ARYAN SCHOOL OF ENGINEERING & TECHNOLOGY

BARAKUDA,PANCHAGAON,BHUBANESWAR,KHORDHA-752050

LECTURE NOTE

SUBJECT NAME- MINE VENTILATION

BRANCH – MINING ENGINEERING

SEMESTER – 4TH SEM

ACADEMIC SESSION - 2022-23

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Natural Ventilation

- small and shallow mines are sometimes ventilated by naturally main only through the ventilation in such of cases is usually work. fluctuated. To a large extend and is even subject to reverse of the direction.
- In the case of emergency such a fire underground, Mechanical vent. can be subjected control by natural ventilation can't be It is for this reason all mine should be preferably be Mechanical ventilated.
- How ever, natural ventilation does play in a role in all Mechanical mines.

Cause of Natural ventilation or Factor affecting by natural ventilation

- Temperature.
- Moisture contains of the air.
- Barometric pressure
- Addition of gas.
- Leakage,
- Circulation of refrigerated air.

Other Factor

- spring of water in the down cast shaft.
- unequal depth of shaft.

(i) Temperature

Natural ventilation can be visualized to be caused by the diff. in density of air in up cast shaft and down cast shaft.

→ The heavy cool air sinks down and the lighter air moves up these setting of an air current.

→ The diff. in air density in upcast and down cast shaft is mainly cause by the heating and rarefaction of air in the mine working due to the addition of heat from roof, man, machinary, light & spontaneous heating, mine fire etc.

Auto compression in the down cast shaft.

Change in the density of air and the effect of change of the density of air is max^{m} at the bottom of the shaft but the reverse process takes place at the upcast shaft due to Auto expension so the result carry there is no diff. betn the average air density in the two shaft. and hence natural Ventilation Auto compression and Auto expension.

Moisture containing of air :-

→ Addition of moisture in a down shaft decrease of the density of air.

→ moisture is lighter than air - but this also cause evaporate cooling of a down sast and consequent increase in heat in density so that in effect evaporation of moisture in the down cast shaft usually Aids natural Ventilation.

Barometric pressure :-

→ It is well natural air density is a fun^{n} of Barometric Pressure.

→ If the main barometric pressure of the down cast shaft air column is higher than of the the up cast shaft air column,

→ It help natural ventilation and reverses flow - ever since barometric pressure rarely, varies to any appreciably extend. from place to place. within the limit of mining properties, the effect of such variation is negligible,

Addition of gas:-

→ Methane emitted from the working coal mines, the reduced the density of return air thus adding natural ventilation.

→ Large addition of carbon dioxide on the other hand has the opposite effect.

→ Addition of compressed air from exist of Compressed the air machinary used underground has little effect of air density.

Leakage:-

→ In multi level mines. leakage of cooler down cast air to the up cast shaft caused and increase in the density of up cast air. thus reduced the natural ventilation.

Circulation refrigerated air:-

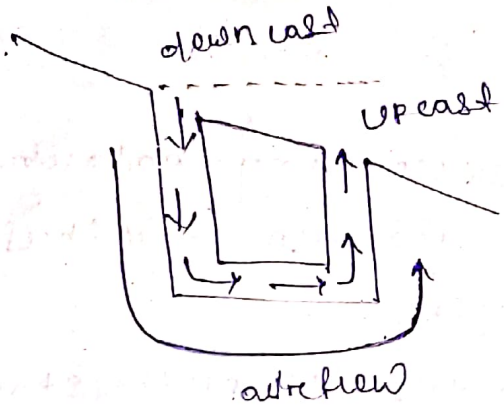
→ Circulation refrigerated air through the down cast air. Increase the density of down cast air. thus. adding natural vent.

to the large extend.

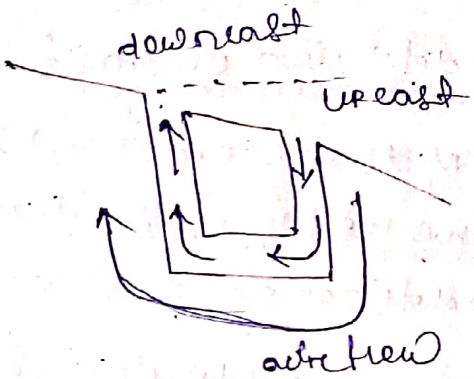
* The quantity of air circulated by natural ventilation, depends on above factors, then the most important factors being the heat added to the air from the strata bounding.

*

In case of summer season



In case of winter season



Types of damps :-

(i) fire damp :- A mixture of air and methane (explosibility limit 5.4% to 14.8%)

(ii) Black damp :- CO_2 + excess nitrogen.

(iii) white damp :- carbon monoxide.

(iv) stony damp :- hydrogen sulphide.

(v) after damp :- The gases present after explosion in the mine CO is the main constituents.

Different types of Instruments :-

→ detection of carbon monoxide gas (CO)

(i) P-S detector.
(ii) Hopcalite detector.
(iii) Hopcalite tube.
(iv) Dragen Multigas detector.

(i) P-S detector :-

- This detector consist of a glass tube containing silicagel impregnated with light yellow potassium palladium sulphide with silica gel. At both end for absorbing other gases. A fixed vol. of air is drawn through the tube at a constant weight over a period of two minutes. through a calibrated orifice, by a operating rubber aspirator. carbon monoxide in the air turns the light yellow potassium palladium sulphide to the brown and the length of colour change from one end tube indicates the concentration.

→ The range of percentage is 0.0032% to 0.12%.

(ii) Hopcalite detector :-

→ The generation of heat on the oxidation of carbon monoxide to Carbon dioxide has been utilized by a detector.

→ In Hopcalite detector manganese dioxide and copper oxide is used.

→ Here is drawn into the cell by a hand operated pump.

→ Carbon monoxide in the air is catalytically oxidised by hopcalite and the rise in temp.

SO, produced is recorded by thermocouple connected to a meter which is calibrated in the percentage of carbon monoxide (CO).

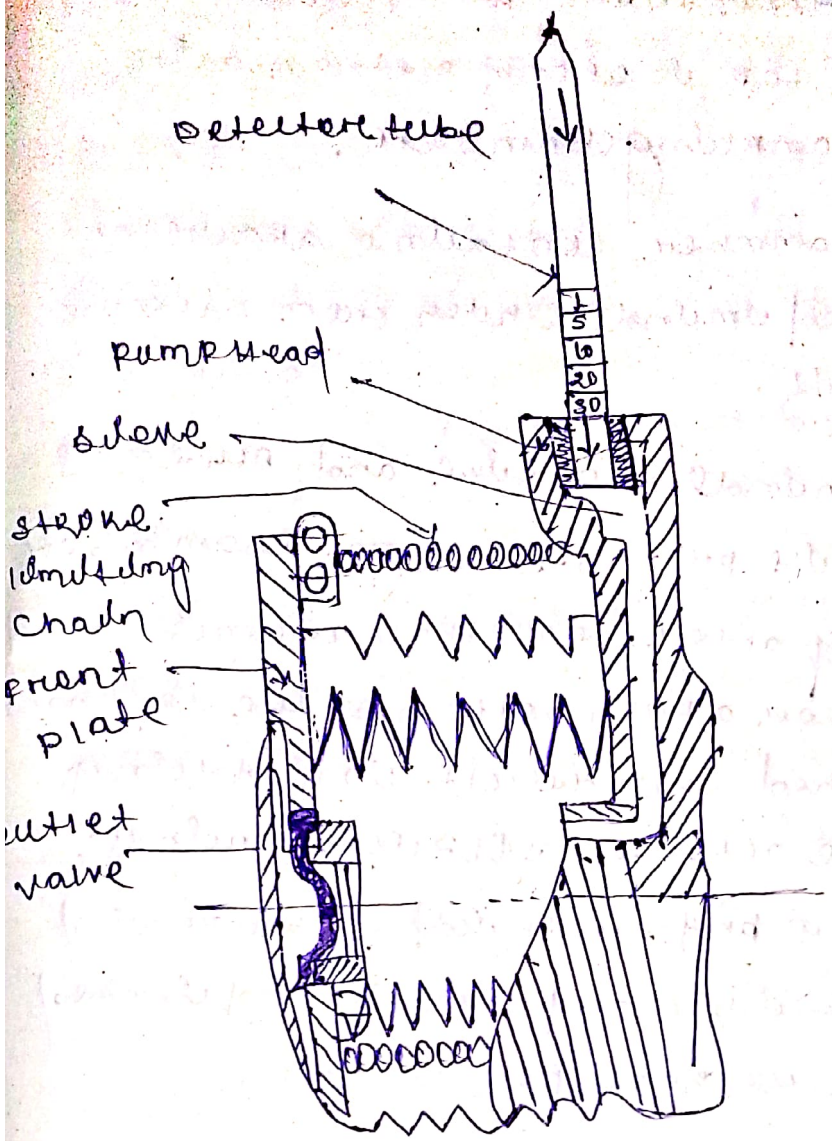
- Range of Instrument from 0.005% to 0.015% CO.

(iii) Hopcalite Tube :-

- In another detector hopcalite which is a mixture of iodine pentoxide and sulphuric acid is used.
- The greyish white colour of hopcalite tube converted to a shade of green, brown or black by the reaction of CO which liberated iodine.
- The percentage of CO may be estimated from a colour chart.

(iv) Dragger Multigas detector :-

- A kind of dragger has produced a very convenient and handy instrument for detection of not only CO but also other gas.
- The instrument is used for on the spot determination of the gas percentage.
- If CO is to be detected a tube containing chemical is sealed at both end and marked 'CO', is fitted at the spot of detection into a hand operated bellow type pump after breaking the sealed tips at both the ends.

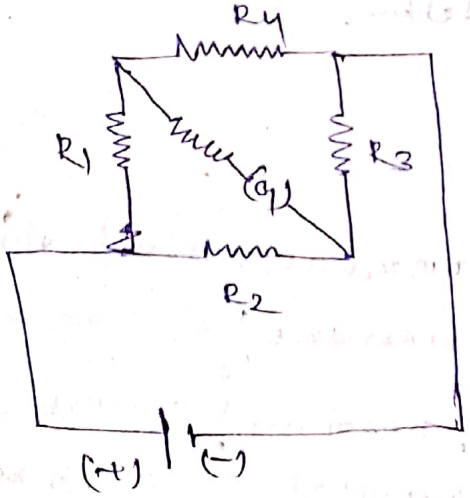


(CO detector tube)

Methanometer :-

- Methanometer is commonly used in India coal mine to detect the methane gas percentage.
- It is portable hand held and suitable for spot checking of gas accumulation with measurement range from 0-5% vol.
- It is battery operated instrument. Rechargeable cadmium battery in series in methano-meter.
- The methanometer work on the principle of wheatstone Bridge and diffusion of gases.

