THERMODYNAMICS

* It is a branch of science which dill with heat applied on a body and its effect due to application of heat.

Heat :-

* Sensation of temperature is called Heat.
* Its a fundamental quantity and its unit is Jule or Calorie.

Work :-

* Work is said to be down by an external force if it causes a displacement.

1st law of Thermodynamics :-

* In a closed ~~system~~ cycle total heat interaction is equal to the total work interaction.

$$\boxed{\oint dQ = \oint dW}$$

Where, dQ = Change in heat
dW = Change in work down
$\oint$ = Cyclic integral

Loss of Perfect gas :-

Boyle's law :- It state that pressure of given quantity of gas varies inversly with its volume ~~and~~ at constant temperature.

Let, P = Pressure of the gas
V = volume of the gas
T = Temperature of the gas.

According to boyle's law

$$P \propto \frac{1}{V} \quad (T = \text{constant})$$

$$P = \frac{C}{V}$$

$$\boxed{PV = C}$$

C = Proportionality Constant

Charles's law :-

It's states that at constant pressure temperature of a gas varies directly with volume of the gas at constant pressure.

Let,

P = pressure of the gas

V = volume of the gas

T = Temp. of the gas

According to charel's law,

$$T \propto V \quad (P = \text{constant})$$

$$T = CV \quad (C = \text{Proportionality Constant})$$

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

Gay-Lussac law :-

It's state that pressure of a gas is directly proportional to temp. of gas at constant volume.

Let,

P = Pressure of gas

V = Volume of gas

T = Temp. of gas

According to gay-lussac law,

$$P \propto T \quad (V = \text{constant})$$

$$P = CT \quad (C = \text{proportionality constant})$$

$$\frac{P}{T} = C$$

General gas equation :-

Let as assume that we have a perfect gas a absolute pressure, volume and temperature.

of P_1, V_1, T_1 respectively.

* suppose the gas expands or contracts at a constant temp. to its volume (V_2) such that the corresponding value of its new absolute pressure is P_2.
* According to boyle's law $P_1V_1 = P_2V_2$ ——— eq①
* Let this gas now expanded or contracted further such that the pressure remains constant and this value of volume & absolute Temperature change V_1 to V_2 & T_1 to T_2 respectively.

According to charle's law

$$\frac{T_1}{V_1} = C \Rightarrow \frac{T_1}{V_1} = \frac{T_2}{V_2} \quad - Eq (2)$$

$$\frac{T_2}{V_2} = C$$

$$P_1V_1 = P_2V_2 \quad — (1)$$

$$\frac{T_1}{V_1} = \frac{T_2}{V_2} \quad — (11)$$

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

form eq^n (1) $V_1 = \frac{P_2V_2}{P_1}$

$$T_1 = \frac{T_2}{V_2} \times \frac{P_2V_2}{P_1}$$

$$\Rightarrow T_1 = \frac{P_2}{P_1} \times T_2$$

form Eq^n (1) & (11) & (111) we get

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

→ or

$$P_1V_1 = P_2V_2 \rightarrow (1)$$

$$\frac{T_1}{V_1} = \frac{T_2}{V_2} \rightarrow (11)$$

According to gay-Lussac law

$$\frac{P_1}{T_1} = \frac{P_2}{T_2} \quad — (111)$$

Form Eq (1) & (11) & (111) we get that

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

This is called General gas Equation.

Specific Heat at constant Pressure :-

It is defined as the amount of heat required of a body of mass 1 kg to range the temperature by 1 unit at constant pressure.

$$Q \propto mc(\Delta t)$$

* It is denoted by C_p

$$Q = mc(\Delta t)$$

$$= mc(t_2 - t_1)$$

$$C = \frac{Q}{m(T_2 - T_1)}$$

$$C = Q$$

$$\boxed{\begin{array}{l} t = 0°c \\ T = 0K \\ 0C = 273K \end{array}}$$

Specific Heat constant Volume :-

It is defined as the amount of heat required of a body of mass 1kg to range the temp by 1 unit at constant volume.

* It is denoted by Cv.

✓Relationship between Cp & Cv :-

→ Let, A gas be heated at constant pressure P form absolute temperature T_1 to T_2.

→ let, Q = Heat added to the gas, Then $Q = mCp(T_2 - T_1)$

Where,
m = mass of the gas
Cp = Specific heat at constant pressure

→ According to general energy equation

$$Q = \Delta u + W \quad \text{—— (1)}$$

Δu = change in internal energy
W = Work done

For any process $\Delta u = mCv(T_2 - T_1)$

We known that $W = P_2V_2 - P_1V_1$ {R = charecterstic gas constant}

$= mRT_2 - mRT_1$ {PV = mRT Gas law equation}

$W = mR(T_2 - T_1)$

Form eq (1)

$$Q = \Delta u + W$$

$$mcp(T_2 - T_1) = mcv(T_2 - T_1) + mR(T_2 - T_1)$$

By cancelling out $m(T_2 - T_1)$, we get

$$Cp = Cv + R$$

$$\boxed{R = Cp - Cv}$$

Where, R = Charcterstics gas constant

$$Rc = \left(\frac{1}{m}\right) \times Ru$$

$$\boxed{Ru = 8.317 \text{ k.J/kg.k}}$$

For air

$$\boxed{Cp = 1.005 \text{ kJ/kg.k}}$$

$$\boxed{Cv = 0.718 \text{ kJ/kg.k}}$$

2.1 A vessel of capacity 0.105 m^3 contents gas at pressure of 0.15 MPa and a temperature of 20°C. Additional gas as known pumped into the system until the pressure rises to 0.75 MPa. and temp. rises to 85°C. Determine the mass of gas pumped in and determine the quality as a volume at a pressure of 0.102 MPa and a temp. of 20°C

Sol^n Given data

{ mega = M = 10^6 Pa
Giga = G = 10^9
kilo = k = 10^3 }

$V = V_1 = V_2 = 0.105 m^3$

$P_1 = 0.15$ MPa $= 0.15 \times 10^6$ Pa

$T_1 = 20°C = 293K$

Additional gas is pumped into the system

$P_2 = 0.75$ MPa $= 0.75 \times 10^6$ Pa

$T_2 = 85°C = 358K$

mass of gas pumped = ?

Let, m_1 = initial mass

m_2 = final mass

$m_2 - m_1 = $.

we known that,

for initial condition

$$P_1V_1 = m_1RT_1$$

$$\Rightarrow m_1 = \frac{P_1V_1}{RT_1}$$

$$= \frac{0.15 \times 10^6 \times 0.105}{8.317 \times 10^3 \times 293} = 8.18 \times 10^{-3} kg$$

After pumping of gas.

$$P_2V_2 = m_2RT_2$$

$$m_2 = \frac{P_2V_2}{RT_2}$$

$$= \frac{0.75 \times 10^6 \times 0.105}{8.317 \times 10^3 \times 358} = 0.026 kg$$

The mass of gas pumped in $m_2 - m_1 = 0.026 - 8.18 \times 10^{-3}$

$= 0.01782 kg$

(ii) $V = ?$

$P = 0.102\ MPa = 0.102 \times 10^6\ Pa$

$T = 20^\circ C = 293K$

$PV = mRT$

$$V = \frac{mRT}{P} = \frac{0.01782 \times 8.317 \times 10^3 \times 293}{0.102 \times 10^6}$$

$$= 0.4257\ m^3$$

CH-3

Boiler

* Boiler is nothing but a steam generator.
* Water pumps into the boiler as a input and steam comes out as an output.
* Generally Boilers are used in power plant, process plant and other manufacturing units.

Classification of Boiler:-

The main classification of Boilers are

1.) According to the contents in the tube:-

The steam boilers, according to the contents in the tube may be

(a) Fire tube or smoke tube Boiler:-

If the hot ~~steo~~ flue gases form the boiler furnace flow through the tubes and water surrounds these tube then these boiler is known as ~~fire~~ tube boiler.

* Ex:- Cochran, cornish Boiler.

(b) water tube Boiler:-

If water flows through the tube surrounded by the fire or hot flue gases form the boiler furnace then the boiler is known as water tube boiler.

* Ex:- Badcock Boiler, wilcox Boiler.

2.) According to the ~~tube~~ use:-

The steam Boiler according to their use may be classified as (a) stationary Boiler.

(a) stationary Boiler:-

If the Boilers are use at one place ~~place~~ only their called stationary Boiler.

⇒ These type of boilers are used in power plant and industrial work.

⇒ Ex:- lanceshire Boiler.

(b) Mobile Boiler:-

These boilers can move one place to another.

⇒ Ex:- Locomotive & Marine.

3) According to the position of furnace!-

According to the position of furnace boilers are classified as

(a) Internal fired Boiler !-

If the furnace is provided inside the boiler shell, it is called internally fired boiler.

⇒ Ex!- Lancaster, locomotive.

(b) Externally fired Boilers!-

If the furnace is arranged outside the region of Boiling water the boiler is known as externally fired boiler.

⇒ Ex!- Bedcock & wellcox Boiler.

4) According to the Axis of the shell !-

According to the Axis of the shell boilers are classified as.

(a) vertical Boiler !-

In case of vertical ~~shell~~ steam boiler axis of the shell is vertical.

⇒ Cochran Boiler.

b) Horizontal Boiler !-

Horizontal steam boiler axis of the shell is horizontal.

Ex!- Lancasier, bedcock ~~wellcock~~ wellcox.

5) According to the method of circulation of water & steam!-

It may be classified as.

(a) Natural circulation Boiler!-

If the circulation of water in the boiler is done naturally by convension of heat, the boiler is known as natural circulation boiler.

⇒ Ex!- Becock & wellcox Boiler.

(b) Forced circulation Boiler :-

In case of forced circulation boiler, their is a forced circulation of water by a centrifugal pump driven by external power.

⇒ Ex :- Laont, Benson

(6) According to the number of tubes :-

According to the no. of tubes boilers are classified as

(a) single tube boiler :-

In case of signal tube boiler their is only one fire tube or water tube.

⇒ Ex :- Cornish, simple vertical Boiler.

(b) multi tube boiler :-

In case of multi tube boiler there are two or more fire tube or water tubes.

⇒ Ex :- Cochroom or Bedcoch or wilcox.

Boiler mounting and Accessories :-

✓ mounting of a Boiler :-

⇒ Boiler mounting are those fittings intended for safety of boiler and form complete control of the process of steam generation.

⇒ As per Indian boiler act the following mounting are usally provided on a boiler.

1.) water level indicator.
2.) Fusible plug.
3.) steam stop value.
4.) Feed check valve.
5.) Blocht of cock
6.) Two sabety valve
7.) Pressure gauge
8.) Man hole

✓Boiler of a Accessories!-

⇒ These are not essential appratus but use to improve the operating condition and overal efficiency of the boiler plant.

⇒ Boiler accessories occupie more space and installed within or near the boiler.

⇒ The following are the important accessories of a boiler:-

1.) Economiser
2.) Feed water heater
3.) Super heater
4.) steam separator
5.) steam trap
6.) Feed pump
7.) Injector

✓Cocharan Boiler!-

⇒ Cocharan Boiler is an improvement over the simple vertical boiler in which the heating surface is greatly increase by providing a large no. of parallel tube.

⇒ The combustion of coal takes place on the greate inside the fire box which is hemispherical shape so, that the unburnt fuel if any is diffected back to great.

⇒ Fuel gases form the fire box are allowed by a to pass via combustion chamber which is provided with a fire brick Lining to prevent the shell form being vamaged due to over heating.

⇒ Thus convert water into steam present in the horizontal fire tube.

⇒ Steam are collected over the water space of the boiler form where it can be taken out through the steam stop valve.

⇒ Fuel gases escape to the atmosphere via smoke box and chinmey. Smoke box door enables the clearning & inspect of the smoke box and the fire tube.

⇒ The crown of the shell is also hemispherical inshape to provided maximum space and strength.

⇒ At the top of the crown of the shell there is a man hole through which a man can entire to clean it.

