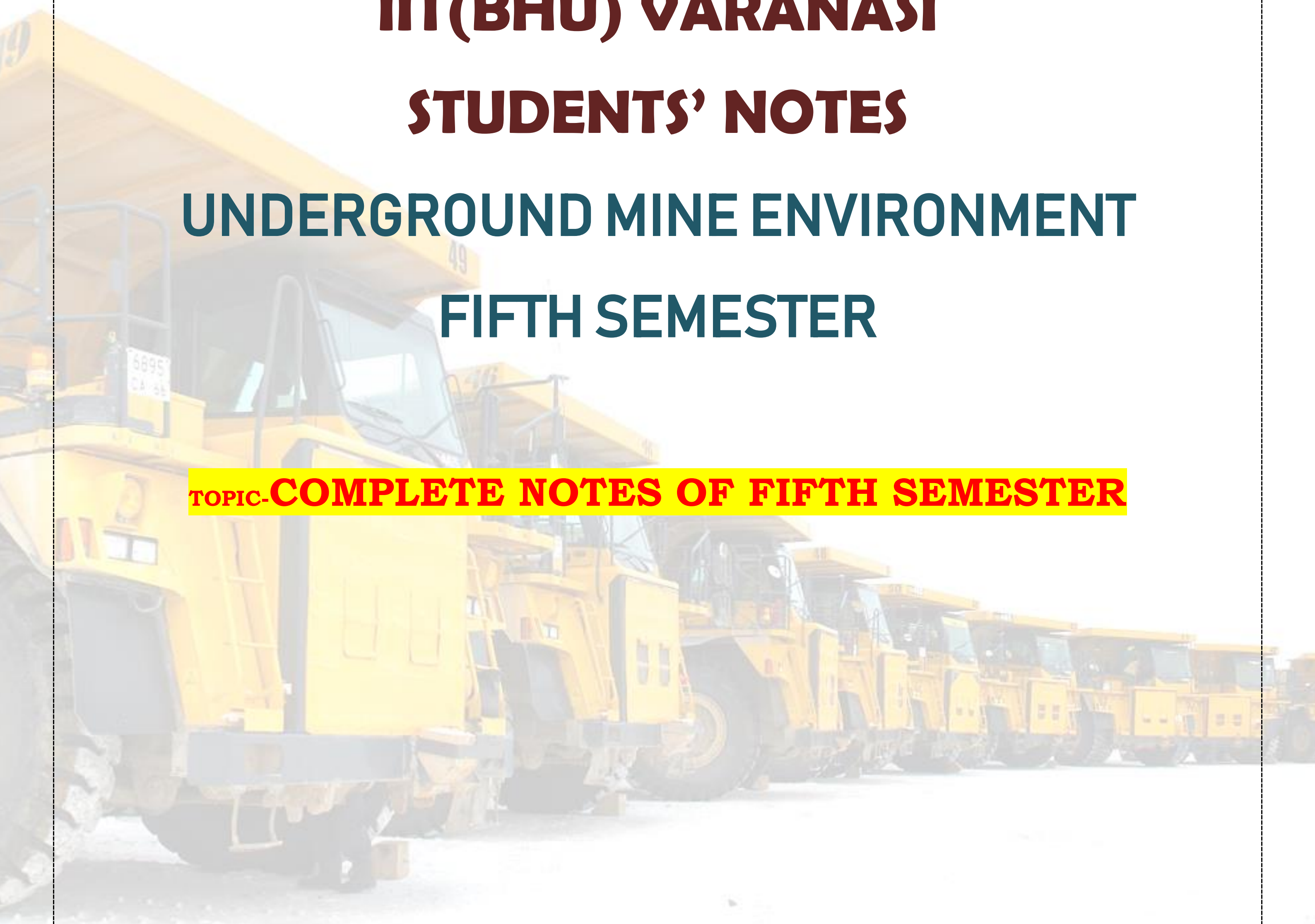

IIT(BHU) VARANASI

STUDENTS' NOTES

UNDERGROUND MINE ENVIRONMENT

FIFTH SEMESTER

TOPIC-COMPLETE NOTES OF FIFTH SEMESTER

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NCK Sir

29/07/2013

Aitkinson Equation:—

$P = RQ^2$

- Q → rate of air flow
- R → airway resistance
- P → Pressure difference

R unit → Ns^2m^{-8}

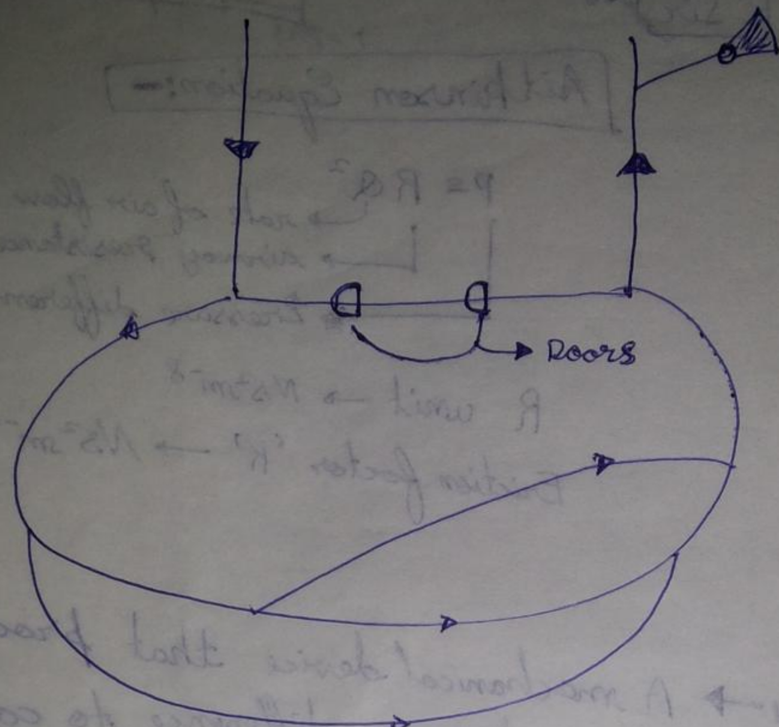
Friction factor 'K' → Ns^2sm^{-4}

Fan → A mechanical device that produces air pressure difference to cause airflow.

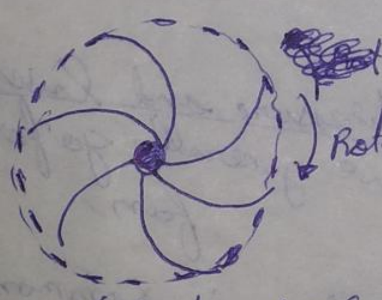
Types
- axial flow fan → The flow of air is along the axial direction.
- Centrifugal → It utilizes centrifugal force of rotating air to cause airflow

For very high pressure and low volume:— we generally go for centrifugal fan.

