Previous Years Solved Questions & Answers

Branch : Electrical

Semister : 3rd

Theory : E.M.E.

Name of the Faculty: *N. Kar, C.K. Pathi*

CHAPTER—I

1. State 1[st] law of thermodynamics ? 2005 1(a), 2000 1(b)

Soln. If state that energy can't be created nor be destroyed, it can only transformed from one form to another form

$d\theta = du + d\omega$

2. Define and write unit of heat and work ? 2010(1-b), 2006(1-iii), 2009(1-a)

Soln. Heat : It is defined as the energy transfer without transfer of mass across system boundry , unit = Joule or Kilo Joule

Work; It is defined as the energy transfer without transfer of mass, its unit the joule or kilo joule

3. State Chalr's law ? 2010(1-a), 2006 (1-ix)

Soln. It state that of constant pressure the volume is given mass of substance is directly propersonal with absolute tempeture

Mathematically it represented

$V \alpha T$

$\Rightarrow \frac{V}{T} = C$

$\Rightarrow V_1 / T_1 = \frac{V_2}{T_2}$

4. State law's of perfect gas and PV = nRT ? 2009 (2-w)

Soln. Boyel's law

If state that temperature constant and volume mass of given substance is diversing properson to absolute pressure.

$V \alpha 1/P$ -------------(1)

Charls law

It state that at pressure constant & volume the mass of substance is directly propersonal to it absolute temp.

$V \alpha T$ ………………..(2)

Avogrodo law

It sstate that equal volume of gas under similar condition of temp. & pressure contains equal no. of molecular mass.

$V \alpha n$ ………………(3)

Combined with equation (1), (2), (3), we get

$V \alpha \frac{Tn}{p}$

$\Rightarrow PV \alpha Tn$

$\Rightarrow \frac{PV}{Tn} = C$

$\Rightarrow \frac{PV}{Tn} = Ru \quad (\because Ru = \text{Undrersal gas cons tan t})$

$\Rightarrow PV = nRuT$

RELATION BETWEEN Ru × R Difference Ru = R× M

1. A gas occupies a volume of 10.1 m^3 at a temperature of 20^oC and a pressure of 1.5 bar. Find the final temperature of the gas, if it is compressed to a pressure of 7.5 bar and occupies a volume of 0.04 m^3. [2013-W 1-C]

Ans: Given :- $V_1 = 0.1\ m^3$;

$T_1 = 20^oC = 20 + 273 = 293$ K ;

$P_1 = 1.5$ bar $= 0.15 \times 10^6$ N/m^2 ;

$P_2 = 7.5$ bar $= 0.75 \times 10^6$ N/m^2 ;

$V_2 = 0.4\ m^3$

Let, T_2 = Final temperature of the gas

We know that

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$$\therefore T_2 = \frac{P_2V_2T_1}{P_1V_1} = \frac{0.75 \times 10^6 \times 0.04 \times 293}{0.15 \times 10^6 \times 0.1} = 586K$$

$$= 586 - 273 = 313^o C$$

2. A mass of 2.25 kg of nitrogen occupying 1.5 m^3 is heated from 25^oC to 200^oC at a constant volume. Calculate the initial and final pressure of the gas. Take universal gas constant 8314 J/Kg mol K. the molecular mass of nitrogen is 28. [2014-W 1-C]

Ans: Given ; m = 2.25 kg
$V_1 = 1.5\ m^3$;
$T_1 = 25^oC = 25 + 273 = 298$ K;
$T_2 = 200^oC = 200 + 273 = 473$ K; Ru = 83 MJ/Kgm
M = 28
We know that gas constant

$$R = \frac{Ru}{M} = \frac{8314}{28} = 297 J/KgK$$

Initial pressure of the gas

Let P_1 = Initial pressure of the gas we know that
$P_1\ V_1 = MRT$

$$P_1 = \frac{MRT_1}{V_1} = \frac{2.25 \times 297 \times 298}{1.5} = 0.133 \times 10^6\ N/m^2$$

$$= 1.33\,\text{bar}\,(\text{Ars})$$

Final pressure of the gas
Let P_2 = Final pressure of the gas since the volume is constant, therefore

$$\frac{P_1}{T_1} = \frac{P_2}{T_2} \text{ or } P_2 = \frac{P_1T_2}{T_1} = \frac{1.33 \times 473}{298} = 2.11\,\text{bar}\,(\text{Ars})$$

3. One kg of ideal gas is heated 18.3°C to 93.4°C . Assuming R = 0.264 KJ/Kg K and γ = 1.18 for the gas, find : 1. Specific heats ; 2. Change in internal energy ; and 3 . change in enthalpy [2012-W 2-C]

Ans: Given : m = 1 kg ; $T_1 = 18.3 + 273 = 291.3$ K;

$T_2 = 93.4^o$ C = 93.4 + 273 = 366.4 K ;

R = 0.264 KJ/Kg K; $\gamma = C_P/C_V = 1.18$

Specific heats

C_P = specific heat at constant pressure, and

C_V = Specific heat at constant volume

Properties of perfect Gases :-

We know that

$$C_V = \frac{R}{\gamma - 1} = \frac{0.264}{1.18 - 1} = 1.47 KJ/K (Ans)$$

$$C_P = \gamma C_V = 1.18 \times 1.47 = 1.73 KJ/Kg K (Ans)$$

Change in internal energy

We know that change in internal energy

$dv = mC_V (T_2 - T_1)$ 1 × 1.47 (366.4 – 291.3)

= 110.4 KJ (Ans)

Change in enthalpy

We know that change in enthalpy

$dH = mC_p (T_2 - T_1)$ = 1× 1.73 (366.4 – 291. 3) = 130 KJ (Ans)

4. One Kg of a perfect gas occupies a volume of 0.85 M^3 at 15°C & at a constant pressure of 1 bar. The gas is first heated at a constant volume & then at a constant pressure. Find the specific heat at constant pressure of the gas. Take γ = 1.4 [2014-W 2-B]

Soln. Given M = 1 Kg ; V = 0.85 M^3 ; T = 15°C = 15+273 = 288 K;

P = 1 bar = 0.1×10^6 N/M^2 ; $\gamma = C_P/C_V = 1.4$

Specific heat of gas dt constant volume

Let C_V = specific heat of gas at constant volume

R = Characteristic gas constant we know that,

PV = mRT

$$R = \frac{Pv}{MT} = \frac{0.1 \times 10^6 \times 0.85}{1 \times 288} = 295 J/Kg K = 0.295 KJ/Kg K$$

$\therefore$ We also know that

$$C_v = \frac{R}{\gamma - 1} = \frac{0.295}{1.4-1} = 0.7375\, KJ/Kg\, K$$

Specific heat of gas at constant pressure we know that specific heat of gas at constant pressure.

C_p=1.4 C_v = 1.4 × 0.7375 = 1.0325 KJ/KgK Ans)

Q→ A cylinder contains 3 kg of air at a pressure of 300 bar and a temperature of 27°C. Find the volume of air occupied by the gas. Assume R for air as 287 J/Kg K.

Q→ A vessel of capacity 5 m^3 contains 20 kg an ideal gas having a molecular mass of 25. If the temperature of the gas is 15°C. Find its pressure

Q→ A certain gas occupies 0.15 m^3 at a temperature of 20°C and a pressure of 1.2 bar. If the gas has mass of 200 g calculate (i) Value of gas constant, and (ii) molecular mass of the gas.

Q→ A certain gas has C_p = 1.96 KJ/Kg K and C_v = 1.5 KJ/Kg K . Find its molecular mass and the gas constant . the universal gas constant is 8.315 KJ/Kg K

Q→ The volume of air at a pressure of 5 bar and 47°C is 0.5 m^3. Calculate the mass of the air, if the specific heats at constant pressure and volume are 1 KJ/Kg K and 0.72 KJ/Kg K. respectively.

Q. Relation between C_p and C_v ? 2010 (2-a) 2003 (2-i) 2011(2-a)

Ans: The 'm' kg of mass heated with constant pressures

Let m = mass of the gas

$P_1 = P_2$ = Pressure of gas (P= C)

V_1 = initial volume of gas

V_σ = final volume of gas

T_1 = initial temp. of gas

T_2 = final temp. of gas

dQ = Change of heat reply

du = change in internal energy

we know that 1st law of thermodynamtes

dQ = du + dω

$$\Rightarrow mc_p\ dT = mC_v\ dT + Pdv$$

$$\Rightarrow mC_p(t_2 - t_1) = mC_v\ (t_2 - t_1) + P(v_2 - v_1)$$

$$\Rightarrow \cancel{m} Cp(\cancel{t}_2 - t_1) = \cancel{m} C_v\ (\cancel{t}_2 - t_1) + \cancel{m} R\ (\cancel{t}_2 - t_1)$$

$$\Rightarrow C_p = C_v + R \Rightarrow C_p - C_v = R$$

$$\Rightarrow \frac{C_p}{C_v} - \frac{C_v}{C_v} = \frac{R}{C_v} \qquad \left(\therefore \frac{C_p}{C_v} = v\right)$$

$$v - 1 = \frac{R}{C_v} \qquad \Rightarrow R = C_v\ (v - 1)$$

$$\Rightarrow C_v = \frac{R}{v-1}$$

Q. State laws of perfect gas Derive $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$? 2006 (7 No.)

Ans: Boyel's law

If state that constant temperature and volume of mass of given substance is directly propersonal to absolute pressure

$V \alpha 1/p$ --------------(1)

Charl's law

If state that constant pressure and volume of given mass of a substance is directly propersonal to absolute temperature

$V \alpha T$ -----------------(2)

From equation (1) & (2), we get

$$v \alpha \frac{T}{p}$$

$$\Rightarrow pv \alpha T$$

$$\Rightarrow \frac{pv}{T} = C$$

$$\Rightarrow \frac{p_1v_1}{T_1} = \frac{p_2v_2}{T_2} \quad \text{(proved)}$$

It is also known as general gas equation.