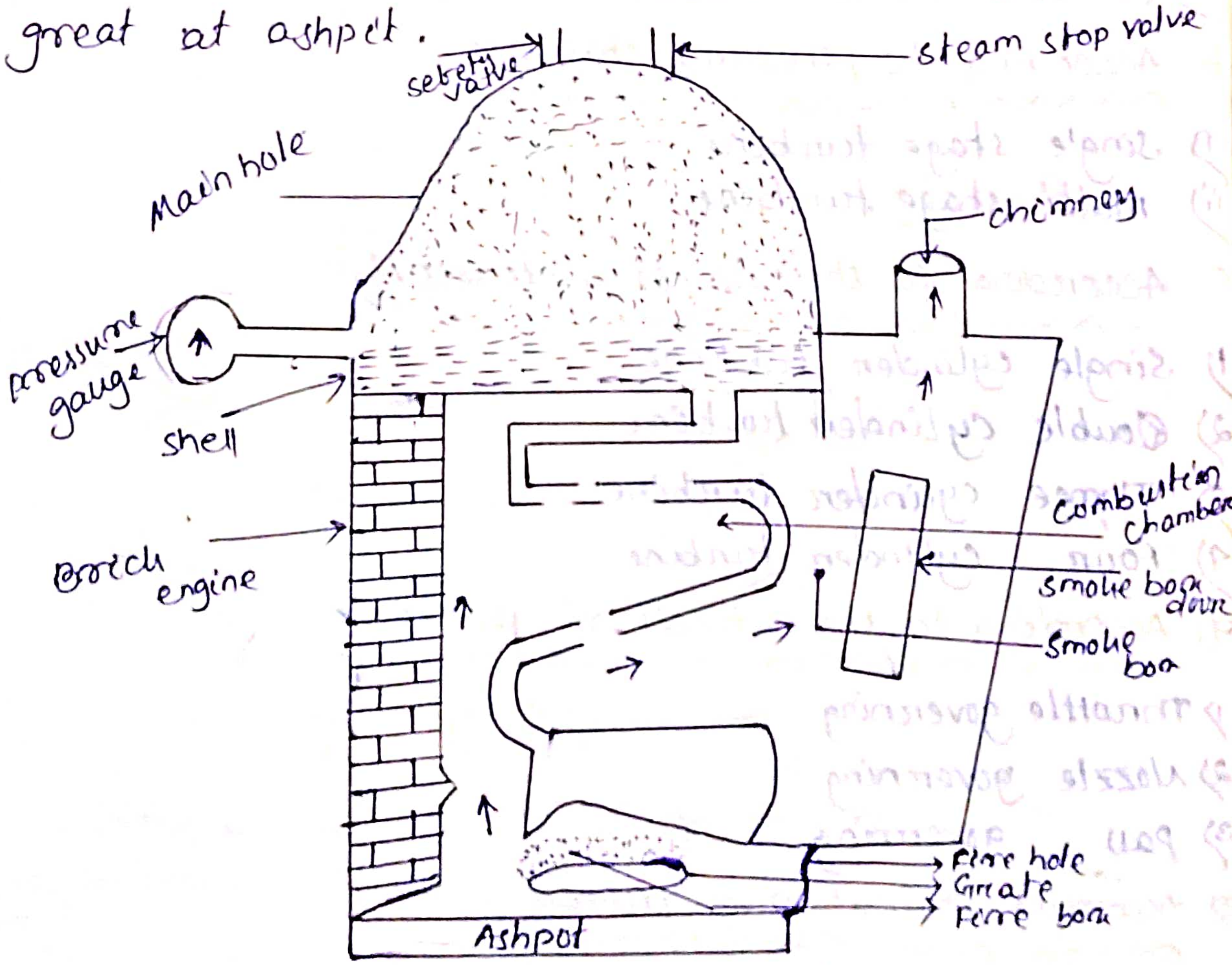
⇒ The coal can be introduce on to the grate to fire hole The boiler may also be oil bired in which an oil burner is fitted at the bire hole.

⇒ A safety valve and pressure gauge are also bitted on the boiler.

⇒ Cochran Boiler can generate steam upto a pressure of 10 bar. and requires a small bloor area.

⇒ The degine is quite compact and which a good accessible lity.

⇒ After combustion of coal ashes are collected form the great at ashpit.



(Cochreon Boiler)

Turbine

⇒ Turbine is a prime-mover in which the potential energy of the steam is transformed into kinetic energy and later transformed into mechanical energy of rotation of the turbine shaft.

⇒ The turbine shaft is connected with driven mechanism with help of a reduction gearing.

Types of turbine :-

a) Respect to action of the steam :-

i) Impulse
ii) Reaction
iii) Combination of reaction and Impulse.

b) According to pressure stages :-

i) Single stage turbine
ii) multi stage turbine

c) According to the no. of Cylinders :-

1) Single cylinder turbine
2) Double cylinder turbine
3) Three cylinder turbine
4) Four cylinder turbine

d) According to the methods of governing :-

1) Throttle governing
2) Nozzle governing
3) Pass governing

e) According to heat drop process :-

1) Condensing turbine
2) Condensing turbine with one or two intermediate stage of extraction
3) Back Pressure turbine
4) Topping turbine
5) Low Pressure
6) Mixed pressure.

7) According to steam condition at inlet to turbine

1) Low Pressure (10-bar)
2) medium Pressure (10-50 bar)
3) High pressure (50 bar above)

9) According to direction of steam flow

1) Axial turbine
2) Radial turbine.

Impulse turbine	Reaction turbine
i) The steam completely expands in the nozzle and it's pressure remain constant while passing through the blades.	i) The steam expands partially in the fixed blade (nozzle) and further expansion takes place in the moving blade
ii) Relative velocity of steam remain constant while passing over moving blades	ii) The relative velocity of steam increases while passing over moving blade.
iii) The shape of the blades each of profile type	iii) The shape of the blade is of aerofoil type.
iv) The blade passes is of constant cross-sectional area	iv) The blade passage is of variable cross-sectional area
v) No. of stages require are less for the some power develop.	v) No. of stages required are large further same power develop.
vi) The blade speed & steam speed are ~~equal~~ large due to large pressure drop.	vi) The blade speed & steam speed are small due to small pressure drop.
vii) Friction loses are more as compare to leakage losses.	vii) leakage losses are more as compared to friction losses.
viii) Less space is needed per unit power	viii) more space is needed per unit power
ix) They are suitable for small power	ix) They are suitable for medium & high power.

Condenser

10mp

⇒ Condenser is a closed air tight vessel in which steam condenses to water.

⇒ Condensers are two types :-

① Jet condenser
② Surface condenser

Jet condenser :-

The exhusting and water come in direct contact with each other. and temp. of the condensate is the same edge that of cooling water living the condenser.

⇒ The water cooling is ually spred into the exhust steam.

⇒ Jet condensers are clasified as

i) Parallel flow type Jet condenser.
ii) Counter " " " "
iii) Ejector " " " "

⇒ parallel flow and counter flow condenser are further some devided into two types.

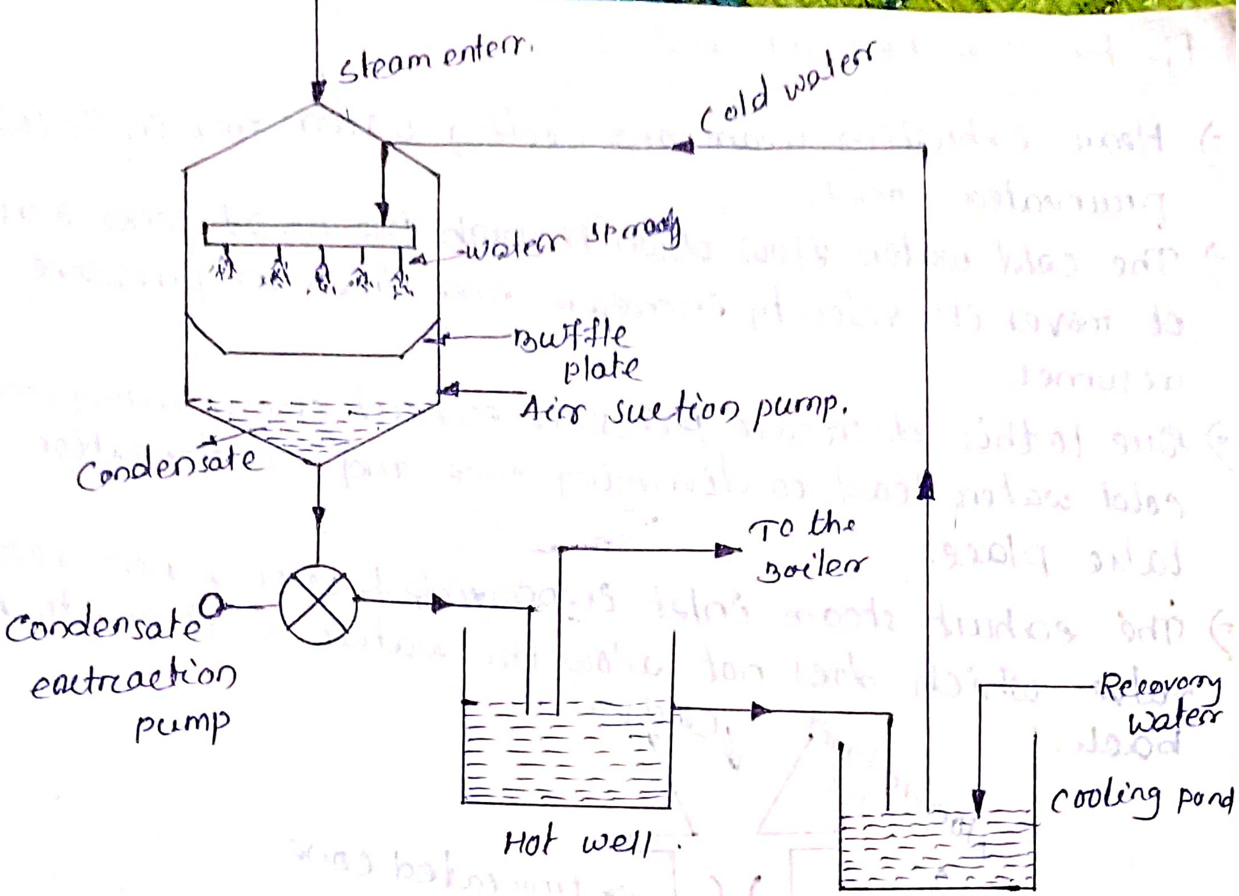
① Low level type
② High level type

Parallel flow type Jet condenser :-

⇒ In parallel flow type condenser both the exhust steam and colling water spread enter at the top of the condenser and then flow down words.

⇒ A Baffle plate ensures proper mixing of the steam and colling water.