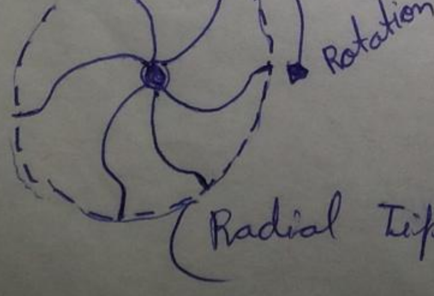
⟹ Axial flow fans is commonly used in mines. Large volume of air is handled



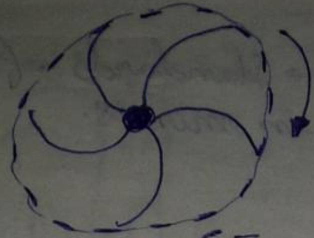
C.F. → Backward bladed
C.F. → Radial tip Bladed
C.F. → Forward Bladed



(Backward Bladed Fan)



(Radial Tip Bladed Fan)



(Forward Bladed fan)

$\boxed{\text{SG Sir}}$ $\boxed{30/07/2013}$

As per regulations, we should have atleast 2 entries to the mine, either shaft or inclines.

Need of fresh air in mines:-

1.) To provide sufficient O_2 (minimum 19%)

2.) To remove pathogenic dusts
desiese of dusts → pneumokoniosis

3.) To remove ~~or~~ dilute noxious and inflammable gases ~~upto~~ its TLV (Threshold limit value)

TLV of dust = 3 mg/m^3 of air when air contains less than 5% free silica

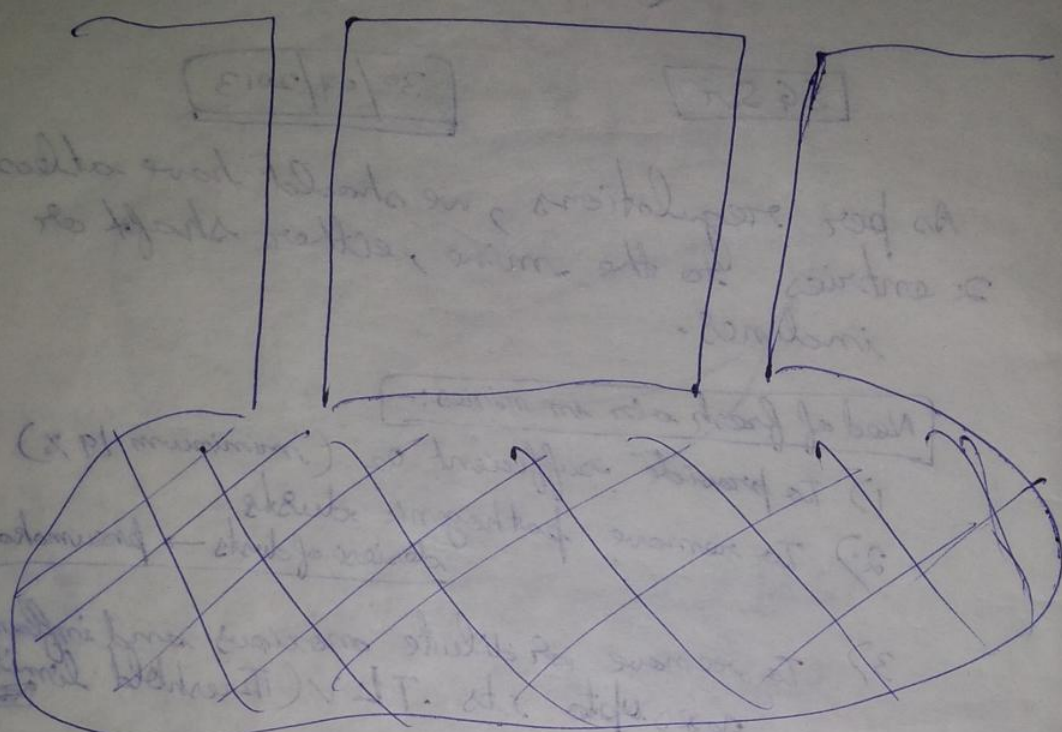
(like metal mines) if % of silica is > 5% then

$$\text{TLV of dust} = \frac{15}{\text{\% of free silica}}$$

4.) Temperature regulation → to provide a comfortable environment for the workers.

(main source of heat in mines is geothermal gradient)

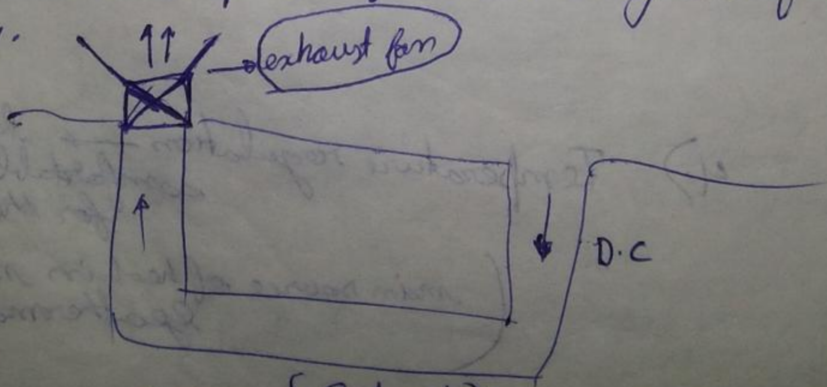
Regulation 144 → Standards of ventilation in mines.



2 types of ventilation of mines:-

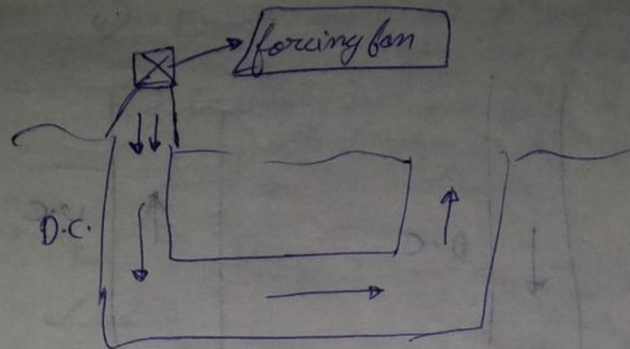
1.) Forcing ventilation system
2.) Exhaust ventilation system.

We have to put a fan on any one of the openning.