1.a) What is the difference between universal gas constant & characteristic gas constant ?

[2014- W]

Ans: $\text{characteristic gas constant} = R = \frac{pV}{mT}$

$$\text{Universal gas constant} = R_u = \frac{PV}{MT}$$

$$m = n \times M$$

$$R = \frac{Ru}{M}$$

b) An ideal gas 0.9 kg living gas constant 2871/kg°k is heated at constant pressure of 8 bar from 30°C to 200°C if the specific heat of constant volume is 0.72 kj/kg k. Find (i) specific heat at constant pressure (ii) Total heat supplied to the gas (iii) Increase in internal energy (iv) Work done in expansion. [2014-W 1-B]

Ans: Given data

M = 0.9 kg ; R = 287 J/kg k

P_1 = 8 bar = 8×10^6 N/m^2 = P_2

T_1 = 30°C , T_2 = 200°C , C_v = 0.72 kj/kf k

(i) $C_P - C_v = R$

$\Rightarrow C_p + R + C_v$

= 28 + 0.72 = 0.287 kj/kg k + 0.72 kj/kg k

C_p = 1.007 kj/kg k

(ii) dQ = du + dw

$du = m\,C_v\,dT = m\,C_v\ (T_2 - T_1)$

$T_1 = 30^oC + 273 = 303$ K

$T_2 = 200^oC + 273 = 473$ K

du = 0.9 × 0.72 (473 – 303)

du = 110.16 kJ

$dw = pdv = p(v_2 - v_1)$

$$v_1 = \frac{mRT_1}{P_1} = \frac{0.9\times 0.287\times 303}{8\times 10^6} = 9.78\times 10^{-6}m^3$$

$$v_2 = \frac{mRT_2}{P_2} = \frac{0.9\times 0.287\times 473}{8\times 10^6} = 15.27\times 10^{-6}m^3$$

$$dw = 8\times 10^6(15.27\times 10^{-6} - 9.78\times 10^{-6})$$

dw = 43kJ

(ii) Increase in Internal energy (dv) = 110.16 kJ

(iv) Work done in expansion (dw) = 43 kJ

CHAPTER – 02

1. Define dryness fraction ? 2011 (1-b)

Ans: It is define as the ratio of mass of the actual dry steam to the mass of same quality of cued steam it is re-hated by ‘x’

$$x = \frac{ms}{ms + m\omega}$$

Let, ,x = mass of the dry steam in kg.

For dry stem $m\omega = 0$

$m\omega$ = mass of the water vapour its suspension

2. Define Latent heat of vaporization ? 2005 (1-b)

Ans: It is defined as the quality of heat required to convert 1 kg of water or its boiling point into dry saturated steam at same pressure without change of temp

It is usually denoted by h_{f_g}

Htg is also caused latent heat of vapourisation.

3. Write the expression for specific enthalpy of superheated steam ? 2007 (w) 1-a)

Ans: Sensible heat = h_f

Latent heat = h_{f_g}

For super heated steam $h = h_f + h_{f_g}$

Degree of upper heat : It is the difference between superheated temp are natural temp.

4. Define latent heat of fusion

Ans: It is defined as the amount of heat required to convert 1 gm of substance from solid to liquid state at it melting point without any change of temperature.

5. Steam engine obtain steam from a boiler at a pressure of 15 bar & 0.98 dry. It was observed that stream losser 21 KJ of heat per kg of gas at it flows through the pipe, pressure remaining constant. Calculate dryness friction of the steam at the engine and of the pipe line.

Ans: Given data

P = 15 bar

X = 0.98

Losser steam = 21 KJ

$H_1 = h_t + x\ h_{f_g} = 62.9 + (0.98 \times 2466.1)$

$= 2479.678$ KJ/kg

After steam losses

$H_2 = H_1 - 21 = 2479.678 - 21$

$= 2458.678$ KJ/kg

$H_2 = h_f + x_2\ h_{f_g}$

$\Rightarrow x_2\ h_{f_g} = h_2 - h_f$

$$x_2 = \frac{h_2 - h_f}{h_{f_g}} = \frac{2458.678 - 62.9}{2466.1} = 0.97$$

$x_2 = 0.97$

Q. 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 ?

Ans: Given P = 8 bar ; x = 0.8

Enthalpy of 1 kg of steam

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

$H_T = 720.9$ KJ/kg and $h_{fg} = 2046.5$ KJ/kg

We know that enthalpy of 1 kg of wet stem

$H = h_f + x\ h_{fg} = 720.9 + 0.8 \times 2046.5 = 2358.1$ KJ

Heat required to raise 2 kg of this steam water at 20°C we have calculated above the enthalpy on total heat required to raise 1 kg of steam from water at 0°C. Since the water, in this case, is already at 20°C, therefore Heat already in water = 4.2 × 20 = 84 KJ

∴ Heat required per kg of steam = 2358 J . 84 = 22.74.1 kJ

And heat required for 2 kg of steam = 2 × 2274.1 = 4548.2 KJ (Ans)

Q. Determine the quantity of heat required to produce 1 kg of steam at a pressure of 6 bar at a temperature of 25^oC, under the following conditions [2010-W 1-C]

1. When the steam is well having a dryness fraction 0.9.

2. When the steam is dry saturated; and

3. When it is superheated at a constant pressure at 250^oC assuming the mean specific heat of superheated steam to be 2.3 KJ/kg k.

Soln. Given p= 6 bar; $t_w = 25^oC$; x = 0.9 ; $t_{sup} = 250^oC$; Cp = 2.3 KJ/Kg k

From steam tables, corresponding to a pressure 0.56, we find that

$h_f = 670.4$ kJ/kg ; $h_{fg} = 2085$ KJ/kg and t = 158.8^oC

1. When the steam is wet

We know that enthalpy on total heat of 1 kg of wet steam,

$h = h_f + x\ h_{fg} = 670.4 + 0.9 \times 2085 = 2546.9$ kJ

Since the water is at a temperature of 25^oC, therefore Heat already in water = 4.2 × 25 = 105 kJ

∴ Heat actually required = 2755.4 – 105 = 2650.4 kJ (Ans)

When the steam is dry saturated.

2. We know that enthalpy or total heat of 1 kg of dry saturated steam,

$Hg = h_f + h_{fg} = 670.4 + 2085 = 2755.4$ kJ

∴ Heat actually required 2755.4 – 105 = 2650.4 kJ (Ans)

3. When the steam is superheated

We know that enthalpy or total heat of 1 kg of superheated steam,

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

∴ Heat actually required

= 2965.16 – 105 = 2860.16 kJ (Ans)

Q. Steam enters an engine at a pressure 12 bar with a 67^oC of superheated. It is exhausted at a pressure 0.15 bar of 0.95 dry. Find the drop is enthalpy of the steam. [2011-W 1-C]

Ans: Given data,

$P_1 = 12$ bar	P = 12 bar
$t_{sup} - t = 67^oC$	$h_f = 798.4$ KJ/kg
$P_2 = 0.15$ bar	$h_{fg} = 1984.3$ kJ/kg
Q = 0.95	

For 1 kg superheated steam,

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

$= 798.4 + 1984.3 + 2 \times 67$

$= 2916.7$ kJ/kg (Taking $C_p = 2$ kJ/kg k)

A pressure 0.15 bar,

H_f= 226 kJ/kkg. H_{fg} = 2373.2 kJ/kg

For 1 kg of wet steam

$h = h_f + x\, h_{fg} = 226 + 0.,95 \times 1984.3 = 2111$ kJ/kg

$\therefore$ Drop enthalpy of the steam = $h_{sup} - h = 2916.7 - 2111 = 805.7$ kJ/kg

Q. Determine quantity of heat required to produce 1 kg of steam at pressure of 6 bar at temp. of 25°C. under the following condition [2009-W 1-B]

(i) When the steam is wet having a dryless friction of 0.9

(ii) When the steam uis dry saturated

(iii) When the steam is superheated at a constant pressure at 250°C. Assume the mean specific heat of superheated steam to be 2.3 kgk/kJ

Ans: $Q = m\, C\, \Delta_t$

$= 1 \times 4.2 \times 25 = 105$ kJ

Given data

P = 6 bar

$t_w = 25^oC$

x = 0.9

$t_{sup} = 250^oC$

Cp = 2.3 kJ/kg k

Wet steam,

$H\, .\, h_f + h_{fg} = 670.4 + 2085 = 2755.4$ kJ

Dry saturated,

$H_g = h_f + h_{fg} = 670.4 + 2085 = 2755.4$ kJ

$= 2755.4 - 105$

$= 2650.4$ kJ

Superheated, for 1 kg of superheated steam,

$H_{sup} = h_g + C_p\, (\, t_{sup} - t)$

$= 2755.4 + 2.3\, (250 - 158.8) = 2965.\ 16$ kJ

$= 2965.16 - 105 = 2860.16$ kJ

Q. Determine the condition of steam in the following cases: [2013-W 2-c]

i) At a pressure of 10 bar and temperature 200°C

ii) At a pressure of 10 bar and volume 0.175 m^3/kg

Soln. Given : P = 10 bar ; t = 200°C ; v = 0.175 m^3/kg

Condition of steam at temperature of 200°C

i) From steam tables, corresponding to a pressure of 10 bar,

We find that

$V_g = 0.194\ m^3/kg$; $h_f = 762.6$ kJ/kg; and $l = 179.9^oC$

Since the saturation temperature at 10 bar is (179.9^oC) or lower than the given temperature of the steam (200^oC), There fore the given steam is superheated. The degree of superheat = 200 — 179.9 = 201^oC (Ans)

ii) Condition of steam at a volume of 0.175 m^3/kg

Since the volume of given steam (0.175 m^3/kg) is less than the specific volume of the dry saturated steam (0.194 m^3 /kg), therefore the given steam is wet. The dryness-fraction of steam.

$$x = \frac{0.175}{0.194} = 0.902 \qquad \text{(Ans)}$$

Q. Stream enters an engine at a pressure of 12 bar with a 67^oC superheat. It is exhausted at a pressure of 0.15 bar and 0.95 dry. Find the drop in enthalpy of the steam.