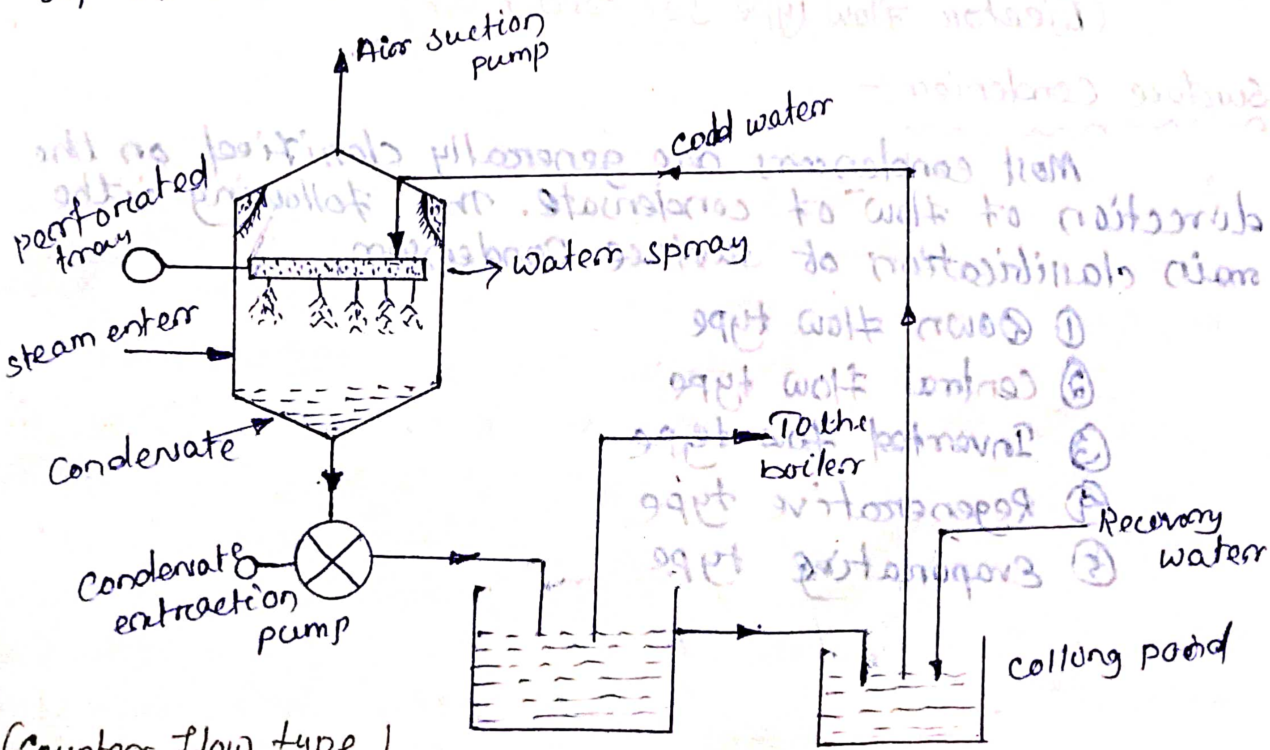
⇒ An extraction pump at the button discharges the condensate to the hot well form where it may be fed to the boiler and the over flow water comes to the colling pond.



(Parallel flow type Jet condenser)

Counter flow type Jet condenser :-

⇒ In counter flow type Jet condenser steam moving upwards comes in contact with water through perforated trey which break up water into jet.
⇒ The condensate and water mixture is sent hot well by means of and extraction pump.
⇒ Air is removed by an air suction pump. provided at the top of the condenser.



(Counter flow type)

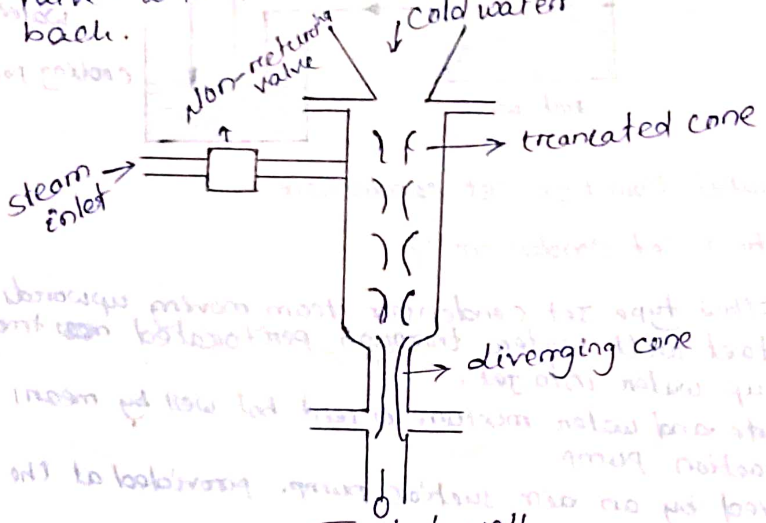
Ejector flow type Jet condenser:-

⇒ Hear exhausting steam and cooling water mix in follow truncated cones.

⇒ The cold water flow down through the no. of cones & as it moves its velocity increase and drop in pressure resumes.

⇒ Due to this decrease pressure exhaust steam along with cold water lead to diverging cone and condensation take place.

⇒ The exhaust steam inlet is provided with a non return valve which does not allow the water or steam to rush back.



(Ejector flow type Jet condenser)

Surface Condenser:-

Most condensers are generally classified on the direction of flow of condensate. The following is the main classification of surface condenser.

1. Down flow type
2. Central flow type
3. Inverted flow type
4. Regenerative type
5. Evaporating type

① Down flow type:-

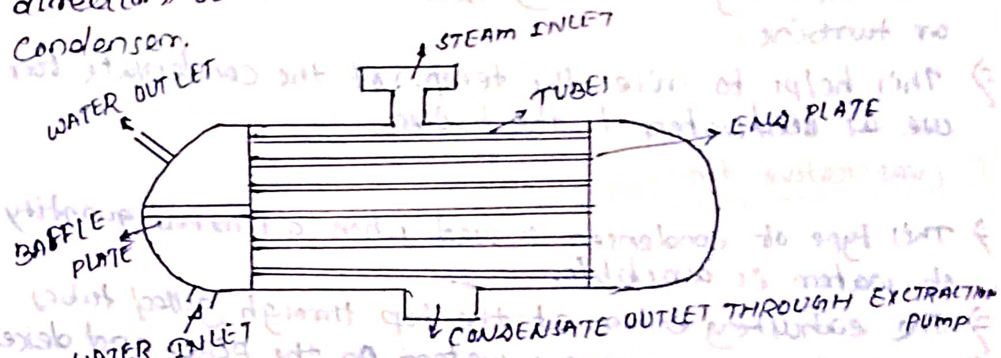
It consist of a shell which is generally of cylindrical shape and furnished with no. of parallel tubes.

⇒ A Baffle plate partitions the water box into two sections.

⇒ The cooling water enters the shell at the lower half and after travelling through the upper half comes out through the out let.

⇒ Exhausting entering the shell form the top flows down over the tubes and get condensed and is finally removed by an extraction pump.

⇒ As the steam flow in a direction right angle to the direction of flow of water, it is also called cross-surface condenser.



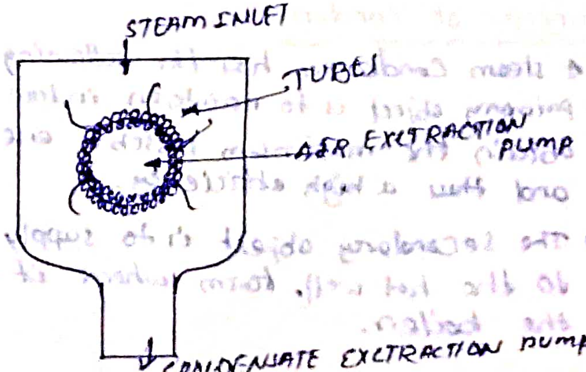
(DOWN FLOW TYPE)

② Central flow type:-

In this type of condenser the suction pipe of the air extraction pump is located in the center of the tubes.

⇒ which results in radial flow of the steam.

⇒ The better contact below the outer surface of the tubes of steam is ensured.



(CENTRAL FLOW TYPE)

③ Inverted flow type :-

This type of condenser has the air suction pump at the top, the steam after entering at the bottom rises of and then again flows down to the bottom of the condenser.

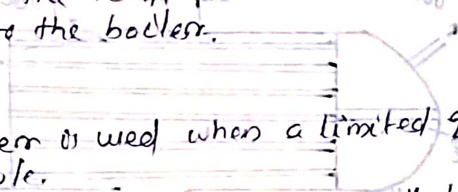
⇒ The condensate extraction pump at the bottom collects the condensate.

④ Regenerating type :-

This type of condenser adopting a regenerative method of heating of the condensate.

⇒ After leaving the tube the condensate is passed through the entering exhausting steam from the steam engine or turbine.

⇒ This helps to raise the temp. of the condensate for use as feed water to the boiler.



⑤ Evaporative type :-

⇒ This type of condenser is used when a limited quantity of water is available.

⇒ The exhausting enters at the top through gilled tubes

⇒ The water pump sprays water on the pipes and descending water condensate the steam.

⇒ The water which is not evaporated falls into the cooling pond from where it can be drawn by circulating water pump and used over again.

⇒ The evaporating condenser is placed in open air and finds its application in small size ~~plate~~ plants.

Function of condenser :-

* A steam condenser has the following two objects
① Primary object is to maintain in low pressure so as to obtain the maximum possible energy from the steam and thus a high efficiency.

② The secondary object is to supply pure feed water to the hot well, from where it is pumped back to the boiler.

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

CH-8

HYDROSTATICS

⇒ Anything which can flow is called as fluid.

Properties of fluid :-

Various fluid properties are
① Density
② Specific gravity
③ Viscosity
④ vapour pressure
⑤ Cohesion
⑥ Adhesion
⑦ surface tension
⑧ Capillarity
⑨ Compressibility

① Density :-

Density of liquid may be defined as the mass per unit volume. (m/v) at a standard temp. & pressure.

⇒ It is usually denoted by ρ.

$$\rho = \frac{m}{V}$$

⇒ Unit :- kg/m^3

Weight Density :-

The weight density is defined as the weight per unit volume at the standard temperature and pressure.

⇒ It is usually denoted by w.

$$w = \rho g$$

⇒ weight density of water is equal to $1000\ kg/m^3$.

2) Specific gravity :-

SP. gravity is the ratio of the SP. weight of the liquid to the sp. weight of a standard fluid.

⇒ It is dimensionless and has no. unit.

⇒ It is represented by S.

⇒ For liquids the standard fluid is pure water and at 4°C.

⇒ Specific gravity = $\frac{\text{SP. weight of Liquid}}{\text{SP. weight of pure water}}$

3) Viscosity :-

Viscosity is defined as the property of a fluid which determines it's resistance to shearing stress.

⇒ Newton's law of viscosity states that the shear stress (τ) on a fluid is directly proportional to the rate of shear strain.

$$\tau \propto \frac{du}{dy}$$

$$= \mu \frac{du}{dy}$$

$\frac{du}{dy}$ = rate of shear strain

μ = Coefficient of viscosity

⇒ Unit of viscosity Ns/m^2

* These are the molecules are gaseous state and exerts own partial vapour pressure on the liquid surface.

- This pressure is known as vapour pressure of the liquid.

5) Cohesion :-

⇒ It means inter molecular force of attraction between molecules of the same liquid.

⇒ Cohesion is a tendency of the liquid to remain as one assemblage of particles.

6) Adhesion :-

⇒ Adhesion mean attraction betwn the molecules of a liquid and the molecules of a solid boundary surface in contact with the liquid.

⇒ This property enables a liquid to stick to another body.

7) Surface tension :- (σ)

Surface tension (σ) is caused by the force of cohesion at the free surface.

⇒ It's unit is N/m.

⇒ Surface tension exhibits a tensile force at the free surface.

8 Capillarity :-

Capillarity is a phenomenon by which a liquid rises into a thin glass tube of below its general level.

⇒ This phenomenon is due to combined effect of cohesion & adhesion of liquid particles.

⇒ $H = \frac{4\sigma\cos\theta}{wd}$

Where H = Height of capillary rise.

d = diameter of capillary tube.

θ = Angle of contact of the water surface

σ = surface tension per unit length.

w = weight density

9. Compressibility :-

Compressibility is the property by virtue of which fluid undergoes a change in volume under the action of external pressure.

⇒ It is reciprocal of bulk modulus of elasticity (K).

$$\boxed{\text{Compressibility} = \frac{1}{K}}$$

Different pressure measuring instruments are

1) Manometer :- manometer

- Simple U tube manometer
- Differential U tube manometer

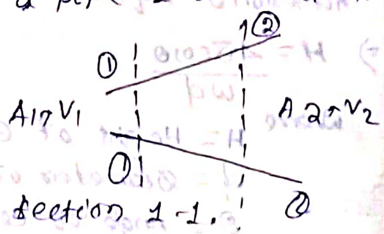
2) Mechanical gauges.

- Diaphragm gauges
- Bourdon tube
- Dead weight
- Bellows

Continuity Equation :-

If an incompressible liquid is continuously flowing through a pipe or channel, the quantity of liquid passing per second is the same at all section. This is known as continuity equation.

⇒ Consider to cross section of a pipe 1-1 and 2-2.



let A_1 = Area of the pipe at section 1-1.