- At the start of detection, when the rotary dust cover at the top is opened methane air mixⁿ enter the sampling chamber.
- The sampling chamber contains a pair of treated pellistered filaments which form half of wheatstone circuit.
- one pellistered filament is active and other is reactivity but it prevents the gas chamber assure stability after the methane air mixture has the way in the meter a push button on the left hand of side. It is pressed this result in unbalancing of the gas on the active pellistered filament thereby creating and electrical unbalanced the wheatstone bridge and this is indicated on the meter the methane percentage.



(wheat stone bridge circuit)

Whirling hygrometer :-

- This Instruments is used measured relative humidity.
- The consist of two thermometer mounted side by side on a scale. from.
- one thermometer was grey bulb that

- The other thermometer has wet bulb covered with a cloth (Muslin cloth) which dips in to a small bottle filled with water. Constant evaporation of moisture takes place from the wet bulb.
- Thereby cooling heat and bringing down the temp.
- When the air is relative dry it has a lower relative humidity. There is large diff. between reading of dry bulb and wet bulb.
- When the air is nearly saturated the two readings have nearly any difference.
- A hygrometer is convenient in underground mine measured the relative humidity.
- When the along with thermometer is united in RH in percent annuli.
- The reading of dry bulb & wet bulb enable the operator to calculation the RH from table.

Formula :-

$RH = 100 - 7(T_D - T_W)$	$T_D > 25^\circ C$
$RH = 100 - 8(T_D - T_W)$	$20 < T_D < 25^\circ C$
$RH = 100 - 9(T_D - T_W)$	$T_D < 20^\circ C$

Q.

If the difference between dry and wet bulb temp is 4°C, the dry bulb temp is 32°C, calculate the relative humidity in percentage?

Sol:- Given the data.

$T_D = 32°C$

$T_W = 28°C$

$R.H = 100 - 7(T_D - T_W)$

$= 100 - 7(32 - 28)$

$= 100 - 7(4)$

$= 100 - 28 = 72\%$

Date - 04.03.23

Kata Thermometer :-

→ To judge whether a working place is suitable for man to work efficiency and without discomfort,

→ It is necessary to know the temp of air at the working place, the relative humidity and air velocity.

→ The joint effect of all these factors can be known with the help of kata thermometer which measures the cooling power by a combination of the above mentioned three factors at the instrument temp of 36.5°C,

→ The bulb is immersed in hot water carried in a thermal flask until the alcohol rises above the upper graduation.

→ The bulb is wiped dry and the time required for the alcohol column to drop from the upper mark to the lower mark is noted.

→ The procedure is repeated with a wet muslin cloth warpped on the bulb.

→ An Instrument factor is marked on every Instrument. The kata factor of an Instrument is the number of millicalories of heat which it loses per sq. cm.

→ Surface area of the bulb on cooling from 38°C to 35°C. It is nearly 480.

$$\text{cooling power} = \frac{\text{Kata factor}}{\text{Time in sec. for alcohol to fall from upper}}$$

Barometer :-

→ It is an Instrument to measure the atmospheric pressure.

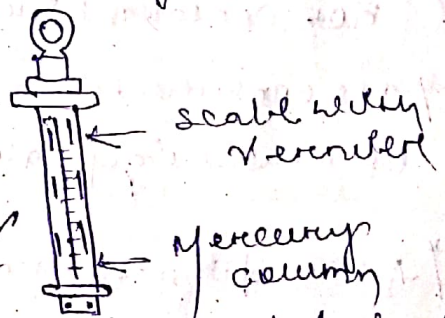
→ The standard atmospheric pressure, also called the mean or normal atmospheric pressure.

→ It is defined as that pressure which supports a column of mercury 760 mm high at the sea level when the temp of the Mercury is 0°C.

The Barometer is divided into two types.

(i) The Fortin Barometer.

(ii) The aneroid barometer.



(i) The fortin Barometer :-

→ This is the standard form of barometer and is of refined construction being used in scientific work for accurate measurement of the atmospheric pressure.

→ It is consists of a straight glass tube about 920 mm long, and about 8 mm inside diameter.

→ the upper end being sealed and the lower end

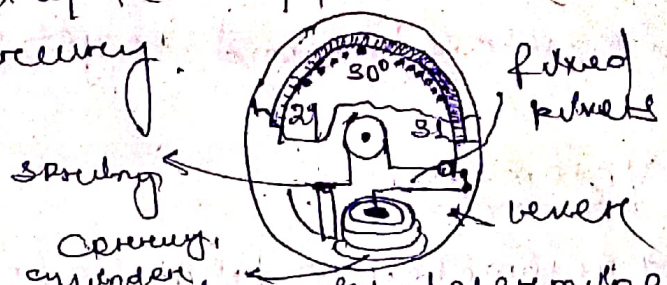
dipping into a small boxwood cistern of mercury having a soft chamois leather base.

- An adjusting screw and plate beneath the flexible bottom enable the level of mercury in the cistern to be adjusted.
- When the instrument is to be moved, the plate may be raised until the lower end of the tube is sealed.
- Before any reading is taken, the level of the mercury must be adjusted so that its surface just touches the tip of an ivory pointer.

(ii) aneroid barometer :-

- This instrument is much more portable (ಪೋರ್ಟೆಬಲ್) and convenient than a mercury barometer for determining differences of level.
- It is much used by prospectors and also in certain types of ventilation surveys.
- The term aneroid means that the instrument does not contain liquid.
- Its construction is based on a different principle of measuring atmospheric pressure.
- According to the Boyle's law a given mass of gas increases in vol, as its pressure fall and the vol, decreases as the pressure rises, temp. remaining the same.
- It consists of hollow, airtight, partially exhausted box made of thin springy corrugated metal and prevented from collapsing by means of a strong flat spring.

- The scale is graduated to read pressure from 700 to 780 mm of mercury.



Anemometer :-

- Anemometer is an Instrument which determines the distance travelled by air in a given time.
- It is used to find out velocity of air in a mine roadway.
- velocity multiplied by area of cross section of roadway gives the quantity of air flowing.
- A commonly used type of anemometer consists of a fan of 100 mm dia.
- having its vanes at 40° to 45° to the direction of the air flow.
- When held in a roadway, the travelling air rotates the fan and through gearing arrangement,
- the needles of a small and a large dial of anemometer show the distance travelled.
- other parts of the Instrument are a clutch for engaging and disengaging the levers, a zero setting lever for bringing the needles back to zero after taking a reading.
- A handle at the top for carrying the Instrument, and a threaded hole at the bottom to receive a stick-holder.
- The Instrument is suitable for measuring velocities from 1 to 15 m/second.
- It is provided with a correction chart showing

the correction to be applied to observed velocity in metre/second to get correct velocity.

Velometer :-

- Velometer indicates air velocity in metre/second at any point of observation.
- anemometer gives average velocity over a period of time.
- To find air velocity in mine roadway by velometer, reading are taken at a no. of equally spaced points over the cross-section, and the average is calculated.
- The Instrument consists of an aluminium vane mounted in jewelled bearing in a bakelite case.
- When held in the roadways, air flows through vane.
- Deflection is proportional to air velocity.
- It is shown by the pointer on the scale in m/s.
- The mechanism is spring balanced so that the Instrument can be tilted or held upside down to facilitate reading in any upward plane.
- By operating a clamp, the vane and needle can be locked in reading position.
- By changing inlet nozzle 3 velocity ranges can be obtained : 0 to 15 m/s, 0 to 1.5 m/s. and 0 to 0.3 m/s,
- Velometer is useful, particularly for measuring very low velocities.

Anemometer :-

$2\pi r / \pi D$

$\frac{\pi DN}{60} = m/s$

*Natural ventilation pressure =

(Metre column × velocity of air D/c shaft)

$$H = \frac{Tv - Td}{273 + Tv} \times \frac{0.4645\ B}{273 + Td}$$

H = Height

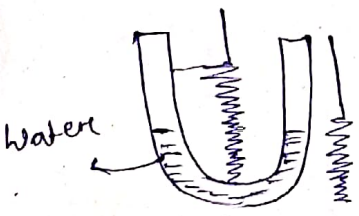
B = Barometer.

Manometer :-

* Pressure measurement instrument :-

(i) U-tube manometer.

(ii) Inclined manometer. (Used to measure low pressure)



$p = \rho g h$

$p_1 - p_2 = \rho g h$

Standard of Ventilation CMR 2017 :- (Regulation - 104)

[A] quantity of air in ventilation district at should be.

1. Minimum 6 m^3/min per person employed in the district on the largest shift.

2. More than 2.5 m^3/min per daily tonne output.

B. Underground air should not have less than 19% oxygen.

C. Underground air should not have more than 0.5% of CO_2 and other noxious gases.

D. Inflammable gas should be below 0.75% in general body of air of return air of any ventilation district and 1.25% at any place at the mines.

E. Wet bulb temp^n should not exceed 33.5°C if it exceed 30.5°C at any place of than the velocity of air should be more than 1m/sec

Law of mine air friction :-

Air flow in mines two ways :-

(i) Laminar

(ii) Turbulent.

Reynold's number :-

$$Re = \frac{VDS}{\mu}$$

$$Re = \frac{VD}{\mu K}$$

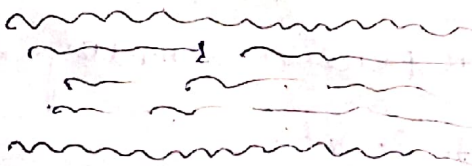
Where, V = velocity (m/s)

D = dia of the air way $\left(\frac{4A}{P}\right)$

S = Density of air

μ = viscosity of fluid.

C Boundary layer condition :-



→ velocity will be max^{n} at centre.
→ If we move away from centre airc velocity get reduced.
→ Air velocity is reduced due to friction betn air and surface of airc way.

Pressure loss in mines due to resistance :-

(Atkinson's equation) :-

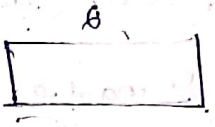
$$\Delta P = \frac{KSQ^2}{A^3}$$

where, K = co-efficient of friction (Ns^2m^{-2})
S = rubbing surface area (m^2) (S = 2 × b(L+B))
Q = quantity of air m^3/s S = 2(h+w)×l
A = Area (m^2) $\therefore \left(\frac{K \cdot S}{A^3} = R\right)$

$$\Delta P = RQ^2$$

Question :-
Calculate the pressure required by the fan to ventilate a district of size (6×4)m. of length if the co-efficient is 0.2 quantity of air flow in airway is 1200 m^3/min.

Ans



K = 0.2
l = 1000m
Q = 1200 m^3/min

$= \frac{1200}{60} = 20\ m^3/sec.$

S = 2 × 1000 (6+4)
= 2000 × 10 = 20000

$$\Delta P = \frac{KSQ^2}{A^3}$$

$$= \frac{0.2 \times 20000 \times 400}{13.1324}$$

$$= 115.74 \text{ (Pascal)}$$

Distribution of air :-

(1) Brattice cloth / partition :-

→ It is also cost temporary arrangement step or divert air flow.