Soln. Given $P_1 = 12$ bar, $t_{sup} – t = 67^oC$; $P_2 = 0.15$ bar ; $x = 0.95$

From steam tables corresponding to a pressure of 12 bar, we find that

$H_f = 798.4$ kJ/kg ; $h_{fg} = 1984.3$ kJ/kg We know that enthalpy or total heat of 1 kg of superheated steam,

$h_{sup} = h_f + h_{fg} + C_p\ (t_{sup} – t) = 798.4 + 1984.3 + 2 \times 67$

2916.7 kJ/kg (Ans)

Similarly, from steam tables corresponding to a pressure of 0.15 bar, we find that

$h_f = 226$ kJ/kkg ; $h_{fg} = 2373.2$ kJ/kg

we know that enthalpy or total heat of 1 kg of wet

steam,

$h = h_f + x\ h_{fg} = 226 + 0.95 \times 1984.3 = 211$ kJ/kg

$\therefore$ Drop in enthalpy of the steam

$= h_{sup} – h = 2916.7 – 211 = 805.7$ kJ/kg (Ans)

Q. A steam engine obtains steam from a boiler at a pressure of 156 bar 0.98 dry. Jt was observed that the steam loses 21 kJ of heat per kg as is flows through the pipe (ire, pressure remaining constant . Calculate dryness fraction of the steam, as the engine end of the pipeline) [2014-W 3-C]

Soln. Given : P = 15 bar ; x = 0.98 ; heat 1055 = 21 kJ/kg

From steam tables, corresponding to a pressure of 15 bar, we find that

$h_f = 844.6$ kJ/kg ; $h_{fg} = 1945.3$ KJ/kg

We know that enthalpy of wet steam at the boiler end,

$H_1 = h_f + x\ h_{fg} = 844.6 + 0.98 \times 1945.3 = 2751$ kJ/kg

Since the steam loses 21 kJ/kg of steam, therefore enthalpy of wet steam at the engine end,

$H_1 = 2751 - 21 = 2730$ kJ

X_2 = Dryness fraction of steam at the engine end.

Let Since the pressure remains constant therefore h_f and h_{fg} is same, we know that

$H_2 = h_f + x_2 h_{fg}$

$2730 = 844.6 + x_2 \times 1945.3$ or $x_2 = 0.977$ (Ans)

2.a) What is meant by saturation temperature and saturation pressure ? [2014 – W]

Ans: saturation temperature at the temperature in which the temperature can be calculated at saturation line and the pressure is calculated at saturation pressure line.

b) Calculate the internal energy per kg of superheated steam, at a pressure 10 bar and temp of 300°C. If the steam is expanded to 1.9 bar and dryness fraction 0.8. Find the change of Internal energy

Soln.: Given data

$P_1 = 10$ bar $T_{sup} = 300^oC$

$P_2 = 1.4$ bar, dryness fraction (x) = 0.8

Assume $C_p = 2.1$ kJ/kg k

From steam tables, corresponding to a pressure of 10 bar, we find that hf = 762.6 kj/kg, $h_{fg} = 2013.6$ kJ/kg , $V_g = 0.1943\ m^3/s$ and $t = 179.9^oC$.

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

$= 762.6 + 2013.6 + 2.1 (300 - 179.9)$

$= 3028.41$ kJ/kg

$$V_{sup} = Vg \times \frac{T_{sup}}{T} = 0.1943 \times \frac{(300+273)}{(179.9+273)} = 0.246\, m^3/kg$$

Internal energy of superheated steam

$U_{sup} = h_{sup} - 100 \times P_1 \times V_{sup}$

$= 3028.41 - 100 \times 10 \times 0.246$

$= 2782.41$ kJ/kg

The superheated steam now expanded to a pressure of 1.4 bar . From steam tables corresponding to a pressure 1.4 bar, we find that

$h_f = 458.4$ kJ/kg. $h_{fg} = 3321.9$ kj/kg

$V_g = 1.2363\ m^3/kg$

Internal energy of the expanded steam

$U_e = h_f + x\, h_{fg} - 100 \times p_2 \times x \times v_g$

$= 458.4 + 0.8 \times 2231.9 - 100 \times 1.4 \times 0.8 \times 1.2363$

$= 2243.92 - 138.4656$ $= 2105.4544$ kj/kg

Change in internal energy $= U_{sup} - U_e = 676.95$ kj/kg

c) (iii) Total Heat of steam [2014-W]

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

Total heat of steam = Sensible heat + Latent heat

CHAPTER : - 3

Q.1. What is the function of safety valve 2007 (1-b)

- These are the devices which function is to release the excess steam when the pressure inside the boiler exceeds the rated pressure.
- A steam boiler is usually provided with two safety valve.

Q.2. What is the function of fire pre-heater 2007 (1-R)

- It is used to recover heats from exhaust flue gases.
- It is installed between econemiser & chimney
- It results is better combustion with less smoke & ash.

Q.3. What do you mean by boiler mounting 2009 (1-c)

Ans: These are the fitting which are mounted on the boiler for the operation & safety of a boiler. The various types of boiler mounting are :

(i) safety value

(ii) stop value

(iii) Water level indicator

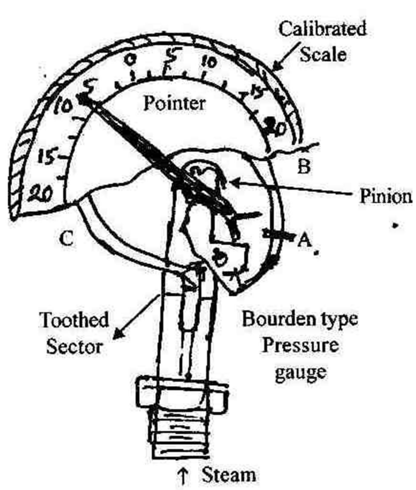
(iv) Blow of cock

(v) Main hole

(vi) Fusible Plug

Q What is burden tube pressure Gauge

Ans:



A pressure gauge is used to measure the pressure of the steam inside the steam boiler . It is fixed in front of the steam boiler. The pressure gauges generally used are of Bourdon type.

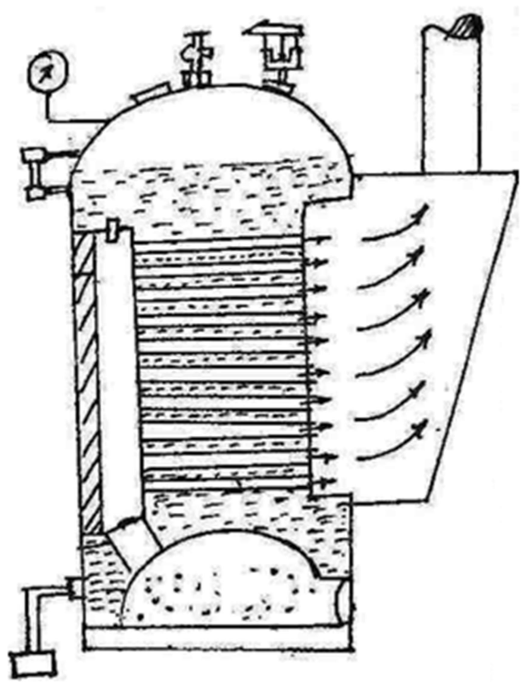
A bourdon pressure gauge, in its simplest form consists of an elliptical elastic tube. ABC bent into an arc of a circle, as shown in figure. |this bent up tube is called Bourdon tube.

One end of the tube gauge is fixed and connected to the steam space in the boiler. The other end is connected to a sector through a link. The steam under pressure, flows into the tube. as a result of this increased pressure, the Bourdon tube tends to straighten itself. Since the tube is encased in a circular curve, therefore it tends to be come circular instead of straight with the help of a simple pinion and sector arrangement, the elastic deformation of the Bourdon tube rotates the point the pointer moves over a calibrated scale, which directly gives the gauge pressure.

Q. Difference between water tube Boiler and Fire tube Boiler. [2013-W 3-C]

WATER TUBE BOILER	FIRE TUBE BOILER
i) In this type of Boiler water circulates inside the tube which are surrounded by hot gases	i) In this type of boiler the hot gases flow inside the tube which are surrounded by the water.
ii) The raising of steam is more rapid	ii) The raising of steam is less rapie
iii) the generates steam at a high pressure upto 165 bar	iii) It generates steam at low pressure upto 24.5 bar
iv) The rule of Generation of steam is high i.e. upto 450 tone per hour	iv) The rate of Generation of steam is low i.e. upto 9 tone per hour.
v) Less floor area is required	v) Move floor area is required.
vi) It's construction is simple	vi) It's construction is complicated
vii) Overall efficiency with economizer is 90 %	vii) Overall efficiency with economizer is 75 %
viii) Transportation is easy	viii) Transportation is difficult
ix) The direction of water circulation is well defined	ix) The water doesn't circulate in a definite direction
x) operating cost is high	x) Operation cost is low
xi) Bursting chances is more	xi) Bursting chances is less
xii) It is used for large power plant	xii) It is used for small power plant
xiii) Externally fire tube boiler are water tube boiler	xiii) Internally fire tube boiler are five tube boiler
xiv) Example :- Babcock, Wilcox Boiler La-mont Boiler	xiv) Example:- Cochran boiler, simple vertical boiler