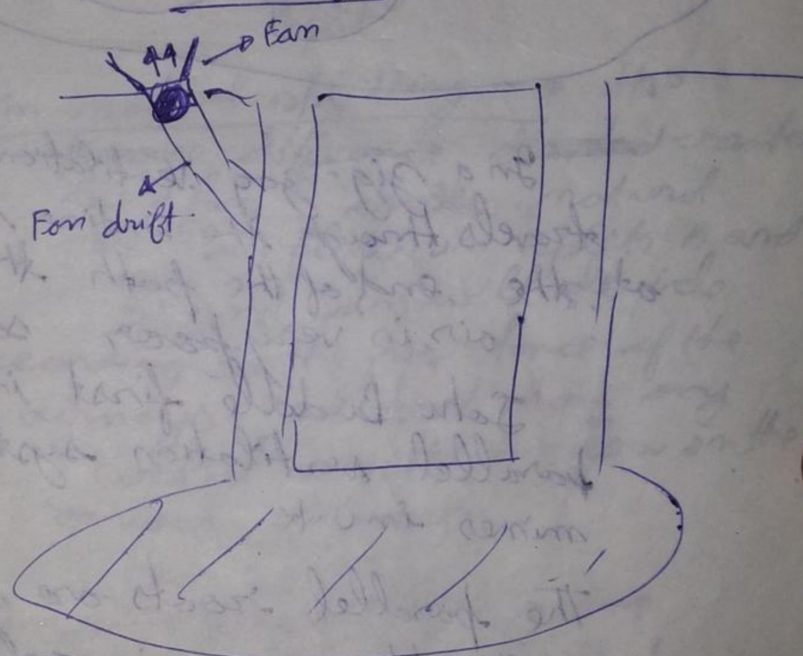
(Exhaust)

(anywhere inside the mine pressure is less than atm. pressure) entilation



(Forcing)

$ Fan is never installed in the main shaft openning but in a <u>Fan drift.</u>



the

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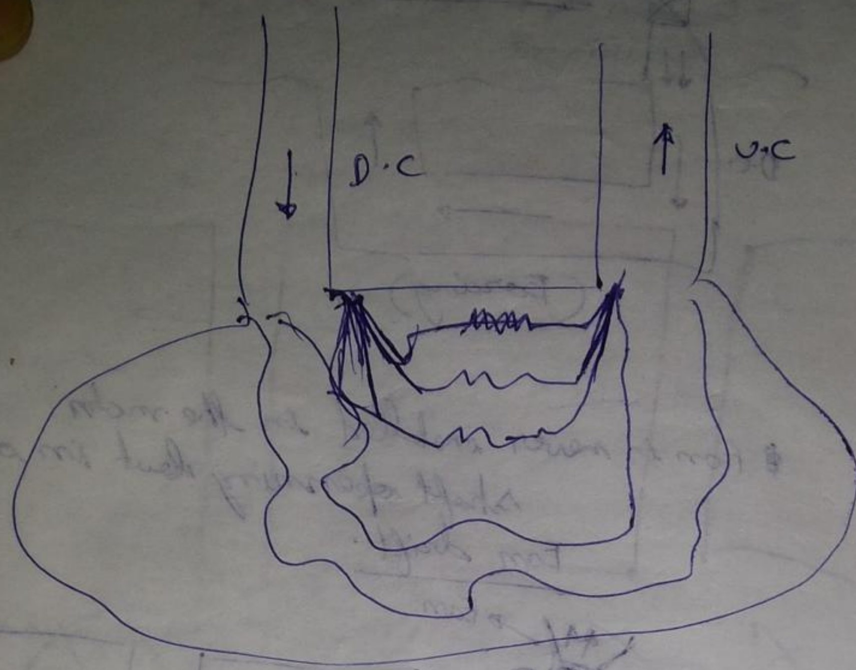
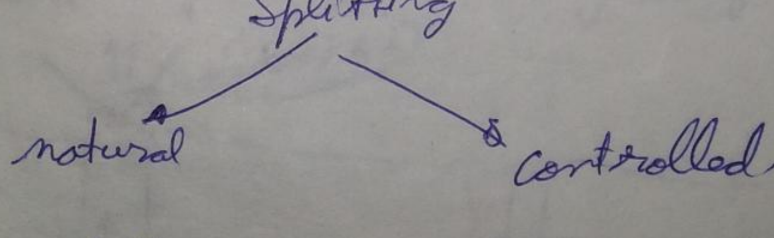


In a zig-zag ventilation system, it travels through the entire mine and so at the end of the path the quality of air is very poor so in 1856 John Buddle first introduced parallel ventilation system in coal mines in U.K.

The parallel roots are called splits and this phenomenon is called splitting.

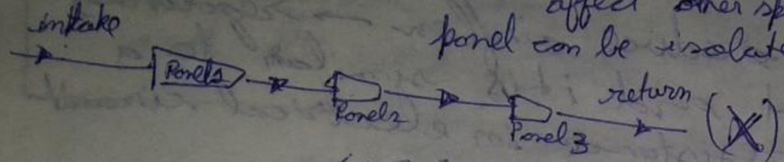


By splitting:—

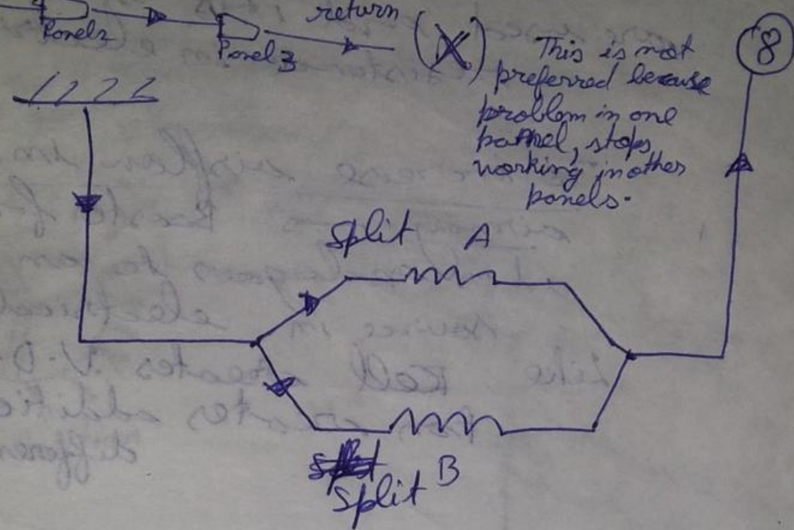
1) mine resistance decreases
2) Cost of ventilation reduces
3) Fan has to overcome lesser resistive force

4) Fresh air is provided to various faces.

5) Problem in one split does not affect other splits. The problematic panel can be isolated.



This is not preferred because problem in one pannel, stops working in other panels.



In natural splitting → the pressure difference created by a fan causes natural air flow in splits A and B and air will divide according to the resistance of the airways. We dont have any control on the airflow in the various airways.