V_1 = velocity of the fluid at section 1-1.

ρ_1 = Density of the liquid at section 1-1.

similarly

A_2 = Area of the pipe at section 2-2

V_2 = velocity of the fluid at section 2-2

ρ_2 = Density of the liquid at section 2-2

⇒ The total quantity of fluid passing through the section 1-1 $= \rho_1 A_1 V_1$

⇒ The total quantity of fluid passing through the section 2-2 $= \rho_2 A_2 V_2$

⇒ From the law conservation of matter.

$$Q_1 = Q_2$$

$$\rho_1 A_1 V_1 = \rho_2 A_2 V_2 \quad \text{—} ①$$

Where,

Q_1 = discharge at section 1-1

Q_2 = discharge at section 2-2

For an incompressible fluid

$$\rho_1 = \rho_2$$

eqn ① becomes

$$\boxed{A_1 V_1 = A_2 V_2}$$

This is called continuity equation.

Q.1 The Diameter of a pipe at section 1 & 2 are 20cm & 30cm respectively. Find the discharge through the pipe if the velocity of water flowing through the pipe at section is 10 m/s. Determine the velocity at section 2.

Soln Given data.

$d_1 = 20cm = 0.2m$

$d_2 = 30cm = 0.3m$

$Q = ?$

$V_1 = 10m/s$

$V_2 = ?$

$$A_1 = \frac{\pi d_1^2}{4} = \frac{3.14 \times 0.2 \times 0.2}{4} = \frac{0.1252}{4} = 0.0314 m^2$$

$$A_2 = \frac{\pi d_2^2}{4} = \frac{3.14 \times 0.3 \times 0.3}{4} = \frac{0.2826}{4} = 0.07065$$

$$Q = AV = 0.0314 \times 10 = 0.314 m^3/s$$

$A_1V_1 = A_2V_2$

$\Rightarrow 0.0314 \times 10 = 0.07065 \times V_2$

$\Rightarrow \frac{0.314}{0.07065} = V_2$

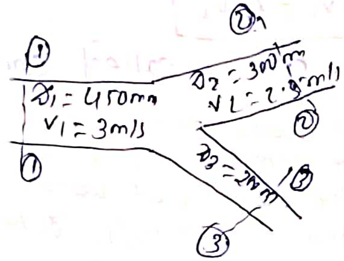
$\Rightarrow 4.44 = V_2$

$\Rightarrow V_2 = 4.44\ m/s$

Q. A pipe (one) 450mm in diameter branches into two pipes 2 & 3 of 300mm & 200mm as shown in fig. If the avarage velocity in pipe (1) is 3 m/s find

1. Discharge through pipe 1.
2. Velocity in pipe 3 if the avarage velocity in pipe 2 is 2.5 m/s.

Given data



$D_1 = 410mm = 0.45m$

$V_1 = 3m/s$

$D_2 = 300mm = 0.3m$

$D_3 = 200mm = 0.2m$

$V_2 = 2.5\ m/s$

$Q_1 = ?$

$V_3 = ?$

$A_1 = \frac{\pi D_1^2}{4} = \frac{3.14 \times 0.45 \times 0.45}{4} = 0.1590\ m^2$

$Q_1 = A_1V_1 = 0.1590 \times 3 = 0.477\ m^3/s$

$Q_1 = Q_2 + Q_3$

$\Rightarrow 0.477 = \frac{\pi}{4}(D_2)^2 \times V_2 + \frac{\pi}{4}(D_3)^2 \times V_3$

$\Rightarrow 0.477 = \frac{3.14 \times 0.3 \times 0.3}{4} \times V_2 + \frac{3.14 \times 0.2 \times 0.2}{4} \times V_3$

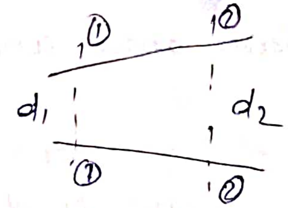
$\Rightarrow 0.477 = 0.176625 + 0.0314V_3$

$\Rightarrow 9.56 = V_3$

$V_3 = 9.55\ m/s$

Q. The diameters of a pipe at the section 1 & 2 are 15cm and 20 cm respectively. Find the discharge to the pipe if velocity of water at section 1 is 4 m/s. Determine also velocity at section 2.

Given data



$d_1 = 15cm = 0.15\ m$

$d_2 = 20cm = 0.2\ m$

$V_1 = 4\ m/s$

$A_1 = \frac{\pi}{4}d_1^2 = \frac{3.14 \times 0.15 \times 0.15}{4} = 0.0176625\ m^2$

$A_2 = \frac{\pi}{4}d_2^2 = \frac{3.14 \times 0.2 \times 0.2}{4} = 0.0314\ m^2$

$Q = A_1V_1 = A_2V_2$

$Q = A_1V_1$

$\Rightarrow Q = 0.0176625 \times 4 = 0.07065\ m^3/s$

form the continuity Equation

$A_1V_1 = A_2V_2$

$\Rightarrow 0.0176625 \times 4 = 0.0314 \times V_2$

$\Rightarrow \frac{0.07065}{0.0314} = V_2$

$\Rightarrow 2.25\ m/s = V_2$

Different type of energys of a liquid in motion

There are three types of energy or heads of flowing liquids.

1.) Potential Energy or head:-

This is due to configuration or position above some datum line. It is denoted by Z.

2.) Kinetic Energy or velocity head:-

This is due to velocity of flowing liquid and is measured as $\frac{v^2}{2g}$

where,

v = velocity of the flowing liquid

g = Acceleration due to gravity = 9.81 (m/s²)

3.) Pressure Energy or pressure head:-

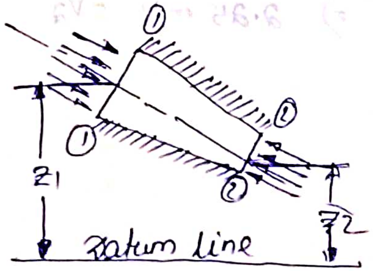
This is due to pressure of liquid and it's value is $\frac{P}{w}$ or $\frac{P}{\rho g}$

where, P = Pressure of the liquid

w = weight density of liquid

⇒ Total Energy or head:-

It is the sum of potetial head, kinetic head, pressure head.



Total head = potential head + kinetic head + pressure head

Total head = $Z + \frac{v^2}{2g} + \frac{P}{w}$

$= Z + \frac{v^2}{2g} + \frac{P}{\rho g}$

$TE/TH = Z + \frac{v^2}{2g} + \frac{P}{\rho g}$

Bernoulli's Theorem:-

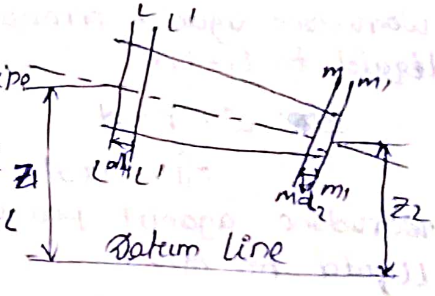
It's states that in a steady ideal flow of an incompressible fluid flowing in a continuous strem, the total energy at any point of the fluid is constant.

⇒ The total energy consists of pressure energy, kinetic energy & potential energy.

Mathmatically Bernoulli's theorem is return as

$$\frac{P}{w} + \frac{v^2}{2g} + z = k$$

let us consider flow of an incompressible fluid through a non uniform tappering pipe, it consists of two sections L-L and m-m.



A_1 = cross-section area of pipe at inlet section L-L

v_1 = velocity of liquid at L-L

P_1 = Pressure of liquid at L-L

Z_1 = Height of L-L above datum line

similarly, A_2, V_2, P_2, Z_2 are cross-sectional area, velocity of liqued, pressure and hight of m-m above datum at out let section m-m.

⇒ Let the liquid between the two sections L-L and m-m move L'-L' and m'-m' through a very small length dL_1 and dL_2.

⇒ dL_1 = distants of movement of fluid form L-L to L'-L'

dL_2 = distants of movement of fluid form m-m to m'-m'

Let w = specific weight of the liquid.

W = weight of the liquid betw^n L-L and L'-L'

We know that

Sp. weight $w = \frac{\text{Weight of the liquid}}{\text{volume of the liquid}}$

Weight of the Liquid $(W) = w \times V$

(V) = volume of the liquid

$W = w \times A_1 dl_1$

Since the flow is continuously

$W = wA_1dl_1 = wA_2dl_2$

$A_1dl_1 = A_2dl_2 = \frac{W}{w}$

* Work done against pressure force at L-L moving the liquid to L_1-L_1.

$W = F \times d$

$= (P_1A_1) \times dl_1$

* Workdone against pressure force at m-m moving the liquid to m_1-m_1

$W = F \times d$

$= -(P_2A_2) \times dl_2$

-ve sign indicates that P_1 is opposite direction of P_2.

Total workdone by the pressure $= (P_1A_1) \times dl_1 - (P_2A_2) \times dl_2$

$= A_1dl_1(P_1 - P_2)$

$= \frac{W}{w}(P_1 - P_2)$ -- ①

Loss of potential Energy $= W(Z_1 - Z_2)$ — ②

Gain in kinetic Energy $= \frac{V^2}{2g} \times W$

$= \left(\frac{V_2^2}{2g} - \frac{V_1^2}{2g}\right) W$ — ③

→ From of law of conservation of Energy is total gain in energy = total loss.

⇒ Gain in kinetic energy = loss of potential Energy + workdone by pressure

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

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

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

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

$= \frac{P_1}{w} + \frac{V_1^2}{2g} + Z_1$ = Constant Hence Bernoulli's theorem.

Limitation:

1. The flow is steady and continuous
2. velocity is uniform over all the section
3. The Liquid is ideal and incompressible
4. The flow is along the stream line that is one dimensional.
5. The only forces acting on a fluid are gravity forces and pressure forces.

Heat :-

⇒ Heat is the energy in ~~transaction~~ on the move form one body or system to another solely because of a temperature defference betw^n the system.

⇒ It is of 2 types

1) Sensiable Heat

2) Latent Heat

Sensiable Heat of water :- (h_f)

It is defined as the quantity of heat absorbed by one kg of water when it is heated form 0°c to boiling point.

Latent Heat of vaporization :- (h_{fg})

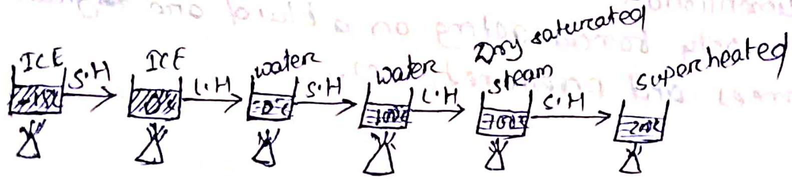
⇒ It is the amount of heat required to convert water at a given temperature and pressure into steam at the same temperature and pressure.

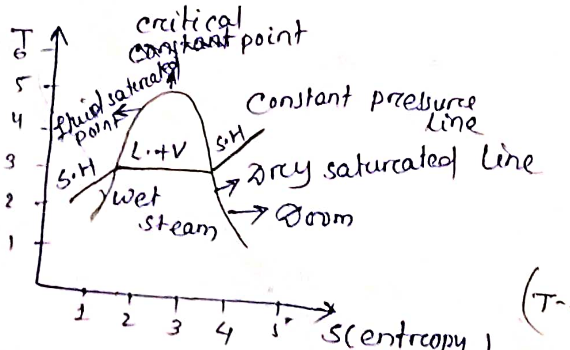
Total Heat of steam :-

⇒ It is defined as the quantity of heat required to convert 1kg of water at 0°c into wet steam at constant pressure.

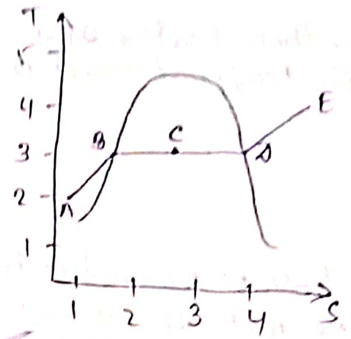
⇒ It is the sum of sensiable heat and latent Heat.