→ Impermeable and fire proof cloth.

→ It is hung tightly to the roof to reduce the leakage of air.

→ It is used for smaller headings.

(2) Stopping :-

→ It is closed to isolate one part to the other part of the mine.

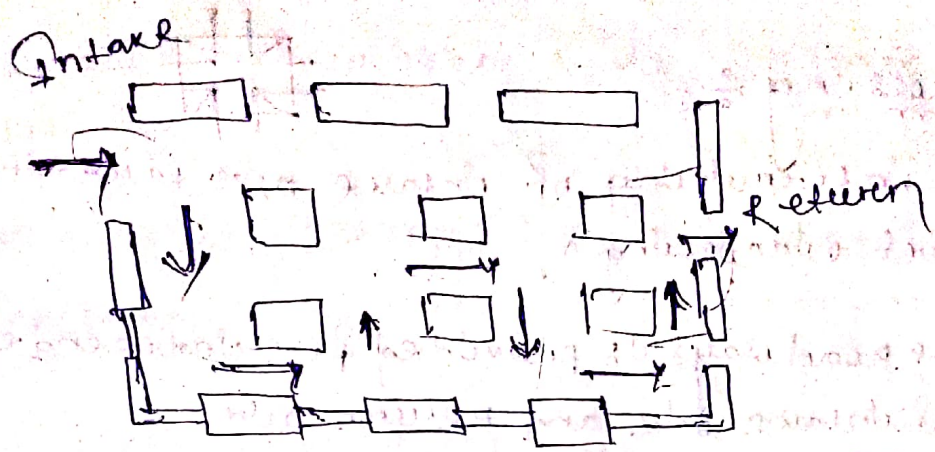
→ Types of stopping :-

(i) Temporary stopping :- It is made for crossing of air (low cost)

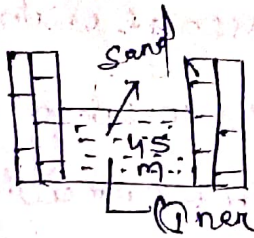
(ii) Permanent stopping :- It is made for isolation or sectionalisation (high cost)

→ fire proof stopping (made up to brick thickness > 33cm)

→ explosion proof stopping (made up of brick and concrete)



RCC (Reinforce cement concrete)



(Inert material)

→ As per CWR :-

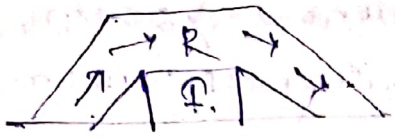
- Brick stopping thickness 25 cm.
- Concrete stopping thickness 15 cm.

(3) DOOR (D) (made up of cast iron)

- It help to create passage from one side to other and in rest of the time it works as stopping.
- It is generally used bet^n main intake and main return.
- We can used door on travelling road ways haulage line etc
- We can used door in district intake and district return.
- Door must open towards high pressure region (Intake), so that it closes automatically.
- Door must be open towards intake sight so that it does not required tackling or attendant.

(4.) Air crossing :-

- To avoid intermixing of intake air to return air (short circuiting).
- A separate roadways is provided for independent passage of intake air and return air.
- Air crossing must be leakage proof to avoid short circuiting of intake air.



Types of air crossing :-

(i) Temporary air crossing :- It is made up of corrugated sheet duct (GI pipe) used in narrow headings. Low cost

(ii) Permanent air crossing :- It is made up of Concrete arched thickness > 25 cm.
Brick thickness > 18 cm concrete

- used for distribution air movement main intake and return.
- Higher cost access throughout life of mine.

(i) Natural air crossing :-

- Return air way is excavated above the intake airway.

→ It doesn't require any brick or concreting and walling.

→ It gives less leakage compare to artificial airways crossing.

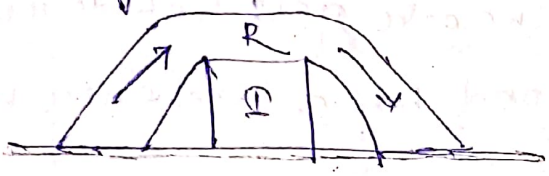
(ii) Natural airways crossing :-

→ Airway is excavated using brick or concrete wall.

→ It is required brick or concrete wall when separate airway provided for intake and return

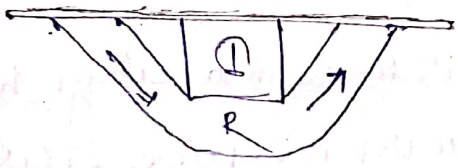
(i) Over head :-

→ Return airway is made by supporting roof of intake airway.



(ii) under head :-

→ Return airway is made by dug up below intake airway.



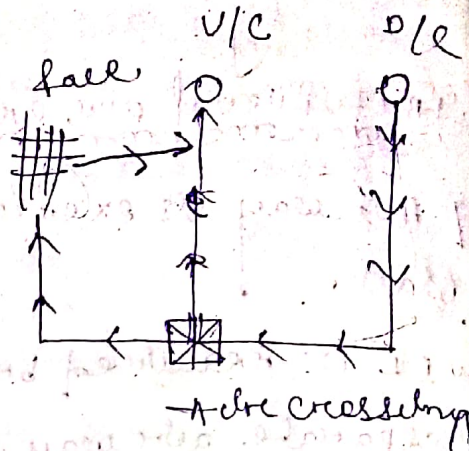
Face - Moving part of any working place is called face

Types of Ventilation :-

(1) Ascensional ventilation :-

→ Air is taken to the bottom and allowed to rise and reach to working until it reaches return.

→ Provided good air to working workers.



Ascensional ventilation is preferable because :-

→ Fire damp being lighter than air is readily carried to higher levels.

→ Natural ventilation pressure assists the fan ventilation because the air gets hot during travels in the mine and has a tendency to go the higher level.

→ If fan should stop the air will continue to flow in the same direction by natural ventilation.

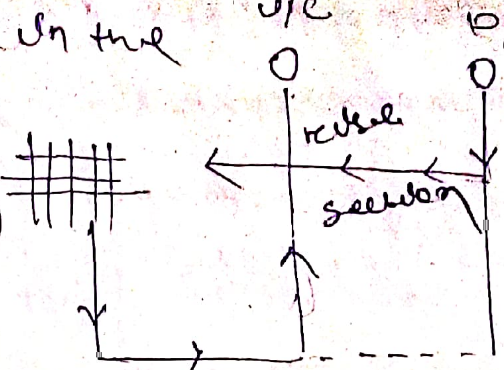
Disadvantages :-

→ Air carries lot of moisture making humid atmosphere and it will reduce efficiency of workmen.

(2) Descensional Ventilation :-

→ The air is forced to move through return airway and it goes to the bottom until it reaches return.

→ It provided adverse air in the working compare to ascensional ventilation.



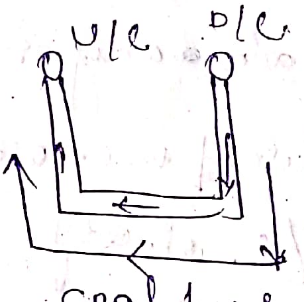
→ It dilute harsher air like black damp as it has higher density compared to ascensional ventilation.

→ Does not assist natural ventilation pressure.

(3) Homotropal :-

→ When the air and mineral flow in the same direction of the ventilation is called Homotropal ventilation.

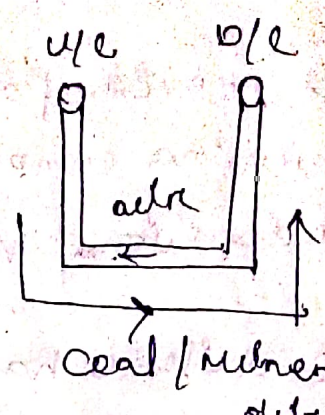
advantages :- In homotropal ventilation the coal dust generate is less compare to antitropal ventilation, the changes of coal dust explosion will be less.



(4) Antitropal ventilation :-

→ When the air and mineral flow in the opposite direction, the ventilation is known as Antitropal ventilation.

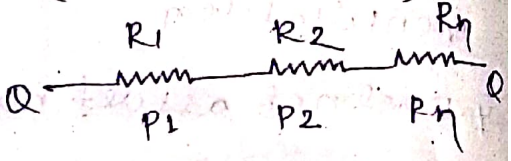
→ In antitropal ventilation the coal dust generate is more and the chances of coal dust explosion will be more.



Ventilation network analysis :-

Series connection :-

(pressure loss)



$P_{Total} = P_1 + P_2 \cdots P_n$

$R_{Total} Q_{Total}^2 = R_1 Q^2 + R_2 Q^2 \cdots R_n Q^2$

$Q_T = Q_1 + Q_2 \cdots Q_n$

$$R_T = R_1 + R_2 + R_n \cdots R_n$$

If $R_1 = R_2 = R_3$

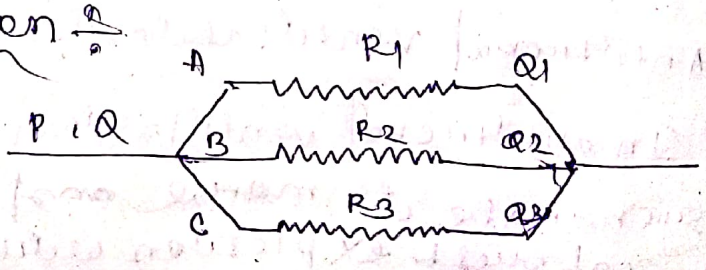
$$R_T = n \times R$$

Q. 25 mtr airway of 0.6 NS²/M² of resistance each find the total pressure loss to maintain 60 m³/s. of qty.

⇒ $P = RQ^2$

$= 25 \times 0.6 \times 60^2 = 54$ K pascal.

Parallel Connection :-



→ pressure loss in parallel circuit remains same.

→ air get distributed as per the resistance of each airway.

$P_1 = P_2 = P_3 \cdots = P_n = P_{total}$

$Q_{total} = Q_1 + Q_2 + Q_3 \cdots Q_n$ $\quad [Q = \sqrt{P/R}]$

a) $\sqrt{\frac{P_{total}}{R_{total}}} = \sqrt{\frac{P_1}{R_1}} + \sqrt{\frac{P_2}{R_2}} + \sqrt{\frac{P_n}{R_n}}$

b) $\frac{1}{\sqrt{R_{total}}} = \frac{1}{R_1} + \frac{1}{R_2} \cdots \frac{1}{\sqrt{R_n}}$

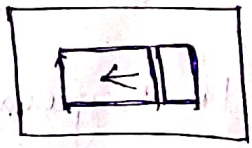
$R_1 = R_2 \cdots = R_n$

$\frac{1}{\sqrt{R_{total}}} = \frac{1}{\sqrt{R_1}} + \frac{1}{\sqrt{R_2}} \cdots \frac{1}{\sqrt{R_n}}$ $\quad R = \left(\frac{1}{\frac{1}{\sqrt{R_1}} + \frac{1}{\sqrt{R_2}} + \frac{1}{\sqrt{R_3}}}\right)^2$

$\frac{1}{\sqrt{R_{total}}} = \frac{n}{\sqrt{R}} = R = R_1 = R_2 = R_n$

$R_{total} = R/n^2$ $\quad n =$ no. of resistance

A ↑	R ↓
A ↓	R ↑



Regulator :-

a) A regulator door is installed on the stepping is known as regulator. It is increases the resistance of airway causing reduction flow of air.