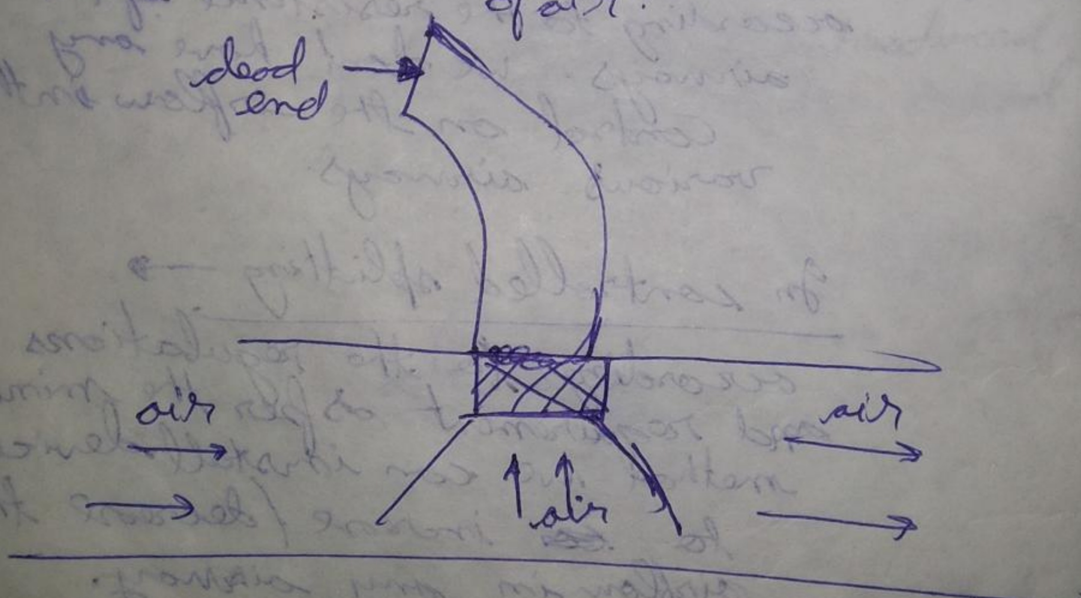
In controlled splitting → according to the regulations and requirement as per the mining method we can install devices to increase / decrease the airflow in any airway.

To control airflow

to reduce airflow → regulators are used and it is similar to a resistance in electrical circuit.

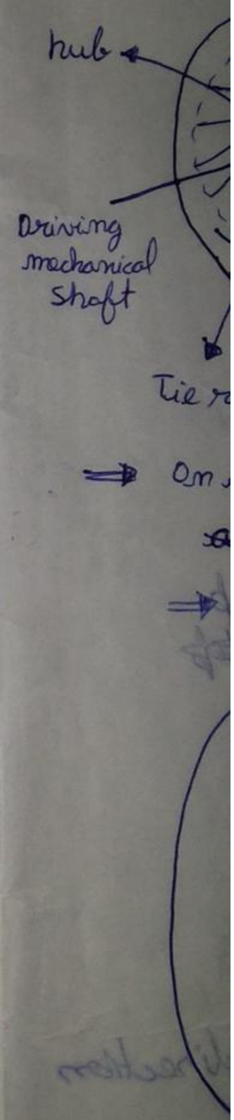
To increase airflow in any airway → Booster fans are used, it is analogous to an extra EMF source in electrical circuit.
Like cell creates V.D., similarly Fan creates additional pressure difference.

auxilliary fans → used to supply fresh air to dead end where there is insufficient ventilation of air.



02/08/20

Constru...
and

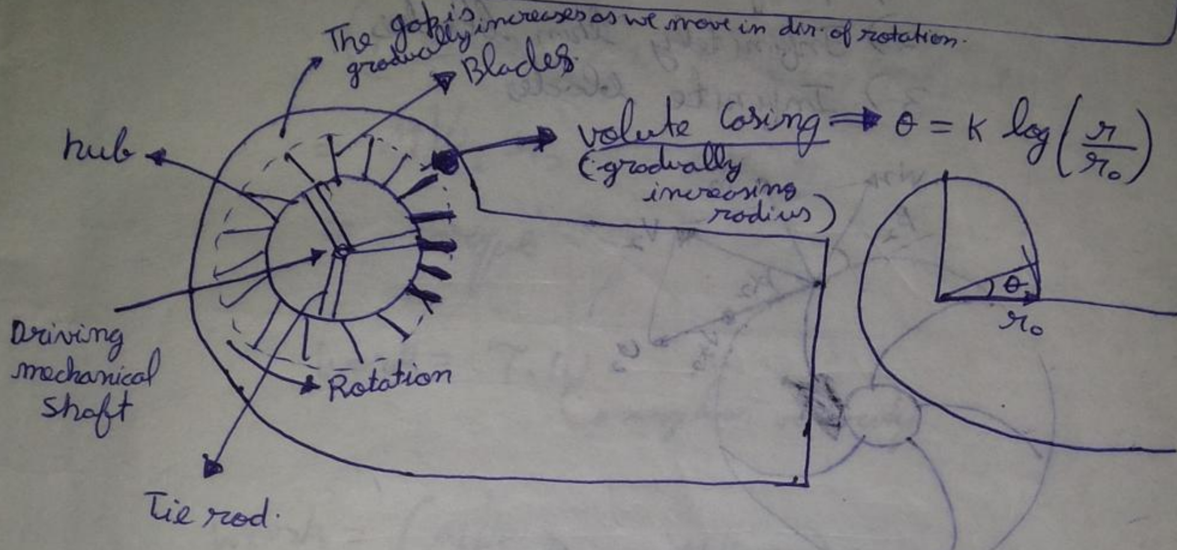


⇒ On

02/08/2013

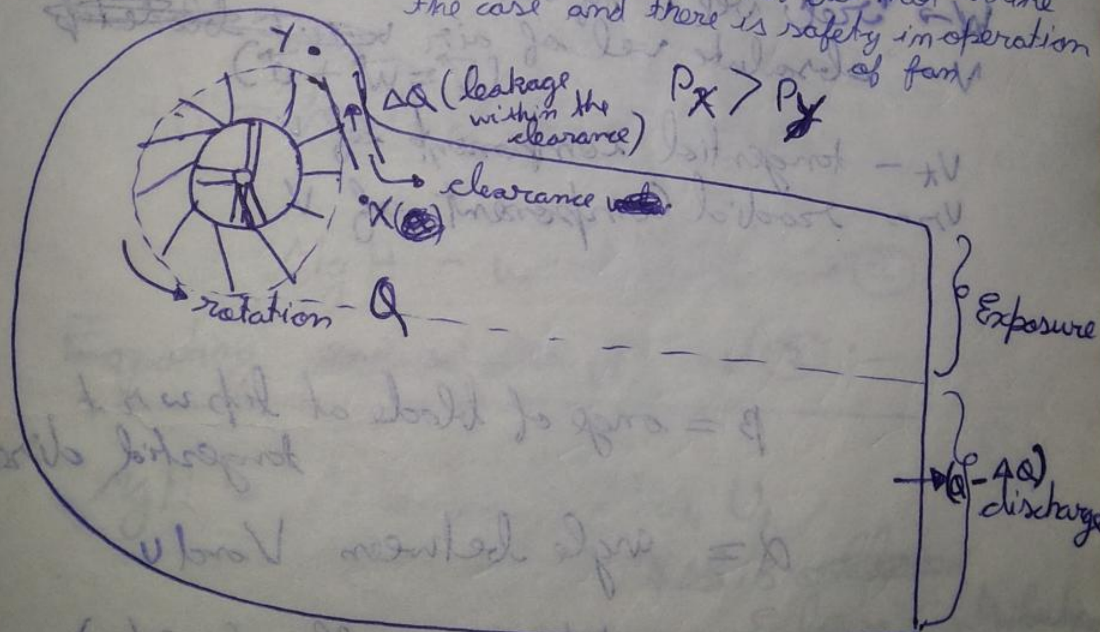
(NCK Sir)