Q. With neat sketch explain the working of Cochran Boiler [2014-W 3-C]

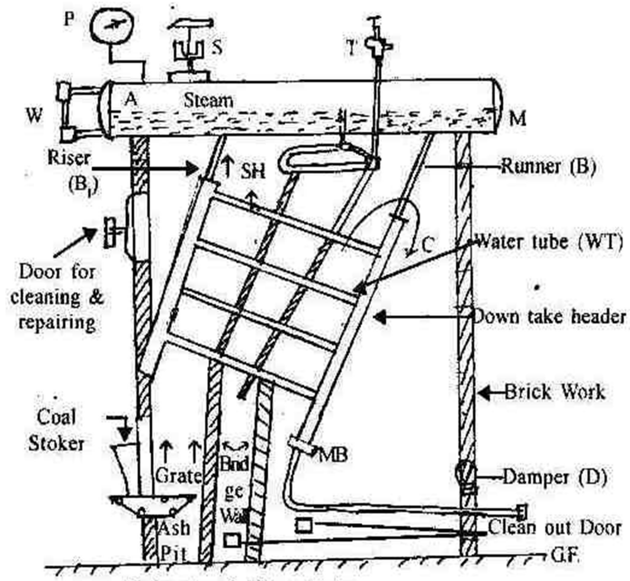


1. The Cochran boiler belongs to fire tube Boiler
2. In this type of Boiler the hot gases circulate the tube which are surrounded by water
3. It is a simple vertical Boiler
4. the boiler consists of external cylindrical shell on the fire box.
5. the shell & the fire box both are hemispherical in shape
6. the shell in the fire box can withstand the pressure of the steam inside the Boiler.
7. The fire box & combustion chamber is connected through a short pipe.
8. The hot gases from the combustion chamber flow to the smoke box through the no. of smoke tubes.
9. These tubes are generally 62.5 mm in external diameter and 165 in numbers
10. These not gases from this smoke box pass to the atmosphere through the chimney.
11. A main – hole near the top of the upper shell is used for cleaning & repairing purpose.
12. At the bottom of the fire box there is a grate and coal is feeded through the fire hole.
13. In this type of Boiler the steam generate upto 24.5 bar of pressure
14. These boiler are required less skill for efficient & economical.

Q. With neat sketch explain the working of Babcock Wilcox Boiler ? [2013-W 3-C]

Ans.

1. The Babcock Wilcox boiler bebrage to water tube boiler.
2. It is a horizontal multi-tubular , stationary type water tube boiler.
3. It is the most popular type of water tube boiler employed for large circular small power station.
4. It consists of large no. of parallel tubes inclined at an angle which varies from 5 to $15^{o}C$ to the horizontal.
5. These tube consists of uptake & down take header.



Babcock and Wilcox Boiler

6. These two heads are connected to the shell or reservoir or pond having a required quantity of water inside it.
7. The uptake header is connected to the reserve through a short tube & down take header through a long tube.
8. The coal is feed to the boiler through it fire hole.
9. The direction of the flow of water is shown in the figure.
10. The water circulate from, the reservoir into the uptake header & through the tube to the down take header & again to the shell.
11. Water continue circulating like this till vaporized.
12. The steam generate above the water leave in the drum flows through the dry pipe.
13. It passes through the tube in the circulated steam box.
14. The boiler is fitted with useful mounting such as safety valve, stop valve, water level indicator & pressure gauge.
15. It generate steam at a pressure of 165 bar

16. The rate of generation of steam is 450 tone per hour.
17. It can be transferred easily.
18. The direction of the water circulation is well defined.
19. Bursting chances are more.
20. Operating cost is more.
21. Over all efficiency with economise3r is 90 %.
22. For a given power the floor area required from the generation of steam is less.

Q. With neat sketch explain Air pre heater [2011-W 3-C]

Ans:

a) The function of the air pre-heater is to increase the temperature of air before of enters the furnace.

b) it is used to recover heat from the exhaust flue gases.

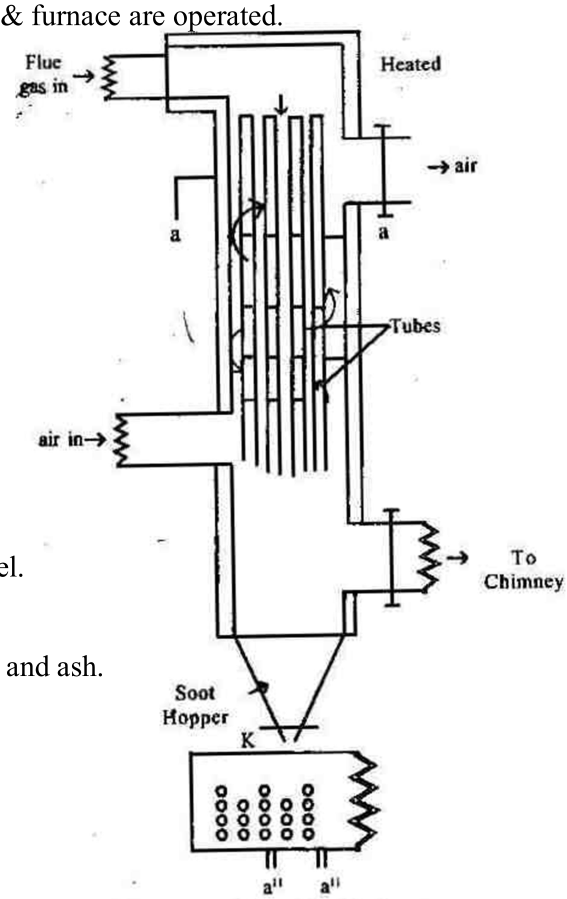
c) It is instated between the economizer and the chimney.

d) After leaving the boiler on economizer the gas products at combustion travel through the inside of the tubes of air pre-heater in a direction opposite to head to air travel & transfer some of their heat to the air to be supplied to the furnace.

e) Thus the air gets initially heated before being supplied to the furnace.

f) Degree of preheating depends upon (i) Type of fuel (ii) Type of fuel burning equipment (iii) Rating at which the boiler & furnace are operated.

g) There are 3 types of air pre-heater
   (i) Tubular type
   (ii) Plate type
   (iii) Storage type



Recuperature Type of Air Pre-heater.

ADVANTAGES:

a) It increases evaporative capacity per kg of fuel.

b) it increases 2 % in the boiler efficiency.

c) Results in better combustion with less smoke and ash.

3.a) Differentiate between mountings and accessories. [2012-W 3-B]

Mounting:-

These are the fitting, which are mounted on the boiler for its proper and safe fume timing

Ex- pressure gauge, safety valve, stop valve

Accessories:-

These are the device which are used as integral points of a boiler and help in running efficiently

Ex- Feed pump, superheater, Economiser Air pre-heater

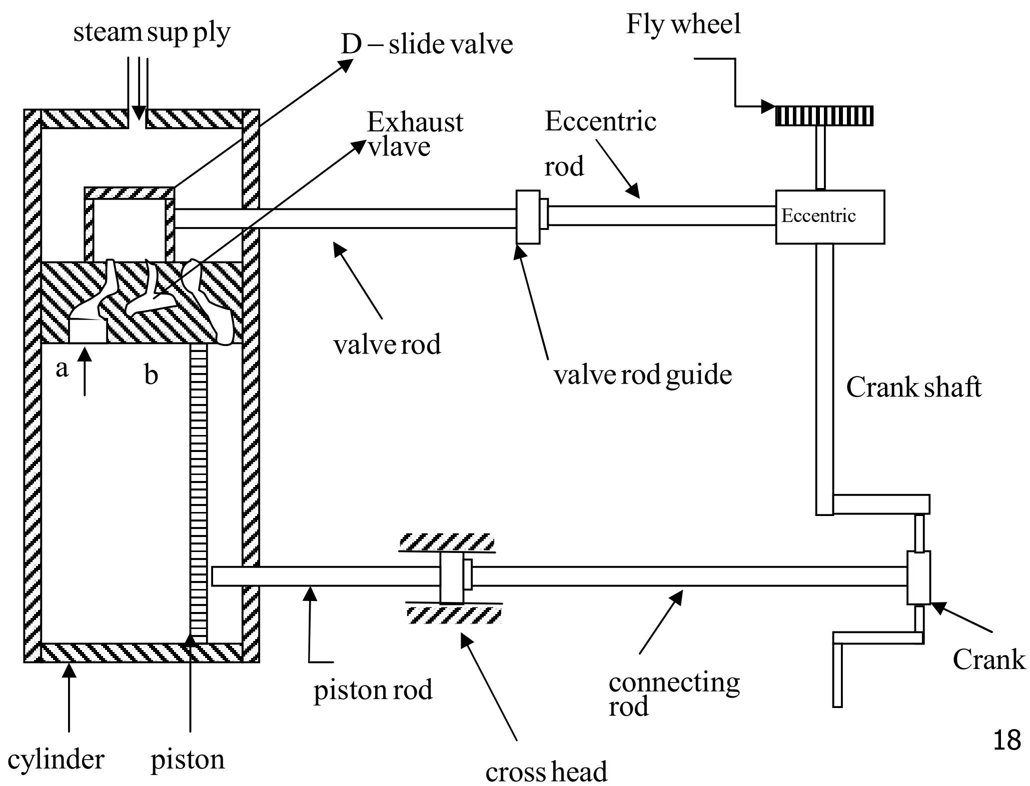
CHAPTER : 4

Q. Working of a single cylinder double acting horizontal reciprocating steam engine.

(2012 W 5-C)

Ans: The principal parts of a single cylinder , double acting horizontal reciprocating steam engine are shown in fig.

The superheated steam at a high pressure (about 20 atmosphere) from the boiler is led into the steam chest. After that the steam makes it way into the cylinder through any of the parts 'a' or 'b' depending upon the position of the D-slide valve. When part 'a' is open, the steam rushes to the left side of the piston & forces it to the right. At this stage, the slide valve covers the exhaust part & the other steam part 'b' as shown in fig. Since the pressure of steam is greater on the left side than that on right side, the piston moves to the right..