→ It increases the total resistance of the mine thereby increases the cost.

→ The area required to be open in the stopping to add resistance is known as equivalent orifice.

Area of Regulator = $\frac{1.190}{\sqrt{P}}$ (m^2) or $\left(\frac{1.19}{\sqrt{R}}\right)$

Area of equivalent orifice = $\frac{\sqrt{f}\,Q}{0.625\sqrt{2P}}$

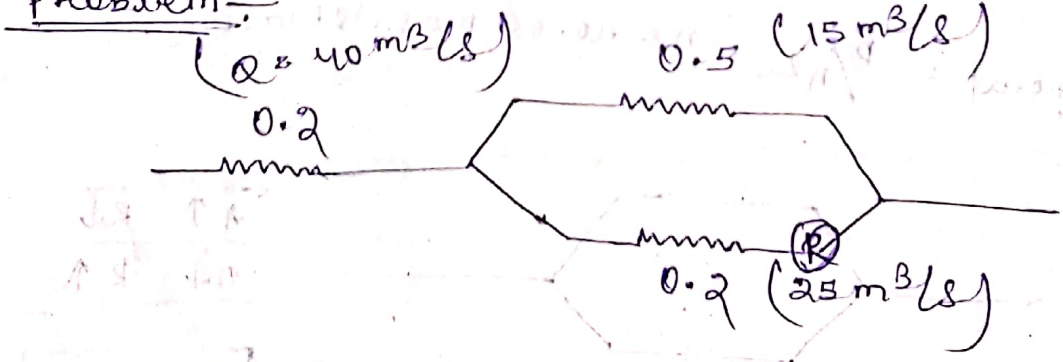
P = pascal, Q = m^3/s

$$\text{Area of Regulator} = \frac{1.19}{\sqrt{R}} \ (M^2)$$

(R = Resistance)

$$R = \left(\frac{1.19}{A}\right)^2$$

Problem:-



If Regulator is 2.5 m^2 then calculate total mine Resistance also calculate, the air in split A and B after Regulator is been placed.

Given data:

R = 0.2

Where A = 2.5 m^2

$$A = \left(\frac{1.19}{\sqrt{R}}\right)^2$$

$$= \left(\frac{1.19}{\sqrt{0.2}}\right)^2$$

$= 0.226$

$$\frac{1}{\sqrt{R}} = \frac{1}{\left(\frac{1}{\sqrt{0.5}} + \frac{1}{\sqrt{0.426}}\right)^2}$$

$$= \left(\frac{1}{1.41 + 1.53}\right)^2$$

$$= \left(\frac{1}{2.94}\right)^2$$

$$\boxed{R = 0.115}$$

$$P = 0.2(40)^2 + 0.5(15)^2$$

$$= 1600 \times 0.2 + 0.5(15)^2$$

$$= 112.5$$

$$Q = \sqrt{\frac{P}{R}} = \sqrt{\frac{112.5}{0.226}} = 15$$

$$Q = \sqrt{\frac{112.5}{0.2 + 0.226}} = 25$$

$$R_{Total} = 0.2 + 0.115 = 0.315$$

$$P = RQ^2$$

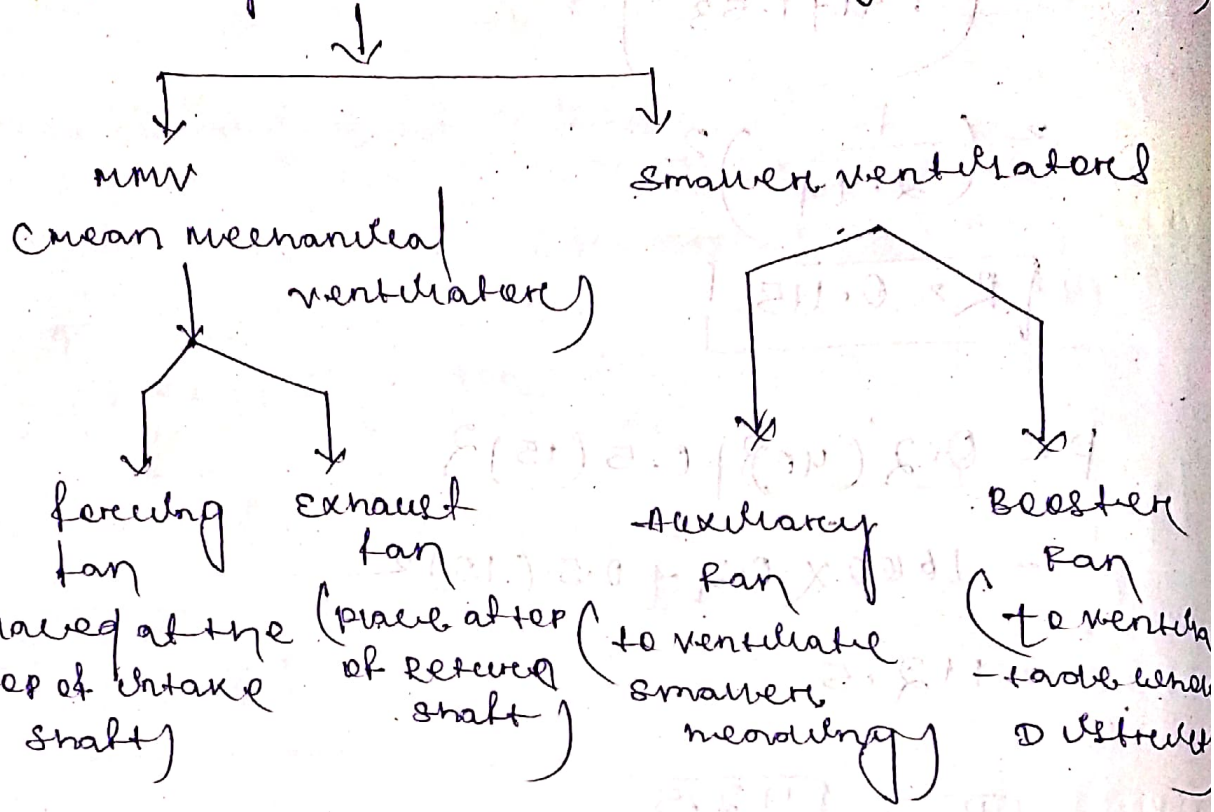
$$= 0.315 (40)^2$$

$$= 502.4$$

Unit-3 :- Mechanical Ventilation :-

Mechanical ventilation mean when we ventilate the mine with the help of fan is known as mechanical / Artificial ventilation.

Types of Fan (According to position)



Forcing Fan :-

- It means it used to forcing the air to ventilate and move air from one place to another place.
- It handle clean air required less maintenance.
- It helps to increase the air power as it handle clean air.
- It is suitable for homotherical ventilation.
- It is suitable for dissensional ventilation.
- It provide air at higher pressure compared to atm pressure.

→ Additional fan can be installed at U/C shaft to augment required ventilation.

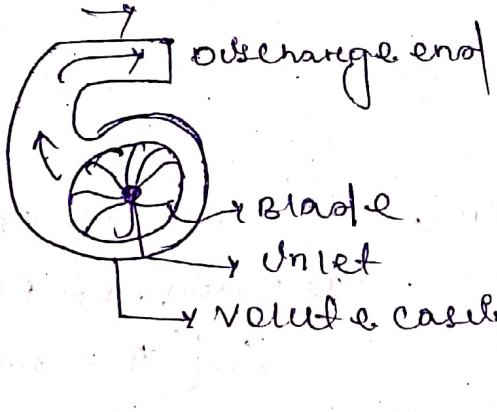
Exhaust Fan :-

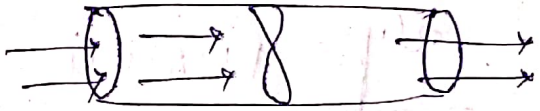
→ It handle dusty and corrosive gases.
→ It required high maintenance,
→ It is suitable for artificial ventilation.
→ Fan doesn't add heat to the mine atmosphere.

(Types of Fan) (According to design and construction)

↓ ↓

Centrifugal Fan | Axial Fan





(Air move axially)

Back worked bladed fan [$\theta < 90°$]

$p = fgh$

where,

$$h = \frac{v^2}{g} - \frac{v u \cot\theta}{g}$$

Radial bladed [$\theta = 90°$]

$p = fgh$

where,

$$h = \frac{v^2}{g}$$

Forward bladed [$\theta > 90°$]

$p = fgh$

where,

$$h = \frac{v^2}{g} + \frac{v u \cot\theta}{g}$$

Tangential velocity / (Blade tip velocity) (V)

$V = \omega \times r$

where,

ω = angular velocity $\left(\frac{2\pi N}{60}\right)$

$\therefore$

$V = \frac{2\pi N}{60} \times r$ $\left[\frac{D}{2}\right]$

$$V = \frac{2\pi N D}{60}$$

where, D = Dia of fan

N = No. of rotation or rpm

Radial velocity / (u)

Quantity = Area × u

qty = $\pi D W \times u$

$$u = \frac{qty}{\pi D W}$$

where, W = width of fan (m)

D = Dia. of fan (m)

$\therefore [\pi = 3.14]$

Head developed = HB > HR > HF

qty = Area × velocity

$m^3/s = m^2 \times m/s = m^3/s$

Air power = Pressure × qty

$= N/m^2 \times m^3/s$

$= Nm/s$ (Joule/s) = watt

Problem :-

A fan of 3m dia has blade rotating at 300 rpm find tangential velocity produced, if the fan has radial bladed handle find the pressure.

Here, D = 3m

N = 300 rpm

$$V = \frac{\pi DN}{60} = \frac{3.14 \times 3 \times 300}{60}$$

$$= 47.1$$

$$h = \frac{V^2}{g} = \frac{(47.1)^2}{9.81}$$

$$= 226.13$$

$$P = \rho g h$$

$$= 0.55 \times 9.81 \times 226.13$$

$$= 124.48 \text{ mm wg (Ans)}$$

(2) centrifugal fan blade angle 135°, produce discharge of 3200 m³/min if dia of fan is 4m, width 1.5m. find the head developed by fan if it rotated at 600 rpm.