Constructional features of Centrifugal Fan and the working principle:—



⇒ On a mechanical shaft a hub with blades ~~are~~ is mounted with the help of tie rods

⇒ clearance volume so that the blades do not strike the case and there is safety in operation of fan

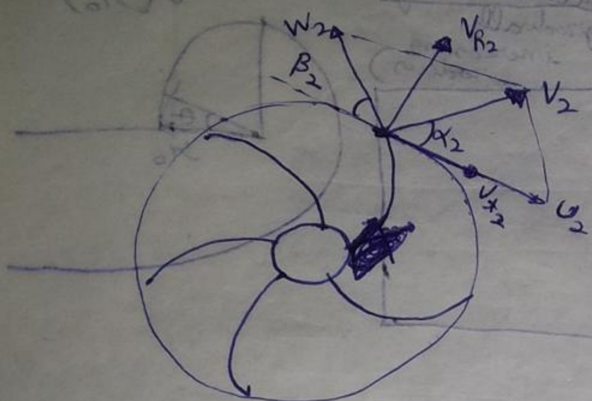


Air ~~so~~ enters through a hub. entry of air can be
1.) unilateral (one side of hub)
2.) Bilateral (both sides of hub)

Theoritical Head developed by C.F.

Ideal conditions:-

1.) No friction
2.) Infinitely thin blades
3.) Infinite blades



1 → inlet
2 → outlet

U → peripheral vel of blade tip (m/s)
W → rel vel. of air w.r.t blade tip
V – absolute vel of air ~~w.r.t blade tip~~
$(\vec{V} = \vec{W} + \vec{U})$

V_t – tangential component of V
V_r – radial component of V

β = angle of blade at tip w.r.t tangential direction

α = angle between V and U

Q = quantity of air flow (m^3/s)

ρ = density of air (Kg/m^3)

m = mass flow rate (kg/s)

$(m_1 V_1 \cos\alpha_1)\, r_1$ → moment of momentum

$m V_1 \cos\alpha_1$ → momentum in tangential direction

rate of ~~change of~~ moment of momentum:-

$$(M V_2 \cos\alpha_2) r_2 - (M V_1 \cos\alpha_1) r_1$$

$$= M V_{t_2} r_2 - M V_{t_1} r_1$$

$$= \text{Torque}$$

$$\text{Work} = T \cdot \omega$$

ω → angular velocity

$$\text{work} = (M V_{t_2} r_2 - M V_{t_1} r_1)\,\omega$$

$$\text{work done} = (M V_{t_2} U_2 - M V_{t_1} U_1) \rightarrow (1)$$

H = pressure head of fluid (m)

$$M g H = \text{work done} \rightarrow (2)$$

Equating ~~~~ (1) and (2) :-

$$M g H = M V_{t_2} U_2 - M V_{t_1} U_1$$

This is ~~~~ Euler's Contribution

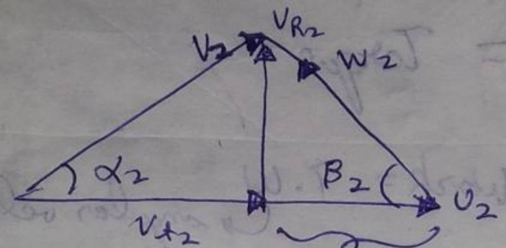
$$H_e = \frac{1}{g}\left[U_2 V_{t_2} - U_1 V_{t_1}\right]$$

(radial entry of air)

Assume Meridional entry of air into the hub :-

$$V_{t_1} = 0$$

$$\therefore H_e = \frac{U_2 V_{t_2}}{g}$$



velocity triangle

$$V_{t_2} = U_2 - V_{r_2} \cot \beta_2$$

$$\therefore H_e = \frac{1}{g} U_2 \left[U_2 - V_{r_2} \cot \beta_2 \right]$$

$$= \frac{U_2^2}{g} - \frac{U_2 V_{r_2} \cot \beta_2}{g}$$

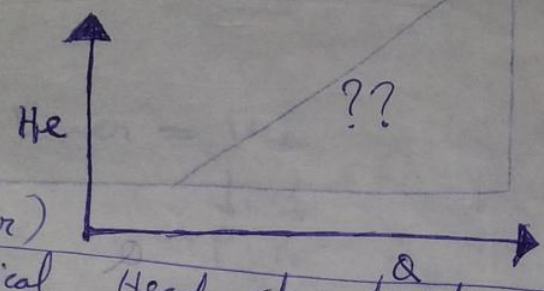
Thickness of the Blade

$$Q = \left(B \cdot 2\pi r_2 \right) V_{r_2}$$

$$\therefore \underbrace{H_e}_{\text{Euler's Head}} = \frac{U_2^2}{g} - \frac{U_2 \, Q \cot \beta_2}{g \, 2\pi r_2 B}$$

$$\therefore H_e = \frac{U_2^2}{g} - \frac{U_2 \cot\beta_2}{2\pi r_2 B g} \cdot Q$$

He and Q → nature of curve



05/08/2013 (NCK Sir)

Theoritical Head characteristic curves:-

$$H_e = -\frac{U_2}{2\pi r_2 B g} \cot\beta_2 Q + \frac{U_2^2}{g}$$

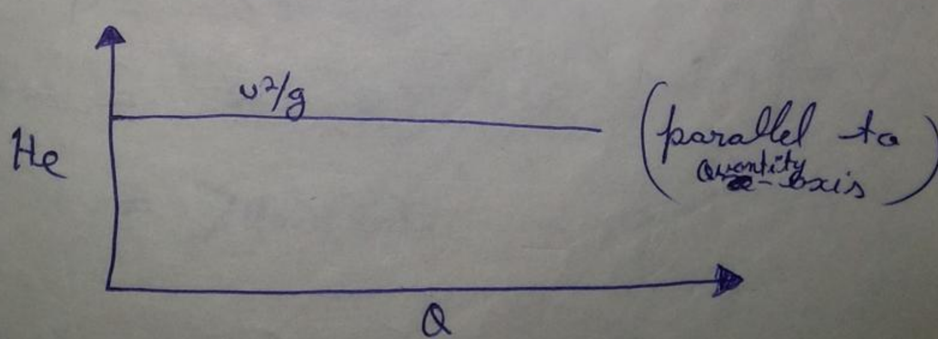
$$y = -m \cot\beta_2 Q + c$$

$\beta_2 = <90°$ (Backward bladed)