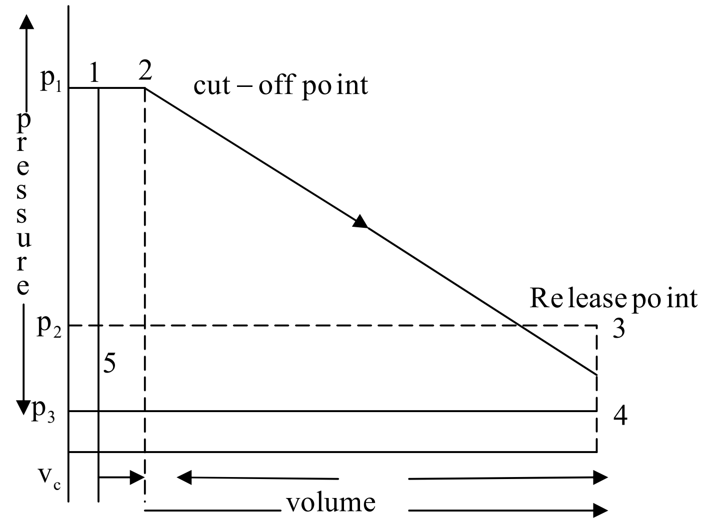


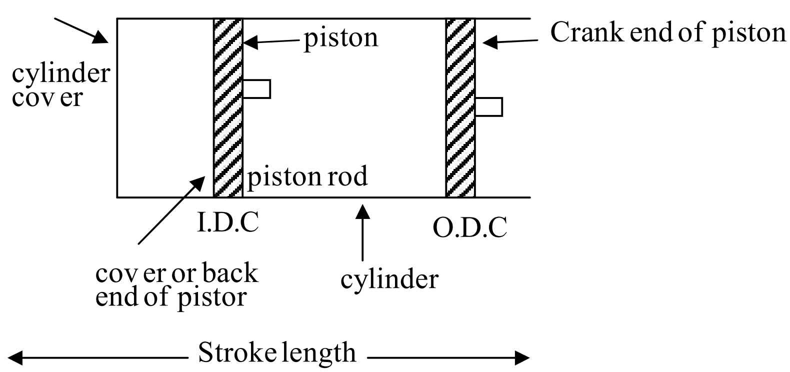
SINGLE CYLINDER DOUBLE ACTING HORIZONTAL RECIPROCATING STEAM ENGINE

When the piston reaches near the end of the cylinder, it closes the steam port ‘a’ & exhaust port. The steam port ‘b’ is now open & the steam rushes to the right side of the piston. This forces the piston to the left & at the same time the exhaust steam goes out through the exhaust pipe & thus completes the cycle of operation. The same process is repeated in other cycles of operation & such the engine works.

Q. Important terms used in Steam Engine

Ans: The theoretical indicator diagram for a simple steam engine in shown in fig. The following are some important terns used in steam engines.





i) Bore:- the internal diameter of the cylinder of the engine is known as bore.

ii) Dead centres:- the extreme position of the piston inside the cylinder during its motion are known as dead centres. There are 2 dead centres.

(a) Inner dead centre (T.D.C)

(b) Outer dead centre (O.D.C.)

In a horizontal engine, the inner most position of the piston is known as inner dead centre, where as the outer most position of the piston towards the crank end is called outer dead centre, as shown in fig.

iii) Clearance Volume : - The volume of space between the cylinder cover & the piston, when the piston is at T.D.C. position is called clearance volume (v_c) . It is usually represented as a percentage of stoke volume.

iv) Stroke volume:- The volume swept by the piston when it moves from T.D.C. to O.D.C. is known as stroke volume (v_s). It is also known as piston displacement mathematically, stroke volume

$vs = \pi/4 \times D^2 \times l$

D = Bore or internal diameter of the cylinder

L= Length of the stroke

v) Cut off volume:- Theoretically, the steam from the boiler enters the clearance space & pushes the piston outward doing external work.

vi) Average piston speed :- The distance travelled by the piston per unit time is known as average piston speed. Mathematically

Average piston speed → LN M/min, for single acting steam engine

= 2LN/M/min, for double acting steam engine

Where L = length of the stroke in mtrs.

N = speed in R.P.M.

vii) Mean effective pressure:- The average pressure on the piston during the working stroke is called mean effective pressure. It is given by the mean depth of the P-V diagram.

Mathematically

$$PM = \frac{\text{workdone per cycle}}{\text{Stroke Volume}}$$

4.a) State the classification of steam engine

Ans: According to no. of working strokes

a) Single acting (b) Double acting

According to the position of the cylinder

(a) Horizontal steam engine (b) Vertical steam engine

According to the speed of the crank shaft

(a) Slaw speed steam engine (b) Medium steam engine

(c) High speed steam engine

According to the type of exhaust

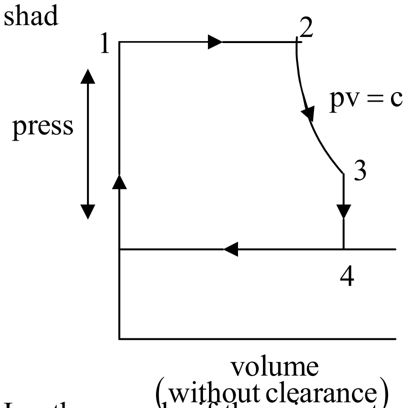
(a) Condensing steam engine (b) non-condensing steam engine

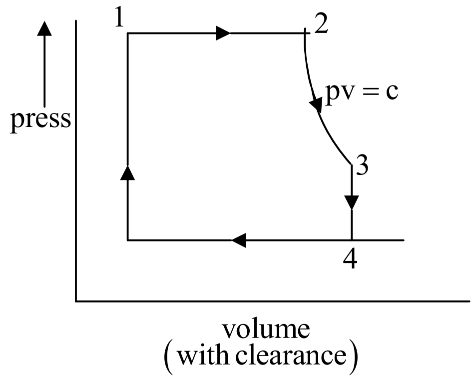
According to the expansion of the steam in the engine cylinder

(a) Simple steam (b) Compound steam

b) What do you understand by hypothetical indicator diagram ? Derive an expression to determine hypothetical mean effective pressure without clearance.

Ans: the teonstical or hypothetical indicator diagram without clearance and with clearance is shad





In other words, if there is no steam in the cylinder (or there is zero volume of steam at pt. If there is some steam in the cylinder at pt l.

Mean effective pressure:

P_1 = Initial pressure of steam

P_b = Back pressure

V_2 = volume of steam in the cylinder at the pt. of Cut-off

V_3 = Stroke volume of swept volume

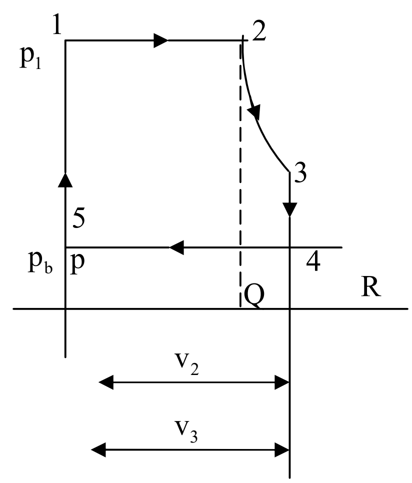
Hypothetical work done per cycle

= Area of figure (123451)

= Area 12 QP + area 23 RQ – Area 4 SPR

$= P_1V_2 + 2.3\ P_1\ v_2 \log (V_3/V_2) - P_b\ v_3$

Hypothetical mean effective pressure



$$p_m = \frac{\text{work done per cycle}}{\text{Stroke Volume}} = \frac{P_1 v_2 + 2.3 P_1 V_2 \log\left(\frac{v_1}{v_2}\right) - p_b v_3}{v_3}$$

$$= p_1 \times \frac{v_2}{v_3} + 2.3 p_1 \times \frac{v_2}{v_3} \log\left(\frac{v_3}{v_2}\right) - p_b = \frac{p_1}{r}(1 + 2.3 \log r) - p_b$$

c) Determine the stroke and diameter of a double acting steam engine cylinder developing 180 kw under the following condition

i) Initial steam pressure 7 bar

ii) Back pressure 1.12 bar

iii) Crank speed 100 rpm

iv) Average piston speed 135 m/min.

v) Diagram fector 0.8

vi) Cut off at 0.4 of the stroke

Ans: Given data

I.P = 180 kw., P_1 = 7 bar, P_b = 1.12 bar

N = 100 rpm, avg, piston speed = 135 m/min

K = 0.8 , $v_2 = 0.4\ v_3$

Stroke of the cylinder

L= length of the stroke in metres

Average piston speed = 2 L N = 135 or $L = \frac{135}{2N} = \frac{135}{2\times100} = 0.675$

Diameter of the cylinder:

D = dia. of the cylinder in metres

$$\text{Area}\,(A) = \frac{\pi}{4}\times D^2 = 0.7854\,D^2 m^2$$

1st we find the actual mean effective pressure (pa)

$$\text{expansion ratio, } r = \frac{v_3}{v_2} = \frac{v_3}{0.4}\ v_3 = 2.5$$

$$P_m = \text{mean effective pressure} = \frac{p_1}{r}(1+2.3\log r) - p_b$$

$$= \frac{7}{2.5}(1+2.3\log 2.5) - 1.12 = 4\,\text{bar}$$

$$P_a = \text{act. mean effective pressure} = P_m \times K = 4\times0.8 = 3.2\,\text{bar}$$

$$I.P = \frac{200\times p_a\times LAN}{60} = \frac{200\times3.2\times0.675\times0.7854n^2\times100}{60}$$

$$180 = 565.5\,D^2$$

$$D^2 = 0.318 \qquad \Rightarrow D = 0.564$$

CHAPTER : 5

Q Difference between Impulse turbine & Reaction turbine [2014-W 5-C]

IMPULSE TURBINE	REACTION TURBINE
i) The steam flows through the nozzle & strikes the moving blade	i) The steam flows first through the guide mechanism & then pass through the moving blade
ii) The blade manufacturing is not difficult	ii) Blade manufacturing is difficult
iii) The steam may or may not be admitted over the whose surface	iii) the steam must be admitted over the whole surface
iv) The steam pressure remains constant during its flow through the moving blade	iv) The steam pressure is reduced during its flow through the moving blade
v) The relative velocity of steam remains constant	v) The relative velocity of steam increase
vi) Blade are symmetrical	vi) Blade are not symmetrical
vii) More power can't be developed	vii) More power can be developed
viii) Require less space for same power	viii) Requires more space for same power

5. What is turbine ? How does it difference steam engine ?

Ans: A turbine is a prime mover in which rotary motion is obtained by the gradual change of momentum of the steam. The basic principle of operation of a steam turbine is the generation of high velocity steam jet by the expansion of high pressure steam and then conversion of kinetic energy so obtained into mechanical work on rotor blades.