⇒ Total Heat of steam $h = h_f + x h_{fg}$





(T-S Diagram of water)



$h_B = h_f$

$h_D = h_g$

$h_C = h_f + x h_{fg}$

$h_E = h_g + C_{pv}(T_E - T_D)$

$h_A = h_f - C_{pl}(T_B - T_A)$

Quality of steam :-

It is the proporction of saturated steam in a liquid vapour mixture.

⇒ If quality of steam = 0 which indicates 100% Liquid and it is 100 this indicates 100% steam.

Wetness Fraction :-

It is fraction expressing the ratio of the weight of free water particles to that of the whole in a quantity of wet steam.

Degree of superheat :-

It is defined as the amount by which the temp. of a superheated vapour/steam exceeds the temperature of the saturated vapour/steam at the same pressure.

Wet steam :-

It is a mixture of steam and liquid water. It exists at a saturated - temperature containing more than 5% water. It is said to be a two phase mix. steam contains droplets of water that have not changed phase.

Dry saturated steam :-

This result when water is heated to the boiling point (sensible heating) and then vapourized with additional heat (latent heat). If this steam is then further heated above the saturation pt, it becomes superheated steam (sensible heating).

Superheated steam:-

When the dry steam is further heated at a constant pressure, this raising its temperature, it is said to be superheated steam.

Dryness fraction of steam:- (x)

The term dryness fraction is related with wet steam. It is defined as the ratio of the mass of actual dry steam to the mass of steam containing it. It is usally expressed by the symbol 'x' or q.

If m_s = mass of dry steam contained in steam considered and

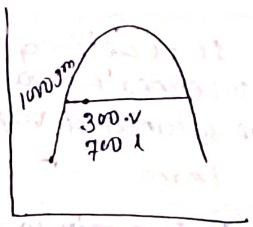
m_w = weight of water particles in suspension in the steam considered.

Then, $$x = \frac{m_s}{m_s + m_w}$$

wet ness fraction (w) $= \frac{\text{mass of liquid}}{\text{Total mass}}$

$= \frac{700}{1000}$

$= 0.7$



Dryness fraction (x) $= \frac{\text{mass of vapour}}{\text{Total mass}}$

$= \frac{300}{1000} = 0.3$

$$w + x = 1$$

$x_A = \frac{m_v}{m_l + m_v} = \frac{0}{m_l + m_v} = 0$

$x_B = \frac{m_v}{m_l + m_v} = \frac{m_v}{m_v} = 1$

$$0 \le x \le 1$$

Q. Calculat the enthapy of 1 kg of steam at a pressure of 8 bar and dryness fraction of 0.8. How much heat will required to raise 2 kg of water at 20°c to steam of dryness fraction of 0.8 at 8 bar pressure.

Ans

Case-I

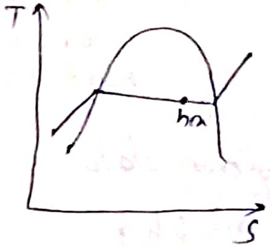
Given data

$m_1 = 1\,kg$

$P = 8\,bar$

$x = 0.8$

$h_x = ?$



$h_x = [h_{f_g} + x h_{fg_g}]\, m$

Form steam table

$h_{fg} = 721.3$ kJ/kg

$h_{fg_g} = 2046.5$ kJ/kg

$h_x = [h_{fg} + x h_{fg_g}]\, m$

$= [721.3 + 0.8 \times 2046.5] \times 1$

$= 2358.5$ kJ

Case-II

Given data

$m_2 = 2\,kg$

$t = 20°c$

$x = 0.8$

$P = 8\,bar$

0 → steam → 2358.5

20 → steam → ?

0-20   0-steam

20-steam = ?

We know that,

Specific Heat of water (s) = 4.21 $\frac{kJ}{kg°}$

Heat required to raise the temperature of water form 0°c to 20°c = $s \times t$ = $4.21 \times 20 = 84.2$ kJ/kg

Heat required to raise 2 kg of water at 20°c to steam

= (Heat required to produced steam − Heat required to rise the temp form 0°c to 20°c) × m

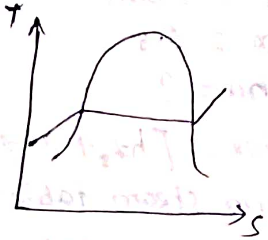
$= (2358.5 - 84.2) \times 2 = 4548.6$ kJ

Q. Find out the quantity to heat required to produced 2kg of steam at a pressure of 0.6 MPa, at a temp. 25°c under the following condition.

1.) steam is wet having quality 90%
2.) ~~wet~~ when is dry saturated
3.) when the steam is superheated at a constant pressure at 250°c assuming mean specific heat of superheated steam to be 2.1 kJ/kg k

Sol

Given data :-



$m = 2kg$

$P = 0.6\ MP = 0.6 \times 10^6\ P$

$= \frac{6}{10} \times 10^5 \times 10\ P$

$= 6 \times 10^5\ P$

$= \frac{6 \times 10^5}{10^5} = 6\ bar$

$t = 25°c$

① wet having quality 90%.

$x = 0.9$

At 6 bar pressure form steam table

$h_c = \{h_f + x h_{fg}\} m$

$= \{670.8 + 0.9 \times 2085.0\} \times 2$

$= 5094.6\ kJ$

② when dry saturate form steam table

$h = \{h_f + x h_{fg}\} \times m$

$= \{670.8 + 1 \times 2085.0\} \times 2$

$= 5511.6\ kJ$

③ $\{h_g + c_{pv}(T_s - T)\} m = \{2755.8 \times 2.1(523 - 298\} \times 2$

$= 2 \times 2.1(523 - 298) = 2 \times 2.1 \times 225$

$= 945$

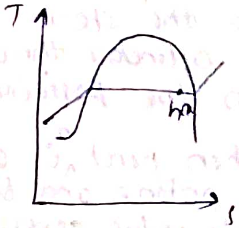
Q. Steam is being generated in a boiler under a pressure of 10 bar. Find the enthalpy of 100kg of steam when
(i) steam is dry saturated
(ii) dryness fraction of steam is 0.95
(iii) temperature of steam is 250°c.

~~Given d~~

Soln

Given data

$CP = 2.1$



$P = 10\ bar$

$m = 100\ kg$

$h_f = 763.0\ kJ/kg$

$h_{fg} = 2013.5\ kJ/kg$

① $h = \{h_f + x h_{fg}\} \times m$

$= \{h_f + 1 h_{fg}\} \times m$

$= \{763.0 + 1 \times 2013.5\} \times 100$

$= 277650\ kJ$

② $h_n = \{h_f + x h_{fg}\} \times m$

$= \{763.0 + 0.95 \times 2013.5\} \times 100$

$= 267582.5\ kJ$

③ $m \times c_{pv}(T_s - T)$

$= 100 \times 2.1(523 - 453)$

$= 100 \times 2.1 \times 70$

$= 14700\ kJ/k$

STEAM ENGINE

⇒ In a steam Engine heat energy in the steam is converted into mechanical work by the motion of the pistone.

Principle of a steam Engine :-

⇒ The supercheated steam at a high pressure is led into the steam chest, After that the steam goes into the cylinder through any of the ports a or b depending upon the position of the D- slide valve.

⇒ When port a is open steam rushes into the left side of the pistone and forces it to the right. at this stage D slide valve covers the exhust port and the other steam port b.

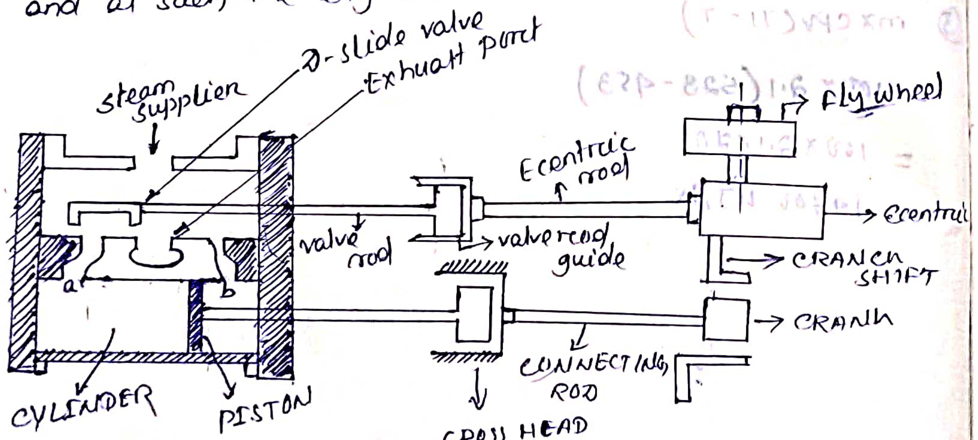
⇒ Since the pressure of steam is greater on left side then that of the right side, the pistone moves to the right.

⇒ when the piston riches near the end of the cylinder, it closes the steam port a and the exhaust port.

⇒ The steam port bo is open now and the steam rushes to the right side of the piston. ~~This forces~~

⇒ This forces the piston to the left and at the same time the exhaust steam goes out through the exhaust port and thus complete the cycle operation.

⇒ The same process is repeated in other cycle of operation and as such the engine works.



(Single cylinder double acting Reciprocating steam)

1) Bore / Diameter of Cylinder (D)
2) Dead contores
   TDC, BDC
3) clearence volume (V_c)
4) swept volume (V_s)
   $V_s = \frac{\pi}{4} D^2 L$
5) Streore volume length
6) cut off volume ($V_{cut\ off}$)
7) Avarage piton speed (V)

Theoritical or hypothetical Indicator Diagram :-

⇒ Indicator diagram is a graphical representation of the variation in pressure and volume of steam inside the cylinder or P-V Diagram.

⇒ The theoritical or hypothetical indicator diagram without clearence and with clearence is shown in the figure.

The sequence of processes is given below.

1) **Process 1-2 :-**

⇒ At point 1 steam is admitted into the cylinder through inlet port. As the piston move towards right, therefore the steam is admitted at constant pressure.

⇒ Since the supply of steam is cut off at point 2 therefore point 2 is known as cut off point.

2) **Process 2-3 :-**

⇒ At point 2 expansion of steam in the cylinder starts with the movement of the piston still it reches dead centre.

⇒ The expansion takes place hyperbolically (PV = Constant) at pressure falls considerable.

3) **Process 3-4 :-**

⇒ At point 3 exhaust port opens and steam is release form the cylinder to the exhaust.

⇒ As a result of steam exhudst pressure in the cylinder falls sudenly without change in volume. The point 3 is known as release point.

4) Process 4-5 :-

⇒ At point 4 return journey of the piston starts.

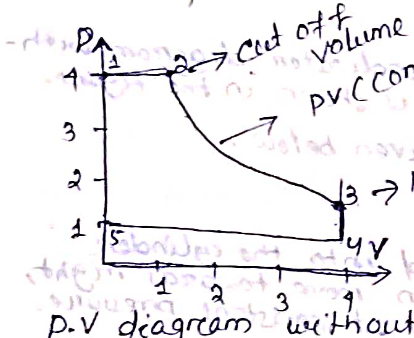
⇒ Use steam is exhausted at constant pressure still the exhaust port is closed. and inlet port is open.

⇒ The steam pressure at point 4 is called Back pressure.

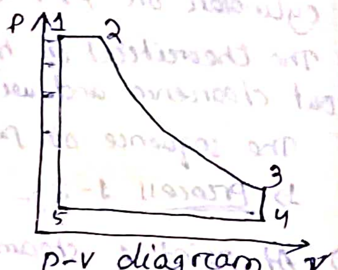
5) Process 5-1 :-

⇒ At point 5 the inlet port is open and some steam suddenly enters into the cylinder which increases the pressure of the steam without change in volume.