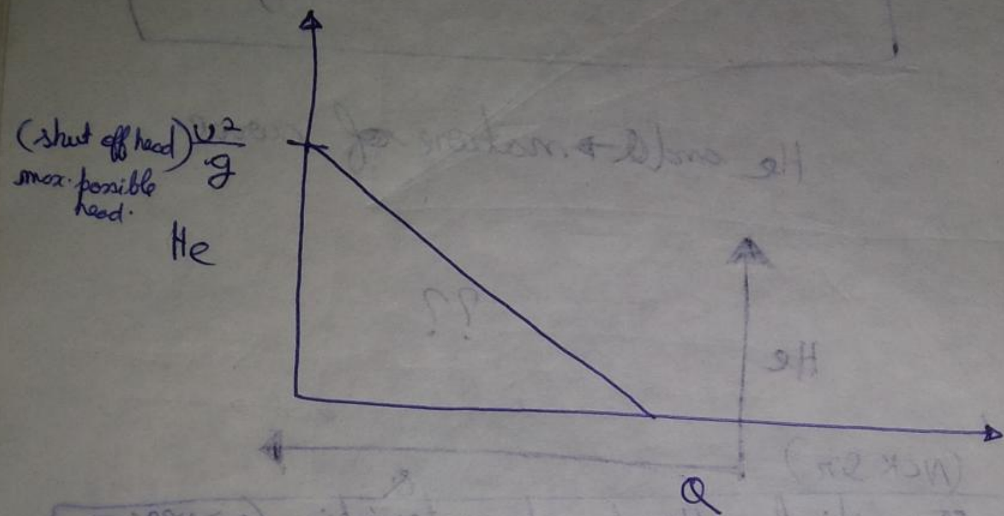
$= 90°$ (radial)

$= >90°$ (forward bladed)

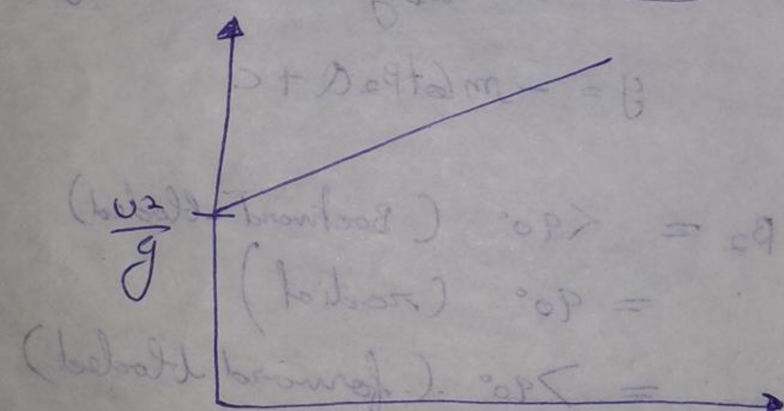
For radial fan:-



For backward bladed :-



For forward bladed :-



Theoritical Power characteristic curve:-

$P = R Q^2$

Head(H) → ht (m) of fluid (in this case air) column

(P) Pressure = $H \rho g$ (Pa)

$$\text{Power} = VI = PQ$$

$\downarrow P$ $\downarrow Q^2$ — for ventilation

$$\text{Power} = H\rho g \cdot Q$$

$$= \left[-\frac{U_2 \cot \beta_2 Q}{2\pi r_2 B g} + \frac{U^2}{g} \right] Q \rho g$$

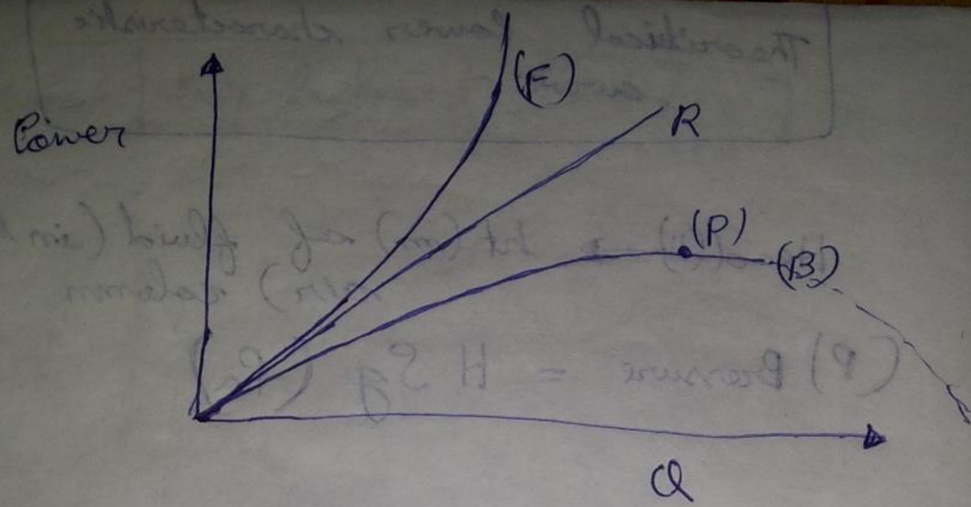
$$\text{Power} = -K_1 \cot \beta_2 Q^2 + K_2 Q$$

$$y = ax^2 + bx$$

$\beta = \; < 90^\circ$ (B)

$= 90^\circ$ (R)

$= \; > 90^\circ$ (F)



Conclusion ⟹ 1.) As ~~of~~ our requirement for Q increases then we should opt for a backward bladed fan.

2.) There is non-overloading characteristic for Backward bladed fan so if the motor can support ~~#~~ load upto point P then ~~$~~ if further Q is increased the load on ~~t~~ fan motor reduces.

Q.) How do we make meridional entry??

A.) inlet guide vanes are used.

⟹ Head of air column does not depend on the density of air.

⟹ Pressure depends on ~~head~~ density of air column.

⟹ Power is a function of δ.