Turbine different from steam engine

i. Steam turbine may develop higher speed and a greater steam range is possible

ii. efficiency of a steam turbine is higher

iii. Steam consumption miss less

iv. There is less frictional loss due to fewer sliding points

v. The applied torque is more uniform to the driver shaft.

vi. A steam turbine requires less attention during running, More over, the repair costs are generally less

viii. All the moving parts are enclosed in a calling, the steam turbine is comparatively safe.

CHAPTER:6

Q Difference between Jet condenser & surface condenser [2013-W 6-B]

JET CONDENSER	SURFACE CONDENSER
i) Cooling water & steam are mixed up	i) Cooling water & steam are not mixed up
ii) Low manufacturing cost	ii) High manufacturing cost
iii) It require small floor area	iii) It require large floor area
iv) Less suitable for high capacity plant	iv) more suitable for high capacity plant
v) Condensate is wasted	v) condensate is reused
vi) It requires less quantity of circulating water	vi) It requires more quantity of circulating water
vii) The condensing plant is economical & simple	vii) The condensing plant is costly & complicated
viii) It's maintenance cost is law	viii) It's maintenance cost is high
ix) more power is required for water pumping	ix) Less power is required for water pumping
x) more power is required for air pump	x) Less power is required for air pump

c) **State the different types of condenser and explain its functions**[2013-W 6-C]

Ans: A steam condenser is closed vessel into which the steam is exhausted, and condensed after doing work in an steam engine or steam turbine.

Function of Condenser: **A steam condenser has the following two objects**

(i) The primary object is to maintain a law pressure (below atmospheric pressure) so as to obtain the maximum possible energy from steam and thus to secure a high efficiency.

(ii) The secondary object is to supply pure feed water to the hot well, from where it is pumped back to the boiler. This reduces feed water treatment considerably.

Thus, the thermal efficiency and capacity of the steam plant are greatly increased by fitting a condenser.

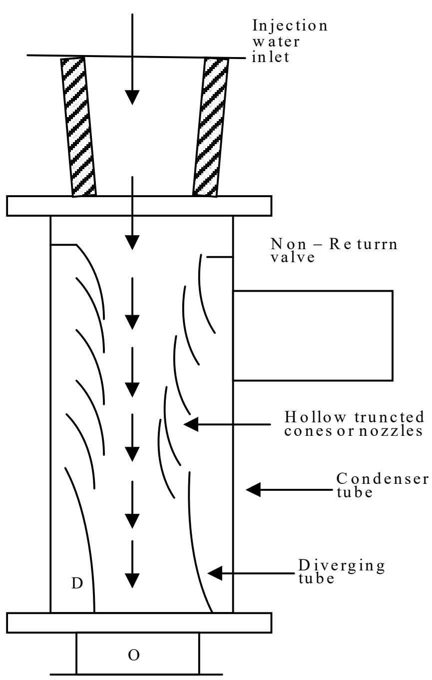
Different types of Condenser:

The Steam Condenser may be broadly classified into the following two types (i) Jet Condenser (ii) surface condensers. According to the method employed to cool the exhaust steam.

In case of Jet Condenser, the cooling water will mix with the exhaust steam. Due to the direct contact of the exhaust steam with the cooling water it condenses at the heat flows from it to the cooling water. Jet Condenser may be used at places where water of good quality is easily available in sufficient quantity. The classification of jet condenser is given below.

(a) Parallel flow jet condenser (b) Counter flow jet condenser (c) Barometric or high level jet condenser and (d) Ejector condenser.

In case of surface condenser, the cooling water and the exhaust steam are separated by a metal plate which prevents their mixing. Condensation takes place as the heat is transferred from the exhaust steam to the cooling water through the metal plate. It may be classified as (a) Down flow surface condenser (b) Central flow surface condenser (c) Regenerative surface condenser and (d) Evaporative condenser.



The working of Ejector condenser is given below . An ejector condenser is suitable for moderate vacuum only. In this type of Condenser cooling water is discharged through a series of convergent nozzles causing partial vacuum by conversion of potential energy to kinetic energy. The condenser consists of cast iron tube fitted with a number of Co-axial nozzles [C]. The cooling water enters the condenser tube through the inlet (W) as shown in the figure and flow through the co-axial nozzles [C] fitted in the tube in which there are steam parts leading into the spaces between the cones. The water enters under a head of 6 meters and in pushing through the cones creates a vacuum surrounding the space between the cones. Due to the vacuum the exhaust steam from the engine cylinder enters the condenser tube through the inlet [S] and the non-return Valve[V] and mixes with the water flowing through the cones. Then the steam being condensed, increases the vacuum. This draws in more steam from the cylinder into the nozzles through the space between them. The condensed steam and air after flowing through the divergent nozzle levels the condenser through the outlet.

The non-return valve is used to prevent the water from flowing into the engine cylinder in case of failure of cooling water supply

CHAPTER:7

Q. If the combustion of fuel takes place inside the engine cylinder, then it is known as I.C. engine. [2013-W 7-B]

Classification:

i)	According to type of fuel used	(a)	petrol engine
		(b)	Diesel engine
		(c)	Gas engine
ii)	According to method of ignition	(a)	Spark ignition
		(b)	Compression ignition
		(c)	Spot ignition
iii)	According to number of stroke	(a)	Two stroke
		(b)	Four stroke
iv)	According to the cycle of engine	(a)	otto cycle
		(b)	diesel cycle
		(c)	Dual cycle

v) According to the speed of engine (a) slow (b) medium (c) high

vi) According to method of cooling (a) Air cooling (b) Water cooling (c) Evaporative cooling

vii) method of fuel injection (a) carburetor injection (b) Air fuel injection

viii) According to the no of cylinder (a) single cylinder (b) multi cylinder

ix) According to the arrangement of cylinder (a) Vertical (b) horizontal (c) inclined

x) According to the have mechanism (a) over head valve (b) side valve

xi) According to ht method of governing (a) Qualitatively (b) quantitatively

1. Difference between Two stroke Engine & Four stroke Engine. [2014-W 7-C]

TWO STROKE ENGINE	FOUR STROKE ENGINE
a) There are ore working stroke for each revolution of the crank shaft.	a) There are one working stroke for each two revolution of the crank shaft.
b) It is mostly single cylinder engine.	b) It is mostly multi cylinder engine
c) Engine is lighter	c) Engine is heavier
d) Engine designer is simple	d) Engine design is complicate
e) It is air cooled	e) It is water cooled.
f) Fuel consumption per KW power develop is more	f) Fuel consumption per KW power develop is less.
g) It consume more lubricating oil.	g) It consume less lubricating oil

2. Difference between SI Engine & CI Engine [2011-W 7-B]

S.I. ENGINE	C.I.ENGINE
a) It is also called spark ignition engine	a) It is also called compression ignition engine
b) It work on Otto cycle	b) It work on diesel cycle.
c) A petrol engine draws a mixture of petrol & air during suction stroke	c) A diesel engine draws only air during suction stroke
d) A carburetors is used to mix the air & petrol	d) An injector or auto miser is used to inject the fuel.
e) A spark plug is used to ignite the charge	e) Ignition takes place due to high pressure and temperature
f) Pressure at the end of the compression is about 10 bar	f) Pressure at the end of the compression is about 35 bar.
g) It has compression ratio 6 – 10	g) It has compression about 15 – 25
h) Starting is easy	h) Starting is not easy
i) It is lighter and cheaper	i) It is heavier and costly
j) Running cost is high because of high cost of petrol	j) Running cost is low because of low cost of diesel
k) It's maintenance cost is less	k) It's maintenance cost is more
l) Thermal efficiency is about 26 %	l) Thermal efficiency is about 40 %
m) Over heating trouble is more due to low thermal efficiency	m) Over heating trouble is less due to high thermal efficiency
n) these are high speed engine	n) These are low speed engine
o) Petrol engine are generally employed in light vehicle like motor cycle, scooters etc.	o) these diesel engine are generally employed in heavy vehicle like bus, truck, car etc.

Q. With neat sketch of four stroke cycle petrol Engine. Explain: [2014-W 7-B]

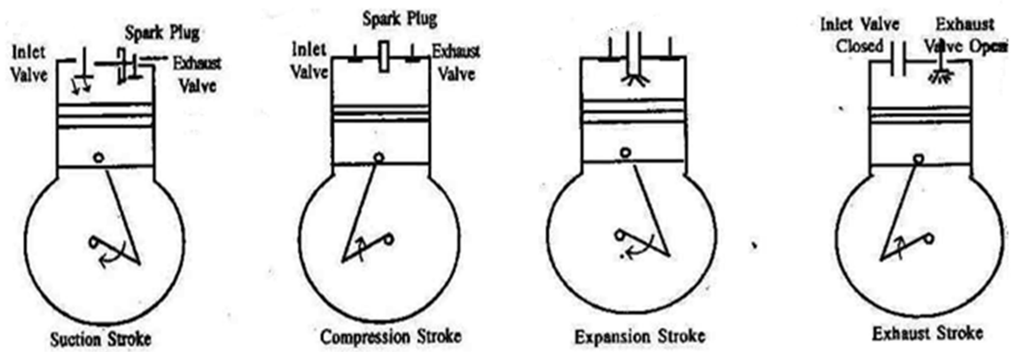
Ans: It is also knows as Otto cycle. It requires four strokes of the piston to complete one cycle of operation in the engine cylinder. The four strokes of a petrol engine sucking fuel air mixture (petrol mixed with proportionate quantity of air in the carburetor known as charge) are described below.

a) **Suction or charging stroke**

In this stroke, this inlet valve opens and charge is sucked into the cylinder as the piston moves downward from top dead centre (T.D.C) It continuously the piston reaches its bottom dead centre (B.D.C)

b) **Compression stroke**

In this stroke, both the inlet and exhaust valves are closed and the charge is compressed as the piston moves upwards from B.D.C to T.D.C. As a result of compression, the pressure and temperature of the charge increase considerably (the actual valves depend upon the compression ratio). This completes one revolution of the crank shaft. The compression stroke is shown in fig.



c) **<u>Expansion or working stroke</u>**

Shortly before the piston reaches T.D.C. (during compression stroke), the change is ignited with the help of spark plug. It suddenly increases the pressure and temperature of the products of combustion but the volume, practically remains constant. Due to the rise in pressure , the piston is pushed down with a great force. The hot burnt gases expand due to high speed of the piston. During this expansion, some of the heat energy produced is transformed into mechanical work.; It may be noted that during this working stroke, as both the valves are closed and piston moves from T.D.C. to B.D.C.

d) **<u>Exhaust Stroke</u>**

In this stroke the exhaust valve is open as piston moves from B.D.C. to T.D.C. This movement of the piston pushes out the products of combustion, from the engine cylinder and are exhausted through the exhaust valve into the atmosphere, as figure. This completes the cycle and the engine cylinder is ready to suck the charge again petrol engine are usually employed in light vehicles such as Cars, Jeeps and Aeroplanes.