Given data :-

$\theta = 135^\circ = 90^\circ - 135^\circ = 45^\circ$

N = 600 rpm

$$Q = \frac{3200}{60} = 53.33 \text{ m}^3/\text{s}$$

D = 4m, b = 1.5m

$$\phi = \frac{Q}{\pi DW}$$

$$= \frac{53.33}{3.14 \times 4 \times 1.5} = 10.90$$

$$V = \frac{\pi DN}{60} = \frac{3.14 \times 4^2 \times 600}{3 \cancel{60}} = 125.6$$

forward bladed (H)

$$H = \frac{V^2}{g} + \frac{uv \cot\theta}{g} = \frac{(125.6)^2}{9.81} + \frac{125.90 \times 125.6 \times \cot 45^\circ}{9.81}$$

Maximum fan capacity :

$$Q_{th} = \text{Area} \times C_{max}$$

C_{max} = maximum possible Rad/a velocity

$$\boxed{V \tan\theta}$$

where, V = tangential velocity

θ = blade angle

Fan efficiency calculation :

$$\boxed{\text{eff} = \frac{\text{output}}{\text{Input}}}$$

(Electrical power) — (Mechanical power) — (Air power)

$$\boxed{\eta_E = \frac{MP}{EP}} \qquad \boxed{\eta_m = \frac{AP}{MP}} \qquad \boxed{\eta_o = \frac{AP}{EP}}$$

$$\eta_o = \frac{AP \times MP}{EP \times MP}$$

$$= \frac{AP}{MP} \times \frac{MP}{EP} = \frac{AP}{EP}$$

$$\boxed{\eta_o = \eta_m \times \eta_E}$$

Electrical efficiency :

ϕ_1 (single phase) $\boxed{E.P = V.I}$

ϕ_3 $\boxed{EP = \sqrt{3}\, VI \cos\theta}$

[$\cos\theta$ = power factor]

Mechanical power :

$$M.P = W \times T$$

$$= \frac{2\pi N}{60} \times T$$

$$\boxed{M.P = \frac{2\pi NT}{60}}$$

Where,

T = force x perpendicular distance

$\boxed{T = F \times \theta}$

Centrifugal Fan	Axial Fan
✓ It is larger in size as compared to axial fan	✓ It is smaller in size.
✓ It is created less noise as compared to axial fan	✓ It is very noise.
✓ It is very high cost fan.	✓ It is very low cost fan
✓ It changes the direction of air flow at right angle	✓ It doesn't changes the direction of air flow.
✓ Installation of centrifugal fan is very complicated.	✓ It is very easy to installed.

Fan Law :-

$Q \propto N$ $\quad P \propto N^3$

$Q \propto D^3$ $\quad P \propto D^5$

Q = qty

N = Rotation per min

P = Power

D = Dia. of Fan

Q.

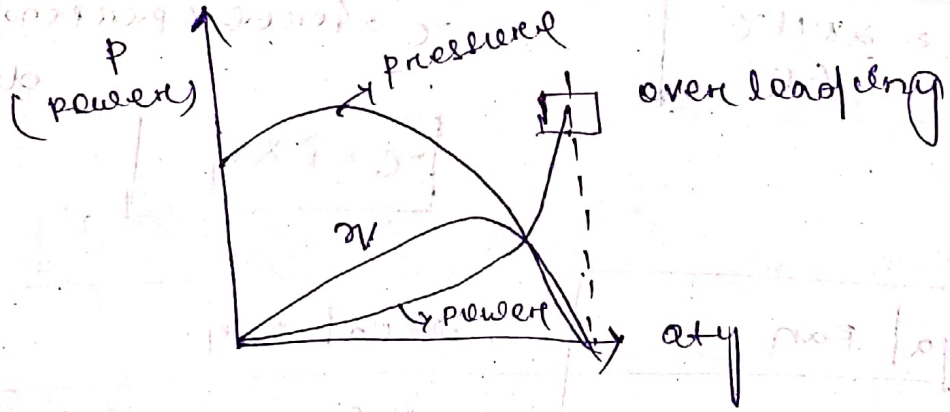
$Q_1 = 20 m^3$, $Q_2 = 40 m^3$

$N_1 = 500$, $N_2 = ?$

$\frac{Q_1}{Q_2} = \frac{N_1}{N_2}$ $\Rightarrow$ $\frac{20}{40} = \frac{500}{?}$

$\Rightarrow \frac{500 \times 40}{20} = 1000$

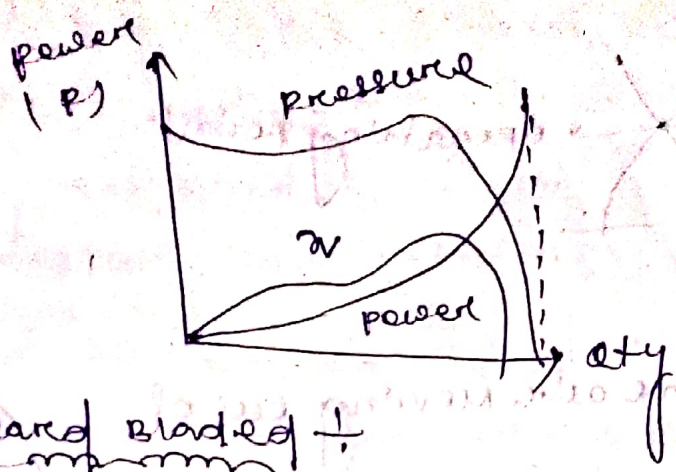
Fan Characteristics curve :- (Centrifugal Fan)



- Power requirement increase in quantity
- It should overloading characteristics.
- pressure provided by fan directly with variation of Q.

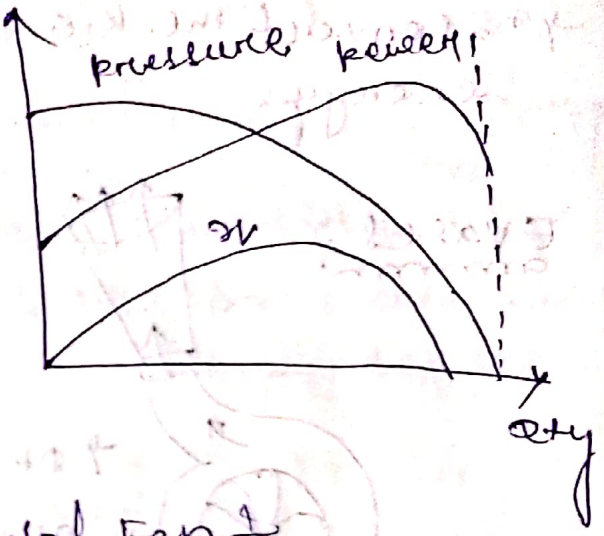
(2) Forward bladed :-

- when same Q, power requirement goes above required power, causing overload.

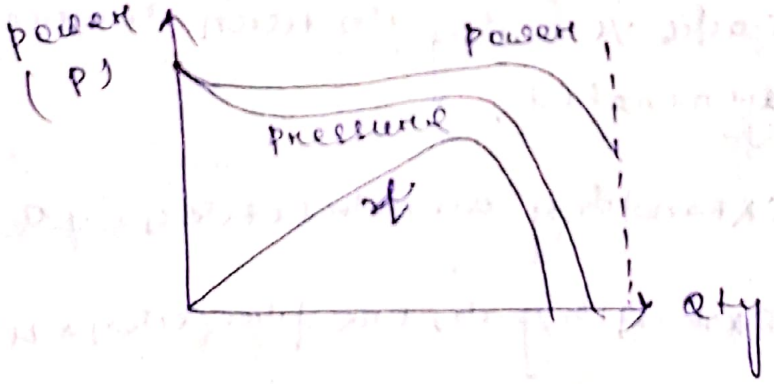


(B) Backward bladed :-

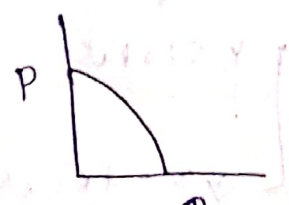
- pressure fall steeply with small variation of Qty.
- power required become constant and reduced at max^{n} Qty.



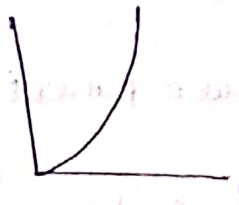
Characteristics of axial Fan :-



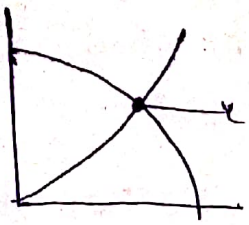
Fan characteristics and mine characteristics/ operating point :-



(mine characteristics)



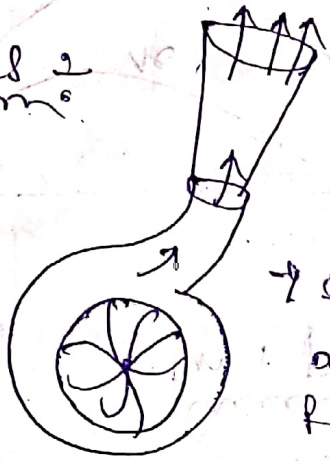
(Fan characteristics)

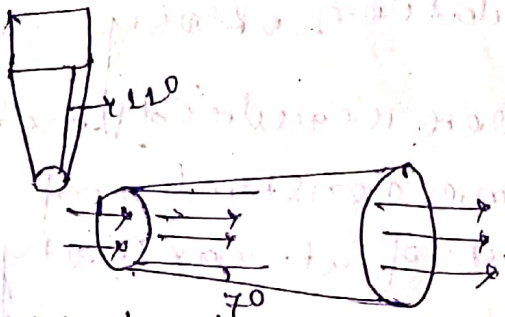


Diffuser :-

- It guide the air moving out of impeller.
- It convert the K.E to pressure energy.

Evasel :-



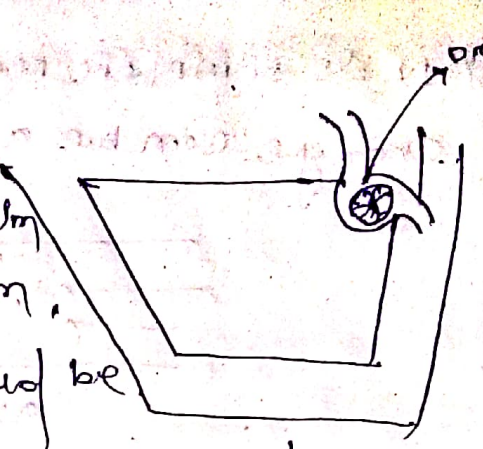


- It has gradual increase of area to air of discharge from fan.
- It reduced the air velocity in turn increasing the pressure generated.
- Evasel { expanding all direction = 70 ; expanding in one direction = 11° }
- Increase in area decrease velocity and pressure also decrease in velocity pressure which leads to in static pressure.
- A fan generated two pressure [static ; velocity]

static - cause dty add when

velocity - cause movement.