~~What factors~~ are -
Q) Which parameters are affected by geometry of a fan??

geometry of fan → 1.) radius (r_2)
2.) width of blade (B)

06/08/2013

SG Sir

Assignment 1:
Submit on or befor 13/08/2013

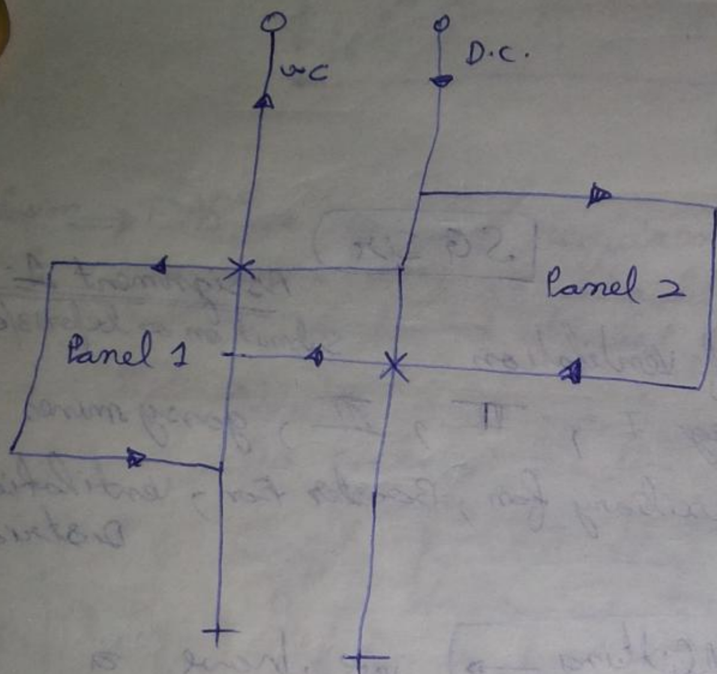
Standards of ventilation
Define → Deg I, II, III, gassy mines
Define → Auxiliary fan, Booster Fan, Ventilation District

Controlled Splitting → we have a full control on the amt of air we want to see to a particular airway which is independent of the resistance of the airway and depends on our wish.

Devices to control air ~~ways~~ flow :-
1.) Booster fan
2.) Regulators
3.) ~~Fans~~ Doors →
- Fire doors (In the event of fire to isolate a particular section of mine so that oxygen supply is cut down so that the fire dies down)
- Ventilation doors → to keep the intake and return separated.

In normal operation :-
Fire doors — kept open
ventilation doors → kept closed.

Ventilation Structures → Doors, Stoppings, air crossings



X → These are air crossings

If we do not separate intake and return airways, then they will mix, which is not allowed so at air crossings there are two airways crossing each other.

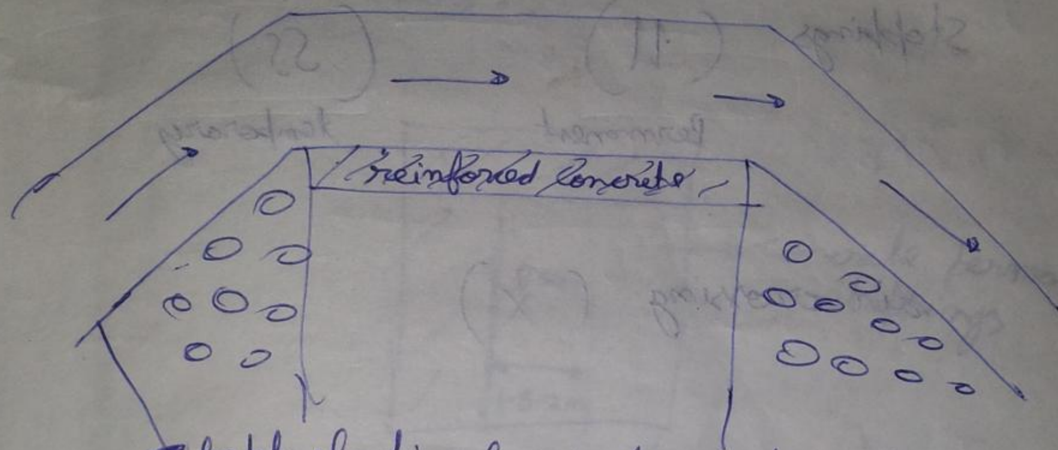
upper → return (air is hotter so it has lower density so it moves up) [due to heat from wall and working process]

lower → intake

air crossing → artificial → cross over
→ natural

excavation of roadways at higher height and inbetween concrete slab is placed so that top is return and down is intake.

Artificial



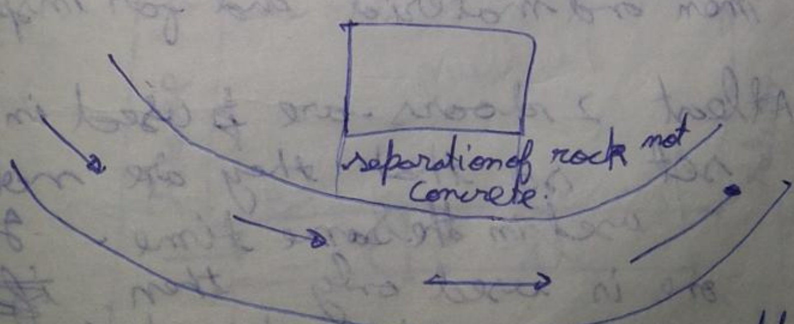
kept slanting to reduce shock losses

is due to
1) sudden change in dir.
2) sudden change in cross-sectional area.

Natural

⇒ It is cross under.

we dig a air way below the floor level



It is rare in indian mines as they are watery so water accumulates in the lower airway and blocks the flow of air.

Symbols →

Doors (D) → towards high pressure side

remember → air flows from high pressure to low pressure

Stoppings (11) Permanent (SS) temporary

air crossing (X)

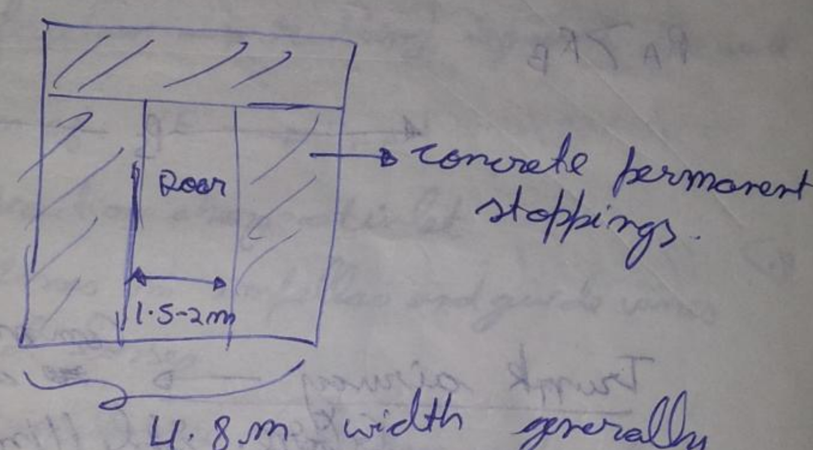
⇒ Doors opens ~~to~~ into the higher pressure zone because in case it opens into the lower pressure zone then it will be automatically opened by the air.

⇒ Doors are used inplace of permanent stopping for transportation of man and material and for inspection.