⇒ This process continues still the original position is restored.



p.v diagram without clearence



p-v diagram with clearence

Mean effective pressure :-

⇒ The average pressure on the piston during the working stroke is called mean effective pressure.

$$P_m = \frac{\text{work done per cycle}}{\text{stroke volume}} = \frac{W}{V_s}$$

~~mean effect~~

✓ Theoritical or hypothetical mean effective pressure without clearence :- {

Let, P_1 = Initial or admission pressure of steam

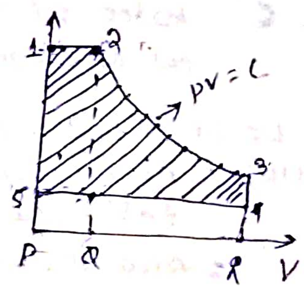
P_b = Back pressure $= P_4 = P_5$

V_2 = volume of steam in the cylinder at the point of cut off or cut off volume.

V_3 = stroke volume or swept volume $= V_3 = V_4$

⇒ we know that work done per cycle = Area of the 1, 2, 3, 4, 5, 1

Area under 12345 1 = Area of 12QP + Area of 23PQ − Area of 4RP5



$$= P_1 \times V_2 + 2.3\, P_2 V_2 \log\left(\frac{V_3}{V_2}\right) - P_b \times V_3$$

mean effective pressure

$$P_m = \frac{\text{work done per cycle}}{\text{stroke volume}}$$

$$= \frac{P_1 \times V_2 + 2.3\, P_2 V_2 \log\left(\frac{V_3}{V_2}\right) - P_b \times V_3}{V_3}$$

$$= P_1 \times \left(\frac{V_2}{V_3}\right) + 2.3\, P_2\left(\frac{V_2}{V_3}\right) \log\left(\frac{V_3}{V_2}\right) - P_b \times \frac{V_3}{V_3}$$

Expansion Ratio (r) $= V_3$

$$= \frac{P_1}{r} + 2.3\, \frac{P_2}{r} \log r - P_b$$

$$= \frac{P_1}{r} + 2.3\, \frac{P_1}{r} \log r - P_b \quad [P_2 = P_1]$$

$$\boxed{P_m = \frac{P_1}{r}\left[1 + 2.3 \log r\right] - P_b}$$

✓ Theoritical or hypothetical mean effective pressure with clearence :- {

let P_1 = Initial or admission pressure of the steam $= P_2$

P_b = Back pressure $= P_4 = P_5$

V_c = clearence volume of the cylinder

V_2 = volume of steam at ~~volume~~ the point of cut off

V_s = swept volume or stoke volume $= V_3 - V_4$

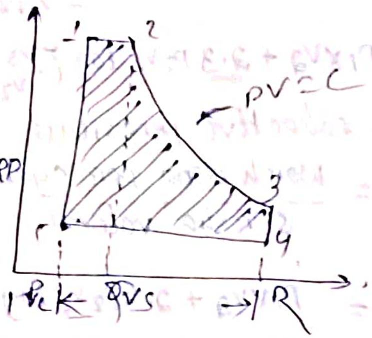
V_3 = Total volume of the steam on the cylinder $= V_c + V_s$

b = Ratio of clearence volume

$= \frac{V_c}{V_s}$

c = Ratio of volume betwn the point of admission and cut of steam to the stroke volume $= \frac{V_2 - V_c}{V_s}$

we know that work done per cycle = Area under the curve 123451



= Area of 12PQ + Area of 23RP − Area of 41PQR

$= P_1(V_2 - V_c) + 2.3 P_2 V_2 \log\left(\frac{V_3}{V_2}\right) - P_b V_s$

mean effective pressure = $\frac{\text{work done per cycle}}{\text{stroke volume}}$

$= \frac{P_1(V_2 - V_c) + 2.3 P_2 V_2 \log\left(\frac{V_3}{V_2}\right) - P_b V_s}{V_s}$

$= P_1 \left(\frac{V_2 - V_c}{V_s}\right) + 2.3 P_2 \frac{V_2}{V_s} \log\left(\frac{V_3}{V_2}\right) - P_b$

$= P_1 C + 2.3 P_1 (b + c) \log\left(\frac{b+1}{b+c}\right) - P$

$b + c = \frac{V_2}{V_s}$, $\frac{V_3}{V_2} = \frac{b+1}{b+c}$

$\Rightarrow \frac{\frac{V_c}{V_s} + 1}{\frac{V_c}{V_s} + \frac{V_2 - V_c}{V_s}}$

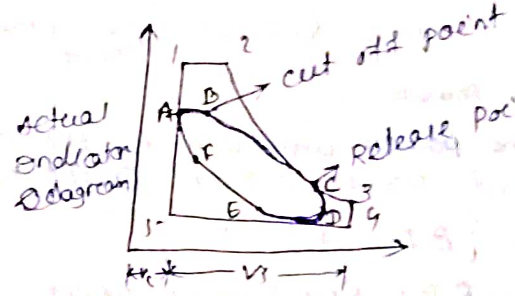
$\Rightarrow \frac{\frac{V_c + V_s}{V_s}}{\frac{V_c + V_2 - V_c}{V_s}}$

$\Rightarrow \frac{V_c + V_s}{V_s} \times \frac{V_s}{V_2} = \frac{V_3}{V_2}$ $(V_c + V_s = V_3)$

Actual Indicator diagram :-

⇒ If the indicator diagram of a steam engine where actual drawn with help of a indicator it will be found to a small area than that of theoritical Indicator diagram

⇒ The coreners would be rounded of to different extent. The deviation in the size and shape of the actual indicator diagram is due to following regions.



1.) The pressure of the steam in the engine cylinder at the begning of the stroke is less than the boiler pressure due to losses.

2.) During the forward stroke of the piston their is always a slide fall in pressure.

3.) As the inlet port cannot closes instataniously, the point of cut off will not be sharpe as to, but arounded of at b.

4.) The exhaust port open before the end of the forward stroke stroke, this causes rounding of the top of the diagram.

5.) During the exhaust stroke pressure in the cylinder is higher than that of outside pressure.

6.) For exhaust valve closes at some point "E" and the remaining steam in the cylinder compressed along the curve "EF" before the end of the exhaust stroke.

7.) Due to wire drawing effect the steam is admitted just before the end of the exhaust stroke. at F.

Indicated Power (IP):-

$$\text{Indicated power (IP)} = \frac{K \times Pa\,LAN}{60} \text{ watt}$$

where,

K = No. of cylinder

Pa = Actually mean effective Pressure (N/m^2)

L = length of the stroke length (m)

A = Area of the cylinder in m^2

N = Revolution/speed of crank shaft in RPM.

Brake Power:-

The power available in the crank shaft of an engine is called power. O/P or Brake power.

$$B.P = I.P - F.P$$

F.P = Frictional power

Mechanical efficiency of a steam Engine:-

It is the ratio of Break hourse power (B.P) to I.P.

$$\eta_{mechanical} = \frac{B.P}{I.P} \times 100$$

Q. In a single cylinder double acting steam engine steam admitted at pressure at 12 bar and exhausted pressure is 1.3 bar and stroke length is 450mm. The The cylinder bore is 250mm. The cutt off take place at 40% of the stroke. The engine speed is 260 RPM. Negleting clearance assuming a diagram factor of 0.9. Determine indicated power.

Ans:-

Given data

Single cylinder double acting steam engine

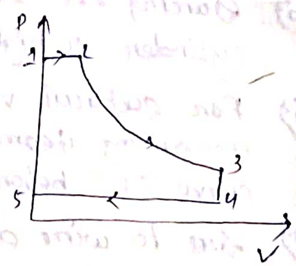
Adimitted pressure P_1 = 12 bar = 12×10^5 Pa

Exhaust Pressure $P_4 = P_b$ = 1.3 bar = 1.3×10^5 Pa

Bore D = 250 mm = 0.25 m

stroke length L = 450 mm = 0.45 m

cut off take place at 40% of the stroke



V_2 = 40% of V_3

$V_2 = 0.4 V_3 \Rightarrow \frac{V_3}{V_2} = \frac{1}{0.4} = 2.5$

$\Rightarrow \frac{V_2}{V_3} = \frac{1}{r}$

Compression Ratio = 2.5 = r

Engine speed (N) = 260 Rpm

Diagram factor (E) = 0.9

Indicated power = ?

Area of the cylinder (A) = $\frac{\pi}{4} D^2$

$= \frac{3.14 \times (0.25)^2}{4} = 0.04\ m^2$

Theoritical mean effective Pressure:

$P_{mt} = \frac{P_1}{r}\{1 + 2.3 \log(r)\} - P_b$

$= \frac{12 \times 10^5}{2.5}\{1 + 2.3 \log(2.5)\} - 1.3 \times 10^5$

$= 789325.76\ N/m^2$

Actual Indicated power mean efficative pressure

$= E \times P_{mt}$

$= 0.9 \times 789325.76 = 710393.184\ N/m^2$

$\text{Indicated Power (IP)} = \frac{KNPa\,LAN}{60}$

$= \frac{2 \times 710393.19 \times 0.45m \times 0.04 \times 260}{60}$

$= 55410.66$ watt

$= 55.41$ kW

Q. Determine actual mean effective pressure and indicated power form the following data?

Bore of cylinder = 300 mm

Stroke = 450 mm

Rpm = 44

Adimittion pressure = 8 bar

Back pressure = 1.8 bar

And the cut off takes place at the 20% at the stroke. Assuming diagram factor of 0.8 neglating clearance.

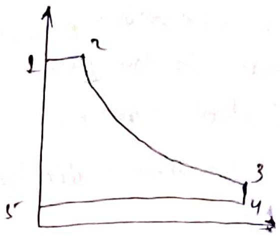
Given data

Bore of cylinder (d) = 300mm = 0.3m

Stroke (L) = 450mm = 0.45 m

Rpm (N) = 44

Admission pressure P_1 = 8 bar = 8×10^5 Pa



Back pressure = P_b = 1.8 bar = 1.8×10^5 Pa

Cut off take place at 20% of stroke

$V_2 = 20\% \, V_3$

$\Rightarrow V_2 = 0.2 \, V_3$

$\Rightarrow \frac{V_3}{V_2} = \frac{1}{0.2} = r = 5$

Diagram factor (Z) = 0.8

Area of the cylinder = $\frac{\pi d^2}{4} = \frac{3.14 \times 0.3 \times 0.3}{4} = 0.07 \text{ m}^2$ ~~0.70 m²~~

Theoritically mean effectivity pressure

$P_{mt} = \frac{P_1}{r}\{1 + 2.3 \log r\} - P_b$

$= \frac{8 \times 10^5}{5}\{1 + 2.3 \log(5)\} - 1.8 \times 10^5$

$= 237220.96 \text{ N/m}^2$

Actual mean effective pressure

$= Z \times P_{mt} = 0.8 \times 237220.96 = 189776.76 \text{ N/m}^2$

Indicated power = $\frac{kP_a LAN}{60}$

= ~~1X 189776~~

$= \frac{1 \times 189776.76 \times 0.45 \times 0.07 \times 44}{60}$

= 4383.84 watt

= 4.38 kW

Q Determine the stroke and diameter of a double cylinder engine developing 180 kW, under the following conditions,

Intial steam pressure = 7 bar

Back pressure = 1.12 bar

Crank speed = 100 Rpm

Avarge piston speed = 135 m/m

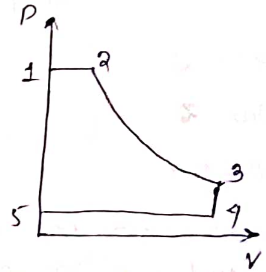
Diagram factor = 0.8

Cut off at 0.4 of the stroke.

Given data

Intial steam pressure (P_1) = 7 bar = 7×10^5 Pa.

Back pressure (P_b) = 1.12 bar = 1.12×10^5 Pa.



Crank speed (N) = 100 Rpm

Avarege piston speed = 135 m/m

Diagram factor (Z) = 0.8

Cut off at 0.4 of the stroke

$r = \frac{1}{0.4} = 2.5$

$2LN = 135$

$\Rightarrow L = \frac{135}{2 \times N} = \frac{135}{2 \times 100} = \frac{135}{200} = 0.675$ m.