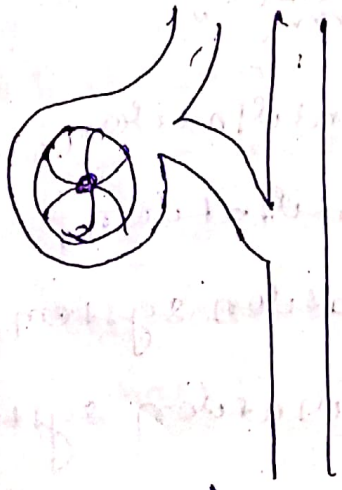
Fan Drift :



- Fan Drift should be carefully designed here minimizing pressure loss in them. For this reason they should be short smooth, wind and with gradual area change
- Bend should be as wall al possible of large radius. the Drift should be open into the shaft well below the banking level (head gear level) to accumulation the surface air less and should have a large area of opening with well rounded edges.

Reversal of centrifugal Fan :

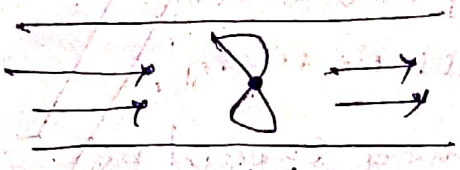
- separating doors are provided to change direction of air flow (air locks).
- costly system to be build and requires maintance



Reversal of axial flow fan :

- The air flow can be reversed by changing the stator rotor connection

→ It is simplest method instantly airflow change can be achieved.



axial Fan.

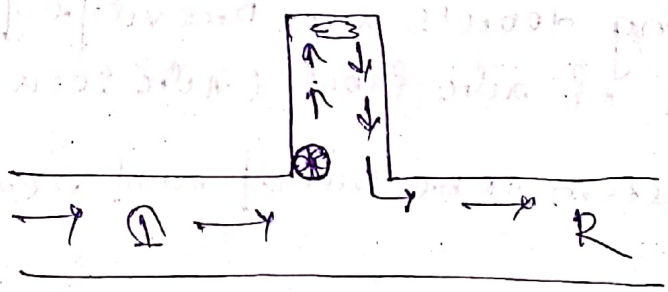
Unit-5 → Auxiliary ventilation →

What is auxiliary ventilation?

It is used to ventilate part of district, narrow heading, tunnel or drift.

→ It is used to reduced dust, humidity, gas concentration.

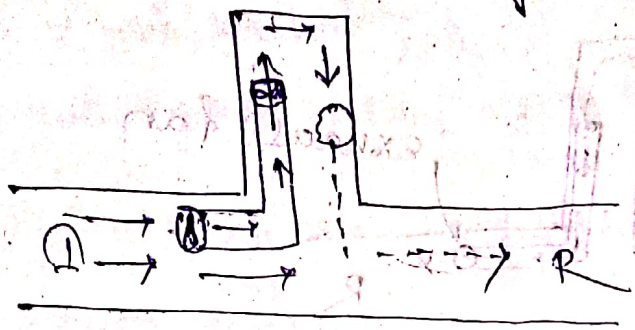
→ Axial flow fan is used for auxiliary ventilation.



Types of Auxiliary ventilation →

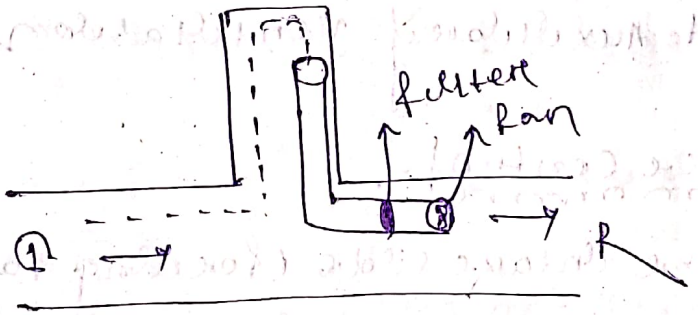
(i) forcing type Auxiliary ventilation.
(ii) exhaust type Auxiliary ventilation.
(iii) overlapping Auxiliary ventilation system.
(iv) Reversible auxiliary ventilation syste

(i) Forcing type Auxiliary ventilation →



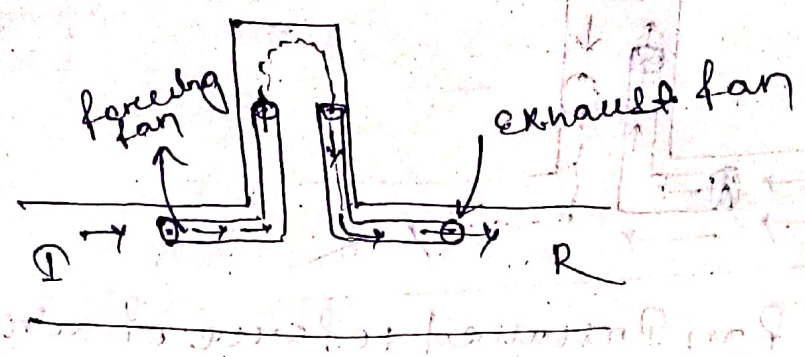
→ A forcing fan installed to force of air into heading through duct. (diagram)
→ But exhaust of air from the heading is slower and it will cause formation of dust cloud and high gas cone. The chances of coal dust fire/amp explosion.

(ii) Exhaust type Auxiliary ventilation →



→ exhaust fan attached with duct to removed removed gases, dust from working area,
→ Rate of air entering to the working area is slower so, removal of dust, gases, humid is slower.
→ Dust cloud formation near the mouth of exhaust dust.

(iii) Overlapping Auxiliary ventilation system



→ Inter locking type system used.
(if one fan stop other fan stops automatically)

→ Higher initial cost.

→ If one fan stop may created dangerous accumulation of dust and gases for this we have to use inter locking system.

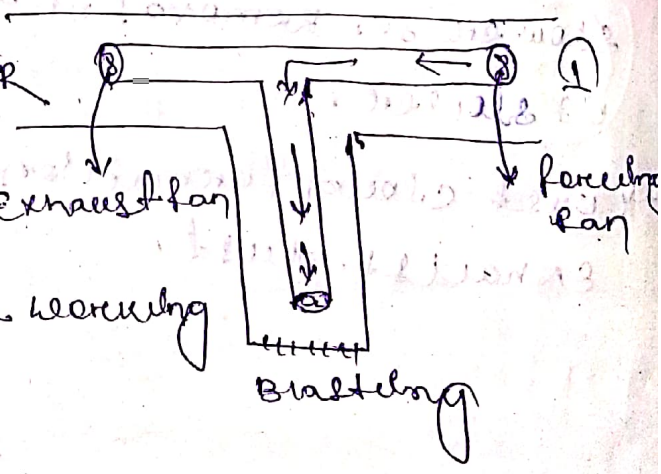
→ It has the advantages of both forcing and exhaust auxiliary ventilation system.

Sequence control :-

Unless the intake side (forcing fan) start return fan (exhaust fan) remain idle.

(iv) Reversible auxiliary ventilation system

→ It is a combination of forcing and exhaust fan (used at a time)



→ Forcing is used to provide fresh air at working area.

- Exhaust system is used to blasting remove dust, after blasting.
- one of the system used at a time.

Ex:- Shaft sinking (Reversible Auxiliary ventilation system).

* Advantage and disadvantage of auxiliary ventilation system.

Advantage	Disadvantage
- It is low cost ventilation system. - It is easy and simple method. - required small fan to ventilate heading. - It needs gas cont. and dust formation.	- It is used to ventilate small part of restrict. ore heading. - It causes formation of dust. - Intern locking system fails then it causes the stoppage of one fan results causes formation of gas, dust. - Leakage of air from duct may cause inefficient of this system.

Date-28/03/2

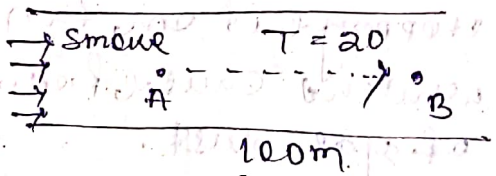
Unit-6 :- Ventilation survey :-

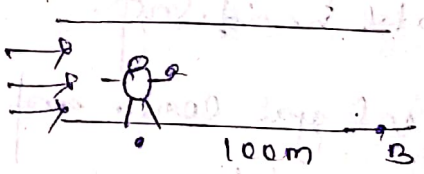
- Quantitative survey
  - (i) Pressure survey.
  - (ii) Quantity survey (A x V)
    - Area survey
    - velocity survey
- Qualitative survey
  - (i) Air constituent (CO_2, N_2, CO...
  - (ii) pathogenic dus
  - (iii) Gas conc.
    - Inflammable
    - Toxic gas
    - Non-toxic gas

Quantitative survey :-

Velocity survey :- (3 ways)

(i) Smoke cloud method :-





$$V = \frac{100\,m}{20\,s} = 5\ m/s$$

↳ Some smoke is generated by burning stone and the crystalline tetrachloride is added together to create smoke cloud.

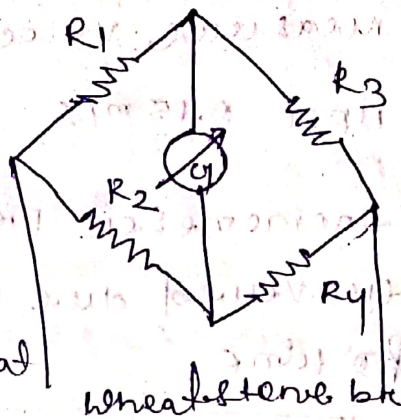
↳ Smoke is allowed to move on a straight path for a distance of 8-10m.

→ Accuracy of 90%, correct of measurement 9-12%.)

Hot Wire Anemometer :-

→ It is used the principle of unbalanced wheatstone bridge.

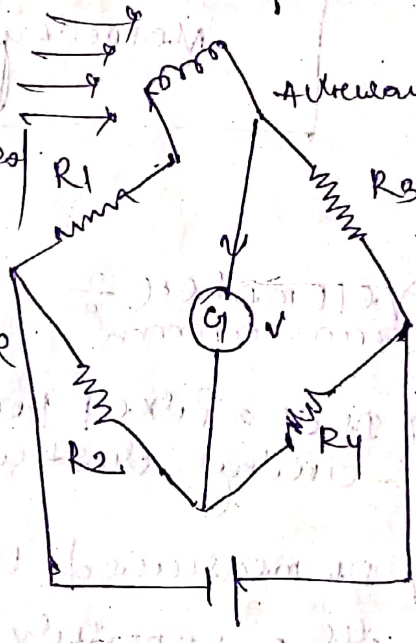
i.e if $\frac{R_1}{R_2} \neq \frac{R_3}{R_4}$, then 'I' flows through 'V'.



Wheatstone bridge

→ In this equipment one arm of wheatstone bridge is exposed to airway, causes change of heat produced in arms.

→ The unbalanced ratio of arms that caused flowing of current through 'V'.



→ Then velocity can be determined w.r.t corresponding current flow.

→ It is highly sensitive reliable and measures at low velocity.

