0.2 = 0.18 \text{ m}^3$$

$$v_L = \frac{V_L}{m_L} \Rightarrow m_L = \frac{V_L}{v_L} = \frac{0.02}{0.000763} = 26.2 \text{ kg}$$

$$m_g = \frac{V_g}{v_g} = \frac{0.18}{0.02685} = 6.7 \text{ kg}$$

$m_t = m_L + m_g = 26.2 + 6.7 = 32.9$ kg

$$x = \frac{m_g}{m_t} = \frac{6.7}{32.9} = 0.203$$

Ex: A vessel contains 0.1 kg Saturated Liquid and vapour water at 100 kpa, quality of 0.25. Find the total volume of vessel and the persentage of Liquid and vapour by volume.

Sol: from Steam tables, at 100 kpa

$v_f = 0.001043 \frac{m^3}{kg}$, $v_g = 1.694 \frac{m^3}{kg}$

$$v = v_f + x\, v_{fg}$$
$$= 0.001043 + 0.25(1.694 - 0.001043)$$
$$= 0.4242 \ m^3/kg$$

$v = V/m \Rightarrow V = v \cdot m = 0.4242 * 0.1$
$= 0.04242 \ m^3$

$V_L = v_L * m_L$, $V_g = v_g * m_g$

$m_g = x \cdot m_t = 0.25 * 0.1 = 0.025$ kg

$m_L = m_t - m_g = 0.1 - 0.025 = 0.075$ kg

$\therefore V_L = 0.001043 * 0.075 = 7.8225 * 10^{-5}\ m^3$

$V_g = 1.644 * 0.025 = 0.0423\ m^3$

$V_t = V_L + V_g = 7.8225 * 10^{-5} + 0.0423 = 0.0423782$

$\% V_L = \frac{V_L}{V_t} * 100 = \frac{7.8225 * 10^{-5}}{0.042378} * 100 = 0.1845\ \%$

$\% V_g = \frac{V_g}{V_t} * 100 = \frac{0.0423}{0.0423782} * 100 = 99.815\ \%$

Ex: Find the dryness fraction, the Specific volume and internal energy of Steam at 7 bar and enthalpy (2600 kJ/kg).

Sol: at 7 bar, from Steam tables,

$h_g = 2764\ kJ/kg \qquad h_f = 697\ kJ/kg$

Since $h_f < h_{steam} < h_g$

$697 < 2600 < 2764 \Rightarrow$ wet Steam

$\therefore h_x = 2600 = h_f + x h_{fg}$

$= 697 + x(2764 - 697) \Rightarrow x = 0.921$

$v_x = x v_g \quad , \quad v_g = 0.2728\ m^3/kg$

$v_x = 0.921 * 0.2728$

$= 0.2515\ m^3/kg$

$u_x = u_f + x(u_g - u_f)$,

$= 696 + 0.921(2573 - 696)$

$= 2420\ kJ/kg$

(Sheet No. 4)

Q1: Find the missing properties among (P, T, v, u, h) together with x if applicable and give the phase of Substance:

a.	H_2O	$T = 120°C$	$v = 0.5\ m^3/kg$
b.	H_2O	$P = 100\ kpa$	$v = 0.18\ m^3/kg$
c.	H_2O	$T = 340°C$	$h = 3150\ kJ/kg$
d.	N_2	$P = 750\ kpa$	$v = 0.2\ m^3/kg$
e.	R_{12}	$P = 600\ kpa$	$h = 230\ kJ/kg$
f.	R_{22}	$T = 10°C$	$u = 200\ kJ/kg$
g.	R_{134a}	$T = 40°C$	$u = 407\ kJ/kg$
h.	NH_3	$T = 20°C$	$v = 0.1\ m^3/kg$

Q2: A water Storage tank contains Liquid and vapour in equilibrium at 110°C. The distance from bottom of the tank to the Liquid level is 8 m. What is the absolute pressure at the bottom of the tank. [218 kpa]

Q3: Saturated water vapour at 60°C has it's pressure decrease to increase the volume by 10% keeping the temperature constant. To what pressure should be expands. [18.9 kpa]

Q4:- 5kg of Steam at pressure of 4.9 bar is produced from water at 20°c. Determine the amount of heat supplied if the Steam is 0.9 dry.

[12263 kJ]

Q5:-

1 kg of water at 47.8°C is heated under constant pressure of 13.7 bar until it is converted into Steam with 111 of Superheated. Determine the quantity of heat Supplied during Superheating and the total heat.

[268 kJ , 2852 kJ]

Q6:- A tank of $2m^3$ volume contains saturated ammonia at a temperature of 40°c. the tank contains 50% Liquid and 50% Vapour by Volume. Find the Specific volume, enthalpy and internal energy of the mixture.

[$3.369 \times 10^{-3} \frac{m^3}{kg}$, 232908 kJ , 229816 kJ]