Indicated power (I.P) = 180 kW = 180×10^3

$P_{mt} = \frac{P_1}{r}\{1 + 2.3 \log(r)\} - P_b$

$= \frac{7 \times 10^5}{2.5}\{1 + 2.3 \log(2.5)\} - 1.12 \times 10^5$

$= 424273.3656 \text{ N/m}^2$

Actual mean effective pressure

$P_a = Z \times P_{mt} = 0.8 \times 424273.3656 = 339418.69 \text{ N/m}^2$

Indicated power (I.P) = $\frac{kLANP_a}{60}$

$\Rightarrow \frac{I.P \times 60}{kLNP_a} = A$

$$\Rightarrow \frac{180\times10^3\times60}{2\times0.675\times100\times339418.69} = A$$

$\Rightarrow A = 0.23 m^2$

Area of the cylinder

$$\Rightarrow A = \frac{\pi D^2}{4}$$

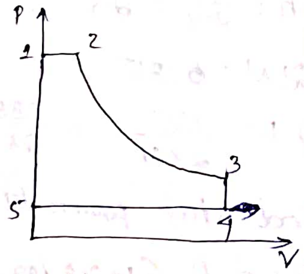
$$\Rightarrow \frac{A\times4}{\pi} = \frac{0.23\times4}{3.14} = D^2$$

$\Rightarrow \sqrt{0.29} = D$

$\Rightarrow 0.53m = D$

$\Rightarrow D = 0.53 m$

Q A steam Engine has a stroke equal to 1.4 times of diameter. And a diagram factor of 0.85. It is supplied with dry saturated steam at 9.2 bar and exhausted at 1 bar. If the expansion ratio is 2.4, speed 220 Rpm and power 200 kW. Find diameter of cylinder.



Given data

$L = 1.4D$

Diagram factor $(Z) = 0.85$

$P_1 = 9.2$ bar $= 9.2\times10^5$ Pa

$P_b = 1$ bar $= 10^5$ Pa

expansion ratio $= (r) = 2.4$

Speed $(N) = 220$ Rpm

Indicated power $(I.P) = 200$ kW $= 200\times10^3$ W

Theoritically mean effective Pressure

$$P_{mt} = \frac{P_1}{r}\{1+2.3\log(r)\} - P_b$$

$$= \frac{9.2\times10^5}{2.4}\{1+2.3\log(2.4)\} - 10^5$$

$= 618552.91 \ N/m^2$

Actual mean effective pressure

$P_{ma} = Z\times P_{mt} = 0.85\times618552.91 = 525769.97 \ N/m^2$

Indicated power $(I.P) = \frac{P_{ma} L A N}{60}$

$$\Rightarrow 200\times10^3 = \frac{1\times525769.97\times1.4D\times\frac{\pi D^2}{4}\times220}{60}$$

$$\Rightarrow \frac{200\times10^3\times60}{525769.97\times220} = 1.4D\times\frac{\pi}{4}D^2$$

$\Rightarrow 0.1037 = 1.4D\times0.785D^2$

$\Rightarrow 0.1037 = 1.099D^3$

$$\Rightarrow D^3 = \frac{0.1037}{1.099}$$

$\Rightarrow D^3 = 0.094$

$\Rightarrow D = \sqrt[3]{0.094}$

$\Rightarrow D = 0.45 m$

Stroke length $(L) = 1.4D$

$= 1.4\times0.45$

$\Rightarrow L = 0.63 m$

CH-10

Hydrolic lift

Function of Hydrolic lift :-

Hydrolic lift is a device used for carring person and loads form one floor to another in a building.

Working Principle:-

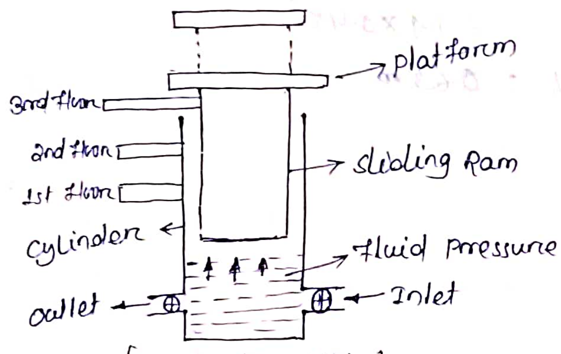
Hydrolic lift consist of a RAM, sliding in fixed cylinder.

⇒ ~~Sliding~~ cylinder ram moves up and down due to pressure of the liquid.

⇒ At the top of the sliding ram a platform is mounted because persons may stand or goods may be placed.

⇒ High Pressure liquid is admitted to the cylinder and due to this an upward pressure axe on the ram. This makes the ram to lift along with the platform, which is mounted on the top of the ram.

⇒ For lowering the ram and platform the valve is open.



(Hydrolic lift)

Hydrolic Accumulator :-

It is a device used for storing pressure energy of a liquid temperarily.

⇒ It is used between a pump and a hydrolic machine, ~~which~~ requires

⇒ In case of hydrolic crane or lift, the liquid under pressure needs to be supplied during upward motion of the load only. This energy is supplied form hydrolic accumulator.

⇒ When the lift is moving down ward ~~where~~ no large external energy is required. and during that period energy form the pump is stored in the accumulator.

Construction and working principle:-

⇒ The Accumulator consist of a vertical cylinder containing a sliding ram.

⇒ A load or weight is placed on the top to create pressure in the cylinder.

⇒ One side of the cylinder is connected to the pump and other side to the machine.

⇒ In the begning the ram is at the lower most position. When high pressure liquid supplied by the pump is admitted in the hollow space of the cylinder it raises the ram. Till it is reaches the upon most position.

⇒ At reach position maximum amount of ~~energy~~ pressure energy is accumulated. This accumulated energy later discharged to the machine.

Capacity of Accumulator :-

⇒ The maximum amount of energy that the accumulator can store is known as capacity of the accumulator.

⇒ Mathmatically capacity of the accumulator

$$= P \times A \times L$$

Where,

P = Pressure of liquid supplied by the pump

A = Area of the sliding ram

L = stroke or length of the ram

Hydrolic Ram :-

⇒ It is a device with which small quantities of water can be pumped to higher levels form the available large quantity of water of low speed. It works on the principle of water hammer.

Working Principle :-

⇒ Hydrolic ram consist of a valve box where low head water flows.

⇒ The box contens a waste valve which opens inwards. and a delivery valve which open out owards. Both valves are nonreturns valves.

⇒ It also contens air vesel which is connected to the delivery tank through delivery pipe.

⇒ Inlet valve is fitted to the supply pipe. when inlet valve is open water starts flowing form supply tank to valve box, which has two valve B and C. B is called waste valve and C is called delivary valve, which is fitted to air vessel.

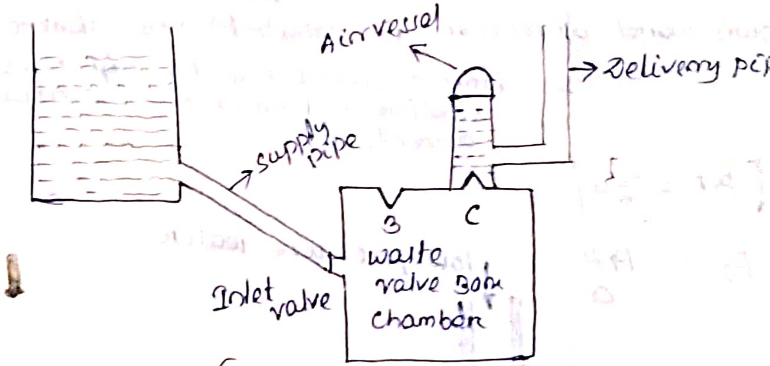
⇒ when water comes into the chamber form supply tank, level of water raises in the chamber and waste valve (B) starts moving upward.

⇒ At some point waste valve (B) suddenly closes and due to this pressure inside the chamber increases. and causes opening of the delivary valve (C).

⇒ Wate form the chamber enters the air vesel and compresses the air inside air vessel.

⇒ Compressed air exhaust force on the water in the air vessel. and small quantity of water is raised to a greater height.

⇒ When water in chamber losses its mometum waste valve (B) open in the down ward direction and flow of water form supply tank starts flowing to the chamber. and the cycle will be repeated.



(Hydrolic Ram)

Intensy fire :-

⇒ Hydrolic intensy fire is a device which increases the intensity of pressure of a given liquid with help of low pressure liquid of large quantity.

⇒ It finds it's application at places where high pressure is to be developed form available low pressure. It is located betwn pump and machine.

Working Principle :-

⇒ Hydrolic intensy fire consist of a fixed ram through which high pressure water flow through the machine.

⇒ There is a hollow inverted sliding cylinder contening high pressure water, mounted over the fixed ram.

⇒ At low pressure a large quantity of water form main supply enters the inverted fixed cylinder. The weight of these water pressure the sliding cylinder in the down ward direction.

⇒ Due to downward movement of the sliding cylinder the water in the sliding cylinder get compressed and its pressure increases.

⇒ Then the high pressure water in the sliding cylinder is forced in to the machine through fixed ram.

⇒ Let P_1 = supply water pressure to the fixed cylinder

A = External area of the sliding cylinder

a = Area of the end of the fixed ram

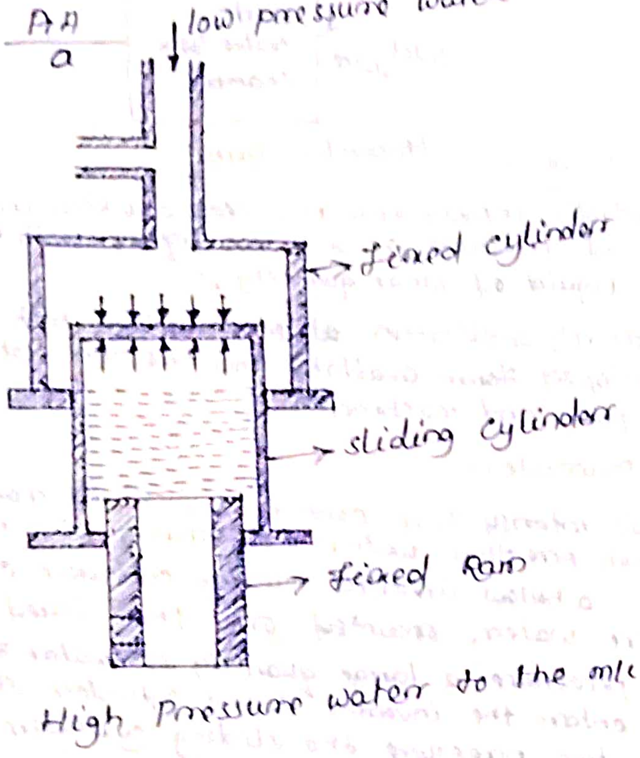
P_2 = Pressure of water in the sliding cylinder That is high pressure water.

We know the force exhausted by low pressure water in the down ward direction is ~~equal to the~~ force

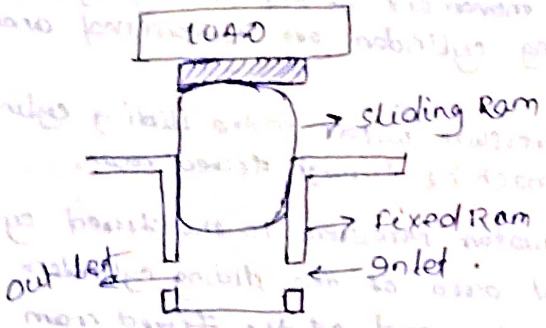
= force exhausted by high pressure on the sliding cylinder in the upward direction.