$\frac{R_1}{R_2} = \frac{R_3}{R_4}$ No (I) in 'V'

Vane Anemometer :-

Angular velocity $= \frac{2\pi N}{60}$

$\frac{\pi D \times N}{60}$

Linear velocity

$V = \omega \times r$

$V = \frac{2\pi N r}{60} = \frac{\pi D N}{60}$

N = No. of rotation per min.

r = radius of Anemometer.

D = Diameter of Anemometer.

$V = \frac{\pi D N}{60}$

→ Vane angle = 0.785 Rad or 45°

Rad × 180/π = degree

Linear velocity = 2πrN/60 × r

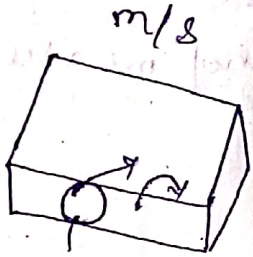
→ Most popular equipment.
→ Measure velocity correctly upto 0.15 m/s at 90% accuracy = πDN/60
→ Anemometer provides reading of distance travelled due to rotation of blades at certain time.

If time taken for 'n' Rotation is 'T', Velocity = πDn/T

π/180 = 0.01

Velometer :-

→ It is a fixed point velocity measuring instrument.

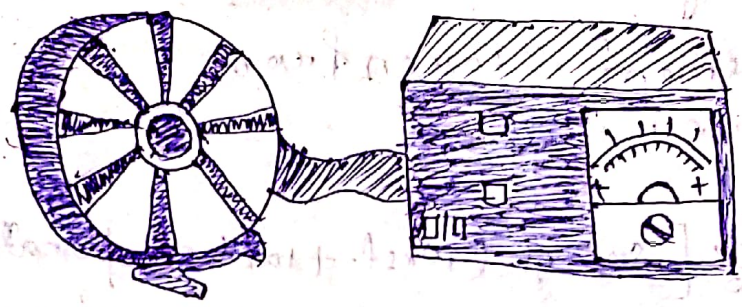


→ It measured low velocity and its a sensitive equipment.
→ It has 3 range 1st 0 – 0.15 m/s
and 0 – 5 m/s
3rd 0 – 15 m/s

→ The use of micro circuits makes the instrument not only compact and trouble free but also permits measurement of air flow rate

accuracy of ± 2%.

→ Besides the advanced electronics, the design incorporated many outstanding features like the specially designed vanes pivoted on jewels which make it extremely sensitive to airflow.



(Velometer)

→ The instrument consist of a sensing head and an indicator unit.

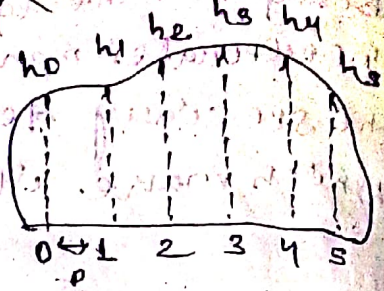
→ The head is either mounted on the indicator unit or a portable head with extension cable and a polarised connection is available.

→ The head incorporates a rotating vane type non-optical, non magnetic and non-contact transducer which is unaffected by vibration, dust, temp. or humidity. This transducer generates electrical signals having a frequency directly proportional to the rate of air flow through the head. These signals are then converted to a direct current, which drives an indicating meter calibrated in terms of flow rate per minute or meters per second.

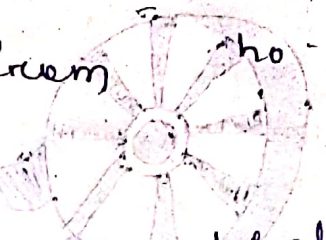
Area Measurement Technique :-

* TAPE triangulation :-

Tape is used to measured height across always.



* The measurement is taken from equidistance points.



Area (m²) = $\frac{D}{3}$ [sum of (first + last ordinates) + 4 (sum of even ordinates) + 2 (sum of odd ordinates)]

Area = $\frac{D}{3}$ [(h0 + h5) + 4 (h2 + h4) + 2 (h1 + h3)]

Q A vane Anemometer measure the velocity as 2.5 m/s if cross sectional Area is measured by tape with equidistance point at 0.6 m. distance. find the quantity of air flow (m³/s) ordinates as → 2.1 m, 2.5, 2.8 m, 3 m, 3.5 m

Area = $\frac{D}{3}$ [(h1 + h5) + 4 (h2 + h4) + 2 (h1 + h3)]

= $\frac{0.6}{3}$ [(2.1 + 3.5) + 4 (2.5 + 3) + 2 (2.1 + 2.8 + 3.5)]

= 0.2 [5.6 + 22 + 16.8]

= 8.88 m²

Q = A × V

= 8.88 × 2.5 = 22.2 m³/s

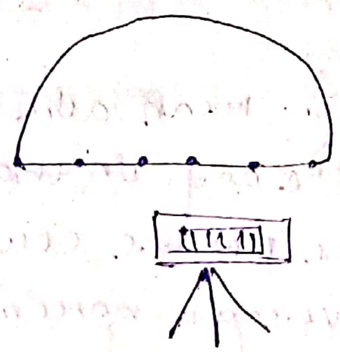
$= \frac{0.6}{3}[2.1+3.5+4(2.8)+2(2.5+3)]$

$= 5.56 \times 2.5$

$= 13.9 \ m^3/s$

* **Plane table survey (Profilemeter) :-**

Cross sectional area is first drawn on a sheet at smaller scale. Area of close traverse is measured by planimeter



→ Manual drawing creates observational error.

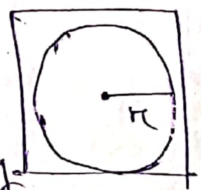
Profilometer :-

It is similar to pantograph.

→ It draws on the sheet, reducing obs. error. It is quicker and accurate.

* **Craven's contour method :-**

An adjustable brass rod is rotated at the center of air way until it is hindered by any side of airway.



→ It measures of imaginary Air way.

= 1.157

N.V.P = 12.8 × 1.157 = 14.80 kgf/m²

= 148.0 Pa

Leakage of air in mines

The sources of Leakage of air that goes down the mine are :-

- Doors of fan drift and air lock. If the air lock is provided with glass windows to admit natural light at the pit top, a broken glass pane causes heavy leakage.
- Where air lock is not provided, the space between the cages and shaft walls and also between the cages and pit top loading level is a source of leakage. If the pit top landing level is covered by a wooden lid which is lifted by the ascending cage, the arrangement permits of substantial leakage.
- ventilation stopping, ventilation doors and air crossing.
- In the longwall method of coal mining, the road-side pack walls if the goaf is not sealed, provide

- Broken or crushed pillars of coal.
- Wrong setting of underground booster fan.

Preventive measures of leakage of air in

- Air locks at the pit top should be properly
- Doors of the airlocks and of the ventilation
  have rubber lining for leakage - proper closing
- Precautions should be taken to see that both
  the doors of an airlock are not opened simu
  -taneously and this point should be impresse
  upon the workers.
- Have the underground intake and return air
  apart as possible and have very few connection
  between them.
- All the underground ventilation doors, ventil
  -ation stopping and aircrossing should be
  well constructed and maintained.
- In longwall method of coal mining worked out
  packwalls should be well constructed to avoid
  leakage through them.
- Where the pillars of coal / mineral are broke
  or cracked, sometimes due to heavy roof
  pressure as in the vicinity of extraction
  / stoping area or near fault zones, they
  should be coated by spraying of cement-
  mortar.

- For reducing leakage it is preferable to use a large number of low pressure fans instead than a single fan producing high pressure.

Vapour pressure :-

- The pressure exerted by the gas in equilibrium with a body of its liquid in a closed container at a given temp. is called vapour pressure.

1. Booster Fan :-

- The fan used to ventilate (booster the original quantity) above district.
- It handled the total quantity of air of the district.
- It should be compact i.e axial flow fan are utilized.
- It should be placed in return side,
  - * reduced heat addition to district.
  - * avoid humidity to travel long passage.
  - * To avoid dust in the district atmosphere
  - * chance of spark an explosion due to coal dust reduced.

* Centrifugal pump :-

→ It converts mechanical energy to hydraulic energy by virtue of centrifugal force which is in radial outward direction.

→ It works on principle of forced vortex flow.

Principle :-

→ conversion of energy occur by virtue of two main parts of pump.

(a) Impeller (b) casing

→ Impeller converts driven energy into the kinetic energy and diffuser converts kinetic energy into pressure energy.

Components :-

(a) Impeller (b) casing (c) suction pipe

(d) foot valve and strainer

Applications :-

→ centrifugal pumps are used a variety of application.

→ Almost 70/80 % centrifugal pumps are used by industry or for domestic purpose.

→ mining domestic appliances.

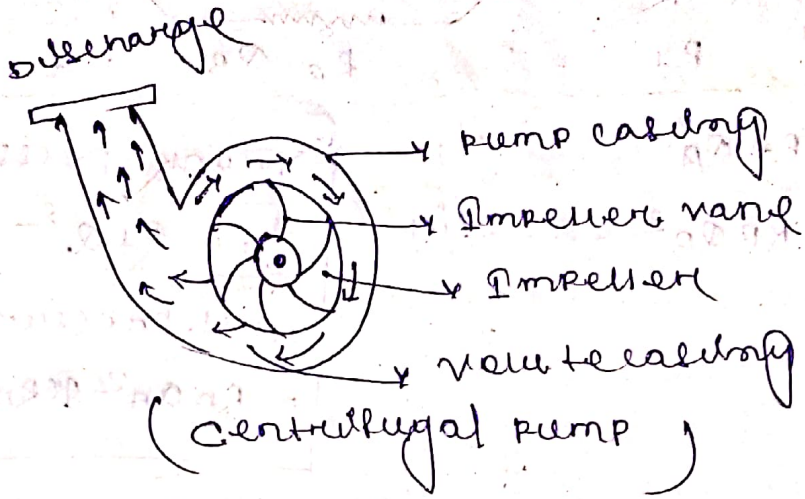
Advantages :-

→ low power consumption.

→ used for domestic / commercial purpose.

Disadvantage :-

- Poor suction.
- Produce cavitation.
- Corrosion.



(Centrifugal pump)

* Critical pressure :-

Booster fan create such pressure that net flow of air in other split that pressure is critical pressure.

* Neutral point :-

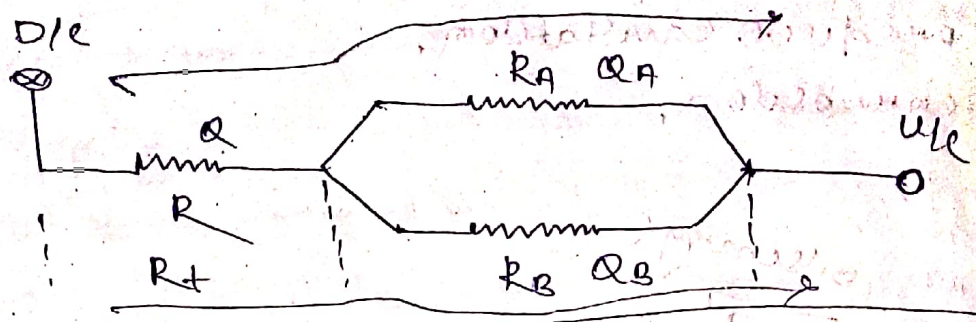
The place at which booster fan is placed, such that pressure difference bet^n intake and return is equal pressure produced by booster fan.