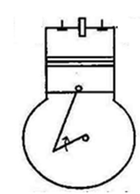
6.b) Explain with help of suitable sketched the working a 4-stroke cycle and a two stroke cycle diesel engine.

Ans: **4 – stroke diesel engine**

It is also known as compression ignition engine because the ignition takes place due to the heat produced in the engine cylinder at the end of compression strokes.

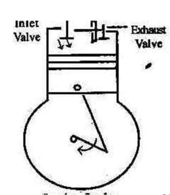
i) **Suction Stroke**

In this stroke, the inlet valve opens and pure air is sucked into the cylinder as the piston masses down wards from the top dead centre (TDC). It continues till the piston reaches its bottom dead centre



ii) **Compression stroke**

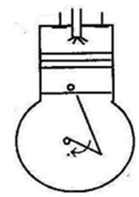
In this stroke, both the valves are closed and the air is compressed as the piston moves upwards from BDC to TDC. As a



result of compression, pressure and temp. of the air increases considerably. This complete are revolution of the crank- shaft.

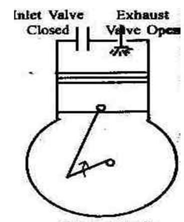
iii) **Working stroke**

Before the piston reached the TDC, fuel oil is injected in the form of very fine spray into the engine cylinder through the nozzle, known as fuel injection valve. At this moment, temp. of the compressed air is sufficiently high to light the fuel. It suddenly increase the pressure & temp. of the products of combustion. The fuel oil is continuously injected for a friction of the revolution. The fuel oil is assumed to be burnt of constant pressure due to one pressure, the piston is pushed down with a great force. Both the valves and closed and the piston moves from TDC to BDC


Expansion Stroke

Exhaust Stroke

In this stroke, the exhaust valve is open as the piston moves from BDC to TDC. This movement of the piston pushes out the products of combustion from the engine cylinder through the exhaust valve into the atmosphere. This complete the cycle and the engine cylinder is ready to break the fresh air again.



Exhaust Stroke

TWO STROKE CYCLE DIESEL ENGINE

i) **Suction Stage : -**

In this stage, the piston while moving down downwards BDC uncovers the transfer part and then exhaust point. The fresh air flows into the engine cylinder from the Crank case.

ii) **Compression Stage.**

In this stage, the piston while moving up, 1st covers the transfer point and then exhaust point. After that the air is compressed as the piston moves upwards . In this stage the inlet point opens and the fresh air enters in the crank case.

iii) **Expansion stage**

Before the piston reaches the TDC, the fuel oil is injected min the form of very fine spray into the engine cylinder through the nozzle. At this moment the temp. of the compressed air is sufficiently high to ignite the fuel. It suddenly increases the prime and temp of the product of combustion. During the expansion, some of the heat engine produced is transformed in to mechanical work.

iv) **Exhaust stage.**

In this stage, the exhaust point is opened and the piston moves down words. The products of combust from the engine cylinder are exhausted through the exhaust point into the atmosphere.

6.a) What is the difference between internal combustion engine and external combustion engine ? [2014 –W]

E.C. Engine	I.C. Engine
i) The combustion of fuel takes place out side the engine cylinder ii) the working pressure and temp. inside the engine cylinder is law iii) It can not be started instantaneously	i) The combustion of fuel takes place inside the engine cylinder ii) the working pressure and temp. inside the engine cylinder is very high iii) It can be started instantaneously

CHAPTER: 8

Q. Properties of Fluid. [2015-W 8-A]

Ans: Fluid means a liquid or gas fluid offers no of resistance to the change of shape

Fluid machines is that branch of physical science which deals with the action

Of a fluid while it is at rest or in motion.

Properties of a Liquid

The basic properties of a liquid are

i) Density

ii) Specific weight

iii) Specific volume

iv) Specific gravity

v) Incompressibility

vi) Viscosity

vii) Cohesion

viii) Adhesion

ix) Surface tension

x) Capillarity

xi) Vapour pressure

Density:

Density of a liquid is the mass per unit volume of the liquid

So, density of a liquid is given by $\rho = M/V$

Where M = mass of the liquid

V = volume of the liquid

In M.K.S. and S.I. unit both density is expressed in Kg/M^3

Specific weight

Specific weight of a liquid is the weight per unit volume of the liquid

So specific weight of a liquid is given by

W = w/v

Where w = weight of the liquid

V= volume of the liquid

In M. K.S units, specific weight is expressed in kgf/m^3 and S.I. units specific weight is expressed in N/M^3 or kw/m^3

Specific Volume :

Specific volume of a liquid is the volume occupied by unit mass of the liquid

So specific volume = v/m

Where v = volume of the liquid

M= mass of the liquid

In M.K.S. and S.I. unit both specific volume is expressed in M^3/Kg

Specific Gravity

Specific gravity of a liquid is defined as the ratio of weight of any volume of the liquid to the weight of same volume of water

So specific gravity is given by

$$S = \frac{\text{weight of any volume of the liquid}}{\text{weight of the same volume of water}}$$

$$\frac{\text{weight of } 1M^3 \text{ volume of the liquid}}{\text{weight of } 1M^3 \text{ of water}}$$

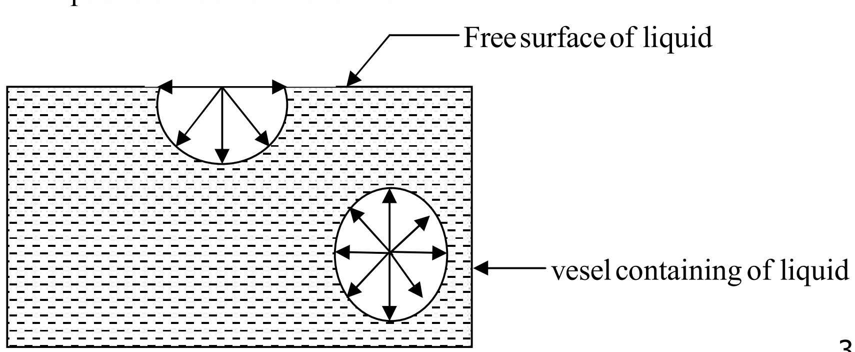
$$\frac{\text{Specific weight of the liquid}}{\text{Specific weight of water}}$$

Viscosity

Viscosity is defined as the property of a fluid by virtue of which the fluid offers resistance shear or to angular deformation greater this resistance greater is the viscosity and point

Surface Tension:

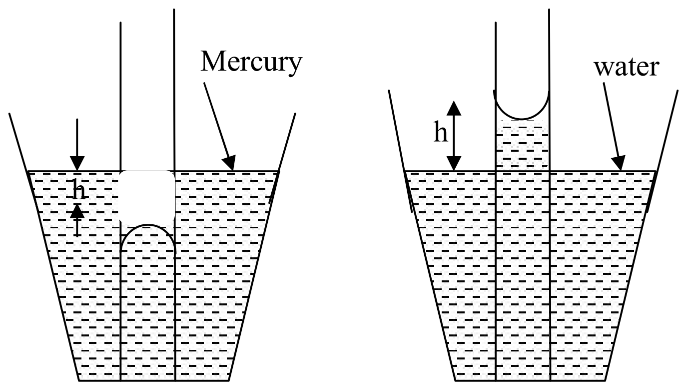
Due to cohesion tensile force occurs on the free surface of a liquid. This tensile force on the surface of a liquid is called surface tension



Surface tension may also occur in the common contact surface between two immiscible liquids such that the contact surface acts like as membrane under tension

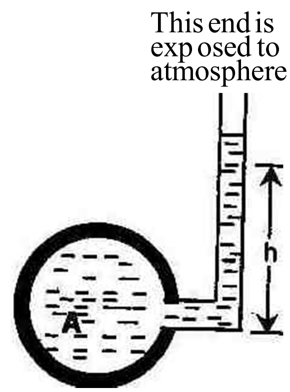
Capillarity

The phenomenon by which a liquid rises up or drops down in a tube of smaller cross-sectional area relative to the general liquid level in the vessel into the liquid is called capillarity



cohesion > Adhesion   Adhesion > cohesion

Piezometer or Piezometer tube



Piezometer tube is the single form of pressure measuring instrument by which pressure head a liquid contoined in a vessel can be directly measured. Intensity of pressure of the liquid in the vessel can then be calculated from the pressure head (h) piezometer consists of a glass tube which is open at both ends. One end is connected to the vessel contoining a liquid whose pressure head or intensity of pressure is required to be found out. The other ends of the glass tube is exposed to the atmosphere.