$\boxed{P_1 A = P_2 a}$

$P_2 = \frac{P_1 A}{a}$

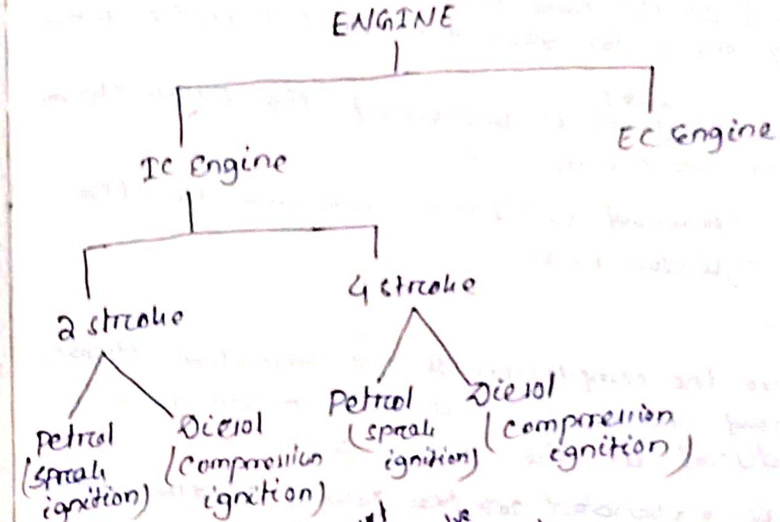


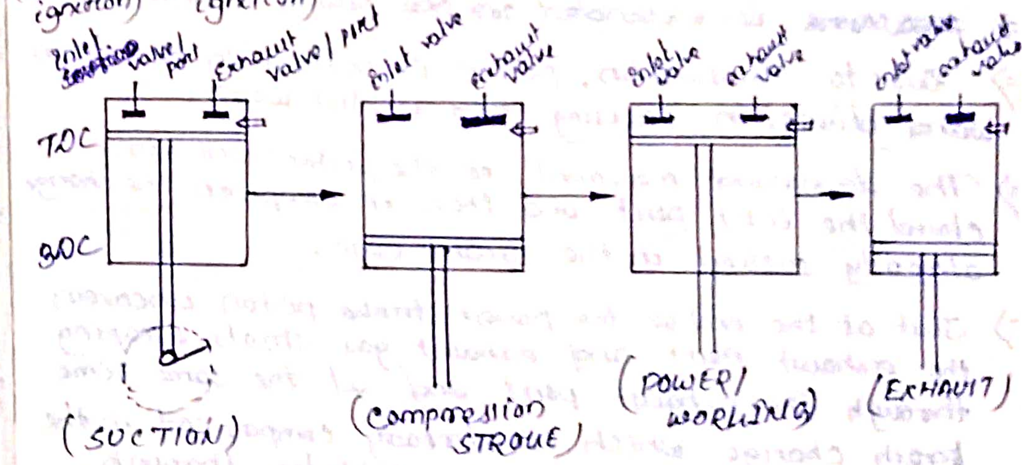
Hydraulic Accumulator :-



IC ENGINE

⇒ An internal combustion Engine is a heat engine in which combustion of fuel occurs in presence of oxygen in a combustion chamber that is an integral part of working fluid ckt.





✓ Two stroke Petrol Engine :

⇒ There is one working stroke for each revolution of crank shaft.

⇒ The working Principle of two stroke Petrol engine is discussed below.

1) First stroke :-

⇒ Let as assume the piston at BDC position.

⇒ As the piston starts rising form BDC position it closes the transfer port and exhaust port.

⇒ The charge which is already present in the cylinder is compressed, at the same time which the upward movement of the piston vacuum is created in the crank case.

⇒ As soon as the inlet port is uncovered the fresh charge is sucked in the crank case.

⇒ Charging is continued untill the crank case and the space in the cylinder is food.

2. Second stroke :-

⇒ Slidly before the completion of the compression stroke, the compressed charge is ignited by means of a sparke produced at the sparke plug.

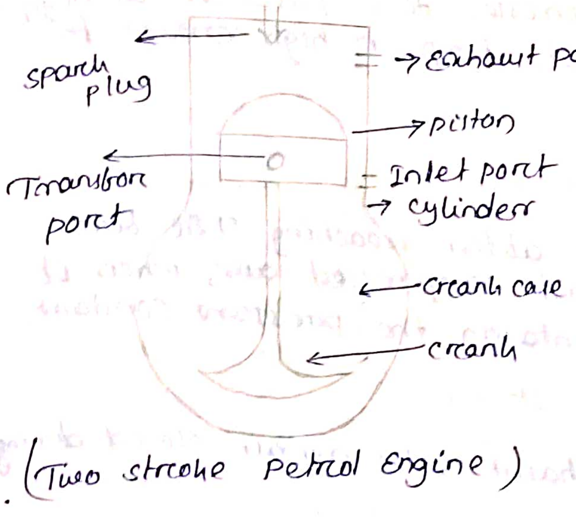
⇒ ~~pressure is extended on the~~ crank of the piston

⇒ Due to combustion, piston is pushed in the downward direction causing some useful work.

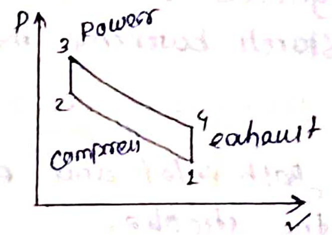
⇒ The downward movement of the piston will first closed the inlet port and then it compress the charge already sucked in the crank case.

⇒ Just at the end of the power stroke piston uncovers the exhaust port and exhaust gas streats escaping through the exhaust port and at the same time fresh charge which is already compressed in the crank case rushes into the cylinder through transfer port.

Thus the cycle repeated again.



(Two stroke Petrol Engine)



Four stroke Diesel engine :-

⇒ This engine works on the diesel cycle. Heavey motor vhecile, stationary power plant and ships mostly employed this engene.

⇒ The diesel or compression ignition engine mostly uses diesel as fuel.

⇒ It's various strokes are as followings.

1) Suction stroke :-

⇒ The piston moves down form TDC.

⇒ The air is drawn into the cylinder through inlet valve, which closes at the end of these strokes.

⇒ The exhaust valve remains closed during this strokes.

2) Compression stroke :-

⇒ The piston moves of form moves of BDC to TDC.

⇒ Both inlet valve and exhaust valve is also closed in the previous stroke

⇒ Air drawn into the cylinder is know, compressed by upward movement of the piston.

⇒ Air is finally compressed to a pressure as high as 40 bar, at which temp. is high enough to ignite the fuel.

3) Constant pressure stroke :-

⇒ As the piston moves after reaching TDC fuel ignected into the hot compressed air, when it starts burning, maintaing the pressure constant.

4) power or working stroke :-

⇒ Both inlet and exhaust valve remain closed during the stroke.

⇒ The hot gases and air expand, pushing the piston down and hence doing work.

⇒ The piston finally reaches the Button Dead center.

5) Exhaust stroke :-

⇒ The piston now moves of once again.

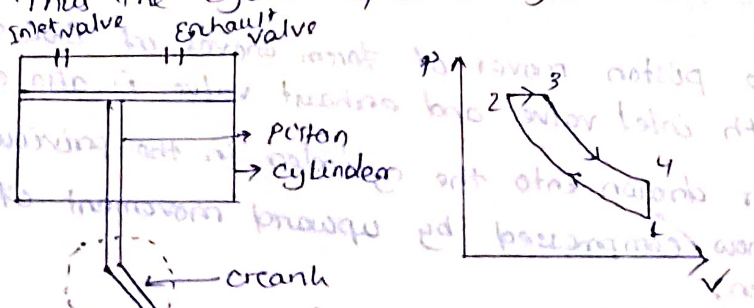
⇒ The inlet valve is closed and exhaust valve open.

⇒ A greater path after burnt gases, escapes out due to their own expansion.

⇒ The upward movement of the piston pushes the remaing gases out through exhaust valve, only a small quantity of exhaust gases stay in the combustion chamber.

⇒ The exhault valve closes at the end of the exhault stroke.

Thus the cycle repeated again.



(Four stroke Disel Engine)

4 stroke Petrol Engine :-

⇒ In case of 4 stroke cycle one cycle of operation is completed in 4 strokes of piston and two revolution of crank shaft.

⇒ petrol engine is also called as spark ignition engine.

⇒ various strokes of 4 stroke petrol engine are described below.

1) suction stroke :-

⇒ During this stroke the inlet valve open and air fuel mixture is sucked into the cylinder.

⇒ piston moves form TDC TO BDC.

2) Compression stroke :-

⇒ In this stroke both inlet and exhaust valve are closed.

⇒ During this stroke air fuel mixture is compressed and automaticall the pressure and temperature are increased.

⇒ piston moves form BDC to TDC.

3) Expansion stroke :-

⇒ During this stroke both inlet and exhaust valve remain closed.

⇒ The gases are burned with the help of an electric spark and suddenly increase the pressure and temperature.

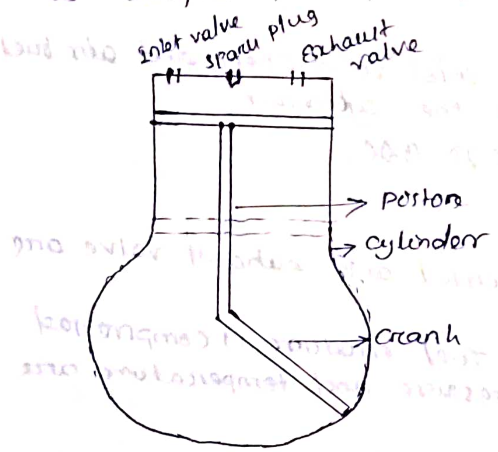
⇒ Due to rise in pressure, the piston is pushed down with a great force.

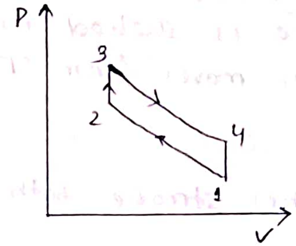
⇒ During this expansion some of the heat energy gets transformed into mechanical work.

⇒ Piston moves form TDC to BDC.

4) Exhaust stroke :-

- In this stroke the exhaust valve open and inlet valves remains closed.
- The piston pushes the burned gases out through exhaust valve into the atmosphere.
- The piston moves form BDC to TDC. Thus the cycle is completed and repeated again.





(4 stroke Petrol Engine)

2 stroke Engine	4 stroke Engine
A two stroke engine requireds one revolution of crank shaft to complete a cycle.	A 4 stroke engine requireds 2 revolution of crank shaft to complete a cycle.
power developed is more (almost 1.7 times) for same revolution of crank shaft.	power developed is less for same revolution of crank shaft.
Smaller fly wheel is required.	Bigger fly wheel is required
space required for two stroke engine is less. As it is smaller and lighter.	more space required.
cylinder temp in 2 stroke engine is higher.	cylinder temp in 4 stroke engine is comporatively lower.
Simple gear arrangement is required.	comparatively complecated gear arrangement is installed.
more lubricating oil is required.	less lubricating oil is required.
Thermal efficiency is less.	Thermal efficiency is more.
Wear and tear is more.	Wear and tear is very less.
A two stroke engine produces more noise.	A foure stroke engine producess less noise.

Petrol Engine	Diesel Engine
It works on otto cycle. in which combustion of fuel takes place at constant volume.	It works on Diesel cycle in which combution of fuel takes place at constant pressure.
Generally petrol engine draws air fuel mixture during suction stroke.	Diesel engine draws only air during suction stroke.
Hear Carburattor is employed to mix air and fuel.	Hear injector or atomiser is employed to inject the fuel at the end of compression stroke.
The engine producess low compression ratio. (6-10)	Diesel engine produces high compression ratio. (15-25)
Thermal efficiency is less.	Thermal efficiency is more.
These are high speed engines.	These are relatively low speed engine.

It's initial cost is less. But running cost is more.	It's initial cost is more but running cost is less.
It is easy to start the engine, because of low compression ratio.	It is difficult to start the engine because of high compression ratio.
maintenance cost is less.	maintenance cost is high.
petrol Engines are generally used in light duty vehicale. such as motor cycle, Car etc.	Diesel engine are generally employed in heavy duty vehicale, such as bus; truck, train etc.
Spark plug is used for combustion. So it is also called spark ignition engine.	In diesel engine air is compressed upto self-ignition temperature of the fuel and then fuel is ingected, that's why it is also called compression ignition engine.