Problem :-

If a booster fan to be placed in split B to increase the qty to 15 m^3/s. Find Q_{total}, Q_A, P_B (Pa)

Ans :-

Without Booster Fan :



$P = R_+ Q^2 + R_A Q_A^2$ ----(i)

$P = R_+ Q^2 + R_B Q_B^2$ ----(ii)

Trunk pressure loss

$\therefore P = R_+ Q^2$

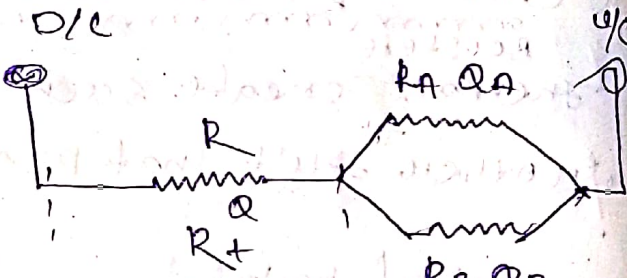
Split pressure loss

$= R_A Q_A^2 \text{ or } R_B Q_B^2$

With Booster Fan :

$P_T = R_+ Q^2 + R_A Q_A^2$ ----(i)

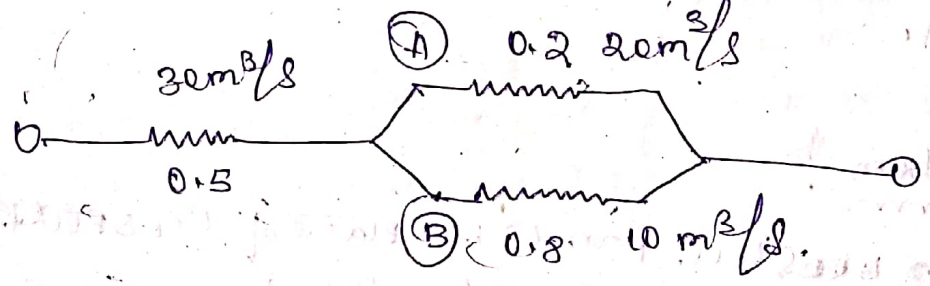
$P_T = R_+ Q^2 + R_B + Q_B^2 - P_B$



* pressure produced by booster fan (-)

Problem :

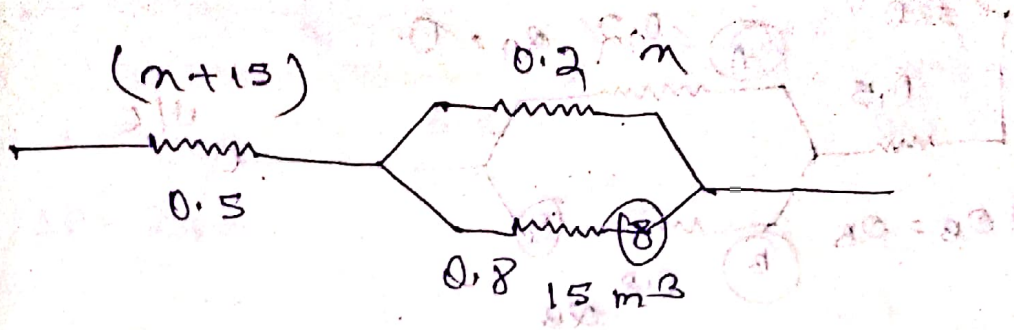
Ans :



$P = 0.5 (30)^2 + 0.2 (20)^2 = 530$ Pascal

$P = 0.5 (30)^2 + 0.8 (10)^2 = 530$ Pascal

After Placing Booster :-



$530 = 0.5(n+15)^2 + 0.2(n)^2$

$n = 15.95 \text{ m}^3/\text{s}$, $Q_t = Q_A + Q_B = 15.95 + 15 = 30.95$

$P_t = 0.5 \times (15.95 + 15) + 0.8(15)^2 - P_B$

$590 = 195.475 - P_B$

$P_B = 395.475 \text{ N/m}^2$

$P_B = 395.475$

$530 = 0.5(30.95)^2 + 0.5(15)^2 - P_B$

$530 = 658 - P_B$

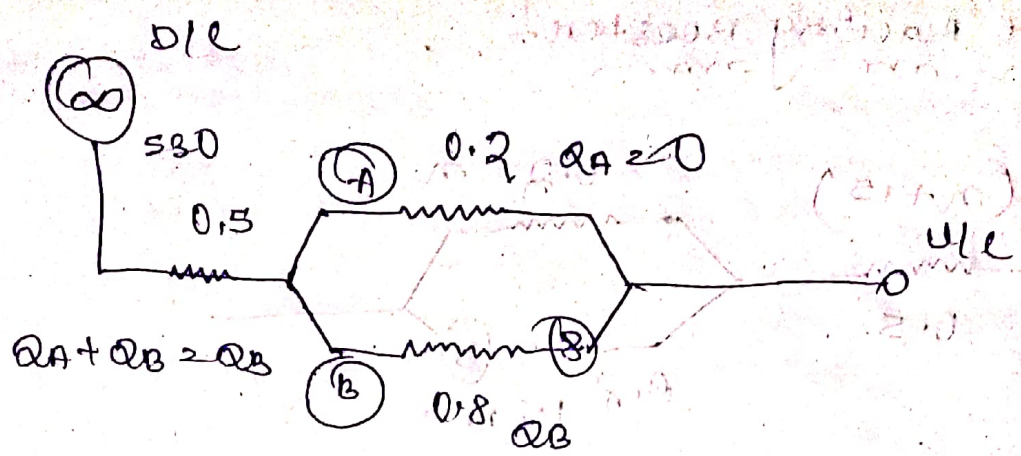
$P_B = 658 - 530$

$P_B = 128$ pascal.

Problem :- 2

In the above circuit of a booster fan placed in split B caused stoppage of air flow to split A. find Q_{total}, Q_B, P_B (Pa).

Ans :-



By split A : $530 = 0.5 Q_B^2 + 0.2 (Q_B)^2$

$\Rightarrow 0.5 Q_B^2 + 0$

$$Q_B = \sqrt{\frac{530}{0.5}} = 32.55 \text{ m}^3/\text{s}$$

Split B :

$530 = 0.5 Q_B^2 + 0.8 (Q_B)^2 - P_B$

$\Rightarrow P_B = 0.5 (32.55) + 0.8 (32.55) - P_B$

$P_B = (-530) + 529.75 + 848$

$= 848.$

Atkinson's equation :

$$\Delta P = \frac{KSQ^2}{A^3}$$

$\therefore \frac{KS}{A^3} = R$

$P = RQ^2$

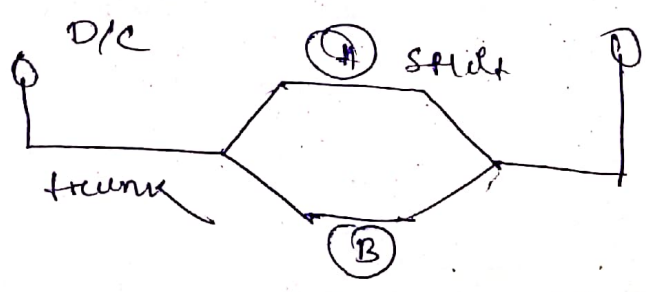
* We will take always pressure constant throughout the calculation

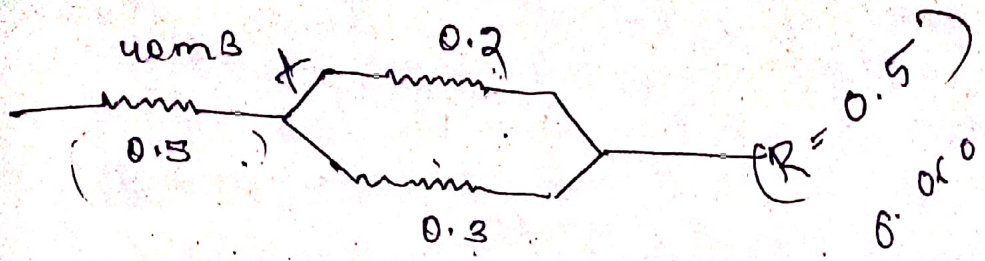
K = coeff. of resistance

S = Resisting surface area

Q = quantity

A = Area



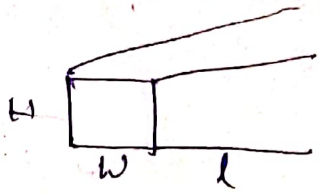


$\Delta P = RQ^2$

$\frac{1}{\sqrt{R}} = \frac{1}{\sqrt{R_1}} + \frac{1}{\sqrt{R_2}}$

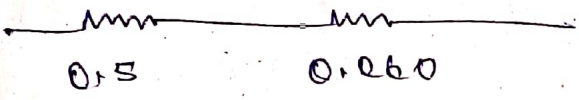
$R = \left(\frac{1}{\frac{1}{\sqrt{0.2}} + \frac{1}{\sqrt{0.3}}}\right)^2$

$= 0.060 \ (Ns^2 m^{-8})$



perimeter $= 2 \times (H + w)$

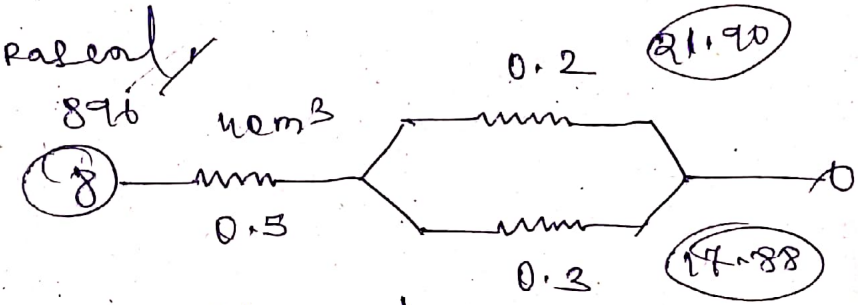
$S = 2 \times (H + w) \times \text{length}$



$R_T = 0.5 + 0.060 = 0.56$

$P = 0.56 \times 40^2$

$= 896$ Pascal



$\Delta P = 0.5 (40^2)$

$= 800$

$96 = 0.2 \times (Q^2)$

$Q = \sqrt{\frac{96}{0.2}} = 21.90$

$\Delta P = 896 - 800 = 96$ Pascal

$96 = 0.3 (Q^2)$

$Q = \sqrt{\frac{96}{0.3}}$

$= 17.88$