Let h = vertical height through which the liquid rises in the piezometer tube

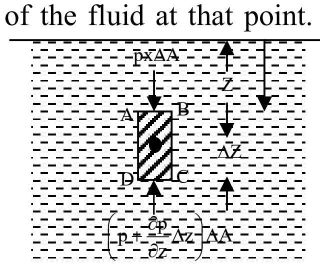
Then pressure head of the liquid is h. Hence intensity of pressure of the liquid in the vessel is given by $P = wh$, where w = specific weight of the liquid

7a. Name any two applications of hydrostatics. [2011-W 7-B]

Ans: Manometer, mechanical pressure gauge

b) What is meant by pressure head and derive an expression for it

Ans: The pressure at any point in a fluid at rest is obtained by the hydrostatic law which states that the rate of increase of pressure in a vertically downward direction must be equal to the specific weight of the fluid at that point. This is proved as



Consider a small fluid element as

Let ΔA = Cross sectional area of element

ΔZ = Height of fluid element

P= pressure on face AB

Z = Distance of fluid element from free surface

The forces acting on the fluid element are :

i) Pressure force on AB= $p \times \Delta A$ and acting perpendicular to face AB in the downward direction.

ii) Pressure force on $CD = \left(p + \frac{\partial p}{\partial z}\Delta Z\right) \times \Delta A$, acting perpendicular to face CD, vertically upward direction

iii) Weight of fluid element = Density × g × Volume = $\rho \times g \times (\Delta A \times \Delta Z)$

iv) Pressure forces on surface BC and AD are equal and opposite. For equilibrium of fluid element, we have

$$p\Delta A - \left(p + \frac{\partial p}{\partial z}\Delta Z\right)\Delta A + \rho \times g \times (\Delta A \times \Delta Z) = 0$$

$$\text{or } p\Delta A - p\Delta A - \frac{\partial p}{\partial z}\Delta Z\Delta A + \rho \times g \times \Delta A \times Z = 0$$

$$\text{or } -\frac{\partial p}{\partial z}\Delta Z\Delta A + \rho \times g \times \Delta A\Delta Z = 0$$

$$\text{or } \frac{\partial p}{\partial z}\Delta Z\Delta A = \rho \times g \times \Delta A\Delta Z \quad \text{or } \frac{\partial p}{\partial z} = \rho \times g [\text{cancelling } \Delta A\Delta Z \text{ on both side}]$$

$$\therefore \frac{\partial p}{\partial z} = \rho \times g = w \qquad (\because \rho \times g = w)$$

Where w = weight density of fluid

Equation (ii, iv) states that rate of increase of pressure in a vertical direction is equal to weight density of the fluid at the point. This is Hydrostatic law.

By integrating the above equation (ii, iv) for liquids, we get

$$\int dp = \int \rho g dZ$$

$$P = \rho g Z$$

Where p is the pressure above atmospheric pressure and Z is the height of the point from free surfaces.

From equation (2,5) we have $Z = \frac{p}{\rho \times g}$

Here Z is called pressure head.

c)i) Bourdon's tube pressure gauge. [2014-W 9-C]

Ans: Bourdon tube pressure gauge is used for measuring high as well as low pressure. It consists of an elliptical tube ABC, bent into an arc of a circle. This bent-up tube is called Bourdon's tube. When the gauge tube is connected to the fluid (whose pressure is required to be found out) at C, the fluid under pressure flows into the tube. The Bourdon's tube as a result of the increased pressure, tends to straighten itself. Since the tube is encased in a circular cover, therefore it tends to become circular instead of straight. With the help of a simple pinion and sector arrangement, the elastic deformation of the €Bourdon's tube rotates the pointer. This pointer moves over a calibrated scale, which directly gives the pressure.

ii) U-Tube Manometer:-

Ans: Generally Piezometers cannot be employed when large pressures in the lighter liquids are to be measured, Since this would requires very long tubes, which cannot be handled conveniently. This U-tubemanometer consists of a glass tube bent in U-shape, one end of which is connected to a point at which pressure is to be measured and other end remains open to the atmosphere

8.a) Distinguish clearly between steam line and streak line motion of fluid.

Ans: The steam line motion of the fluid in the pipe without overlap of the particle with not to be diverse each other continuously. In case of streak line motion of fluid, the particle of the fluid not to be overlap with each other but diverse in that way.

b) Find the size of a pipe, which has to discharge an oil at the rate of 2 ms^3/s and the specific gravity 0.8 with a velocity of 3 m/s

Ans: $Q = 2m^3/s$

Sp. Gravity = 0.8

Velocity = 3 m/s

$Q = a\,V$

$= \pi/4\ d^2 \times V$

$2\ m^3/s = \pi/4 \times d^2 \times V$

$\Rightarrow 2\ m^3/S = \pi/4 \times d^2 \times 3\ m/s$

$$\Rightarrow d^2 = \frac{(2\times 4)}{(\pi\times 3)}$$

$$d = \sqrt{\left(\frac{8}{3.41\times 3}\right)}$$

$$= \sqrt{0.8484}$$

$$d = 0.09\,m$$

CHAPTER:9

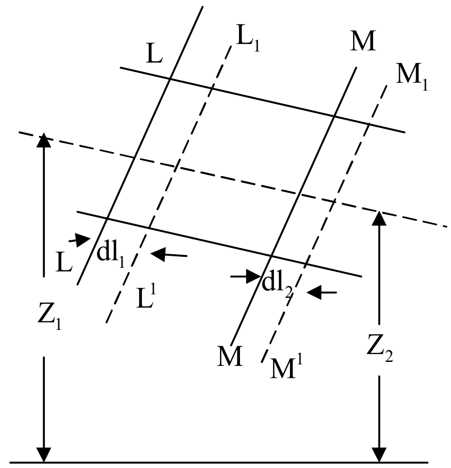
8.c) State and prove Bernoulli's theorem. [2014 W]

$$\frac{p}{\rho g} + \frac{v^2}{2g} + z = \text{Constant}$$

Ans: Statement of Bernoulli's Theorem: It states that in a steady, ideal flow of an incompressible fluid, flowing in a continuous stream, the total energy at any point of the fluid is constant, while the particles moves from one point to another. The total energy consists of pressure energy, kinetic energy and potential energy or datum energy. Mathematically Bernoulli's theorem is written as

$$\frac{P}{W} + \frac{V^2}{2g} + z = \text{Constant}$$

Let us consider flow of an incompressible fluid through a non-uniform tapering pipe as shown in the figure. It consists of two sections LL and MM of the pipe. We assume that the pipe is running full and there is a continuously of flow between the two sections.



A_1 = Area of the cross-section of pipe at inlet section LL.

V_1 = Velocity of liquid at LL

P_1 = Pressure at the inlet section LL

Z_1 = Height of LL above datum line

A_2, V_2, P_2, Z_2 are the area of cross – section velocity of liquid , pressure and height of MM above the datum at outlet section.

Let the liquid between the two sections LL and MM move L^1L^1 and M^1M^1 through a very small lengths dl_1 and dl_2

dl_1= Distance of movement of fluid from LL to L_1L_1

dl_2 = Distance of movement of fluid from MM to M_1M_1

Let w = specific weight of the fluid

W = It is the weight of the liquid between

LL and L^1L^1 since the flow is continuous

$W = w\ A_1dl_1 = w\ A_2dl_2$

$$\text{Since specific weight (w)} = \frac{\text{Wt of the fluid}}{\text{Volume of the fluid}}$$

Or, Wt of the fluid = (w) × volume of the fluid = (w) × A_1dl_1

$$\therefore A_1 dl_1 = \frac{W}{w}$$

$$\text{similarly } A_2 dl_2 = \frac{W}{w}$$

$\therefore$ Work done against pressure force at LL moving the liquid to

$$L^1L^1 = \text{Force} \times \text{Distance} = P_1 A_1 dl_1$$

$$\left[\because P = \frac{F}{A} \therefore F = PA\right]$$

Similarly work done by pressure at MM in moving the liquid

$$M^1M^1 = -P_2 A_2 dl_2$$

Since P_2 is opposite to that of P_1

$\therefore$ Total work done by the pressure $= P_1 A_1 dl_2 - P_2 A_2 dl_2$

Total work done $= A_1 dl_1 (P_1 - P_2) [\because A_1 dl_1 = A_2 dl_2]$

$$= \frac{W}{w}(P_1 - P_2) [\because \text{from eq (1) \& (2)}]$$

Loss of potential Energy $= W(Z_1 - Z_2)$

$$\text{Gain in kinetic energy} = W\left(\frac{V_2^2}{2g} - \frac{V_1^2}{2g}\right)$$

$$= \frac{W}{2g}(V_2^2 - V_1^2)$$

From the law of conservation of Energy total gain in energy = Total loss.

$\therefore$ Gain in Kinetic Energy = Loss of potential Energy+Work done by pressure

$$\therefore W(Z_1 - Z_2) + \frac{W}{w}(P_1 - P_2) = \frac{W}{2g}(V_2^2 - V_1^2)$$

$$\text{or} \quad W(Z_1 - Z_2) + \frac{W}{w}(P_1 - P_2) = \frac{W}{2g}(V_2^2 - V_1^2)$$

$$\text{or} \quad \left[(Z_1 - Z_2) + \frac{1}{w}(P_1 - P_2)\right] = \frac{W}{2g}(V_2^2 - V_1^2)$$

$$\text{or} \quad Z_1 - Z_2 + \frac{P_1}{w} - \frac{P_2}{w} = \frac{V_2^2}{2g} - \frac{V_1^2}{2g}$$

$$\text{or} \quad Z_1 + \frac{P_1}{w} + \frac{V_1^2}{2g} = \frac{V_2^2}{2g} + \frac{P_2}{w} + Z_2$$

$$\text{or} \quad Z_1 + \frac{P_1}{w} + \frac{V_1^2}{2g} = Z_2 + \frac{P_2}{w} + \frac{V_2^2}{2g}$$

Which proves Bernoulli's theorem

THE END