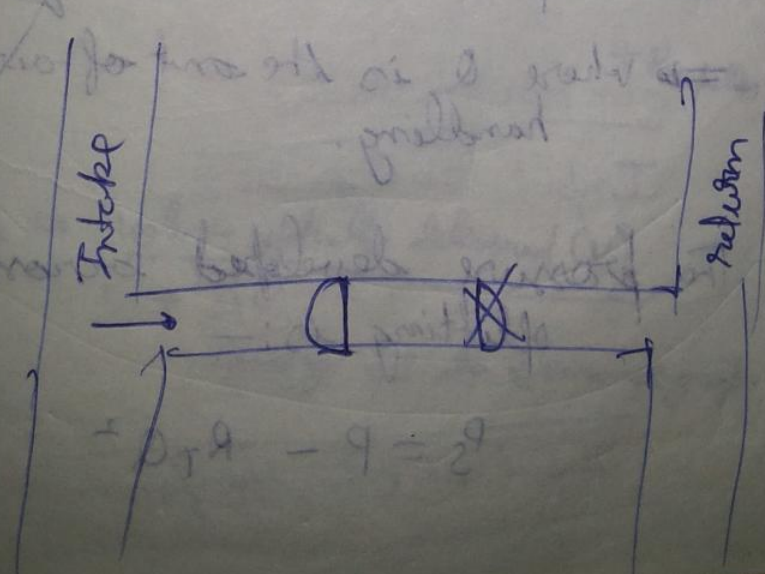
⇒ Atleast 2 doors are used in a set so that they are not used in the same time. In case one is used only then ~~it~~ as soon as it is operated then the air is shortcircuited.

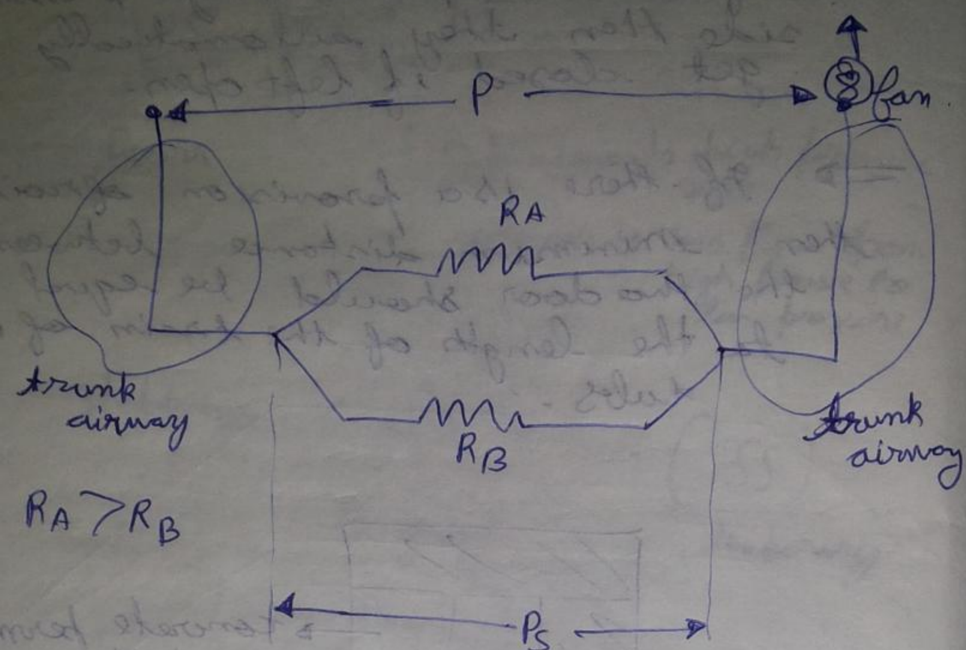
⇒ If doors open on High pressure side then they automatically get closed if left open.

⇒ If there is a provision of rails then minimum distance between the two door should be equal to the length of the train of coal tubs.



Booster fan → An extra source of pressure in the circuit that will develop pressure in a particular section.





$R_A > R_B$

Trunk airway $\longrightarrow$ Common airways ~~which~~ before splitting is trunk airway. It takes into account the shaft and other common passages.

If resistance of trunk airway is R_T

Pressure drop in trunk airways $= R_T Q^2$

$\Rightarrow$ where Q is the amt of air, fan is handling.

The pressure developed across the splitting is :—

$$P_S = P - R_T Q^2$$

Assignment - I by (SG Sir)

gassy mine → refers to mines that have levels of gases that must be diluted with pure air to prevent an explosion.

12/08/2013. (NCK Sir)

Fan Losses

* Skin friction → rubbing against the wall
* Conversion of KE → Pr. E
* ~~Pr~~ Direction change at inlet
* Shock losses in impellar and guide vanes
* mechanical losses
* Volumetric losses (leakage into clearance volume)

Efficiency →

1.) $$\eta_{Hydraulic} = \frac{\text{available Pr. head}(P)}{\text{Input head}} = \frac{P}{P + (P_{volute} + P_{impellar} + P_{diffuser} + P_{shock})}$$

2.) $$\eta_{volumetric} = \frac{\text{Volume actually delivered }(V)}{V + \underbrace{\Delta V}_{\text{leakage due to clearance gap}}}$$

3.) $\eta_{mechanical} = \dfrac{\text{Power absorbed by impellar and converted to head } (N_w)}{N_w + \text{mechanical losses}}$

$$= \frac{bhp - \text{mechanical losses}}{bhp}$$

bhp → Brake horsepower

Instead of directly calculating the horse power of the machine we apply the ~~blade~~ brakes ~~and~~ ~~make~~ we can easily calculate the brake horse power

4.) $\eta_{combined} = \eta_{overall\,(\text{in Books})} = \eta_{Hydralic} \times \eta_{Volumetric} \times \eta_{mechanical}.$

⇒ If at every ~~efficiency~~ level we have a 90% efficiency then the output efficiency is only 73%.

$$\eta_{combined} = 0.9 \times 0.9 \times 0.9 = 0.73$$

$$\eta_{static} = \frac{\text{air power (static)}}{\text{Input BhP to the fan}}$$

$$\eta_{total} = \frac{\text{air power (total)}}{\text{Input BhP to the fan}}$$

(A.P.) Air power $= P \times Q$

Static $\rightarrow P_{st} \rightarrow$ A.P. Static

Total $\rightarrow P_t \rightarrow$ A.P. Total

P_i electricity $\rightarrow$ [motor] $\xrightarrow{P_i'}$ [Drive] $\xrightarrow{P_i''}$ fan $\rightarrow$ air power (P_{air})

$$\eta_{overall} = \frac{P_{air}}{P_i}$$

$$= \frac{P_i'}{P_i} \times \frac{P_i''}{P_i'} \times \frac{P_{air}}{P_i''}$$

$$\eta_{overall} = \eta_{motor} \times \eta_{drive} \times \eta_{impellor}$$

If $\underline{0.9}$ if $\underline{0.9}$ $\underline{0.73}$

$$\eta_{overall} = 0.59$$

Actual Head Characteristic →

i) Skin friction and diffusion loss
(ii) Eddy and ~~sper~~ separation loss

} we categorize losses into 2 main headings

h_f (due to skin friction) $= K_1 Q^2$

h_d (diffusion loss) $= K_2 Q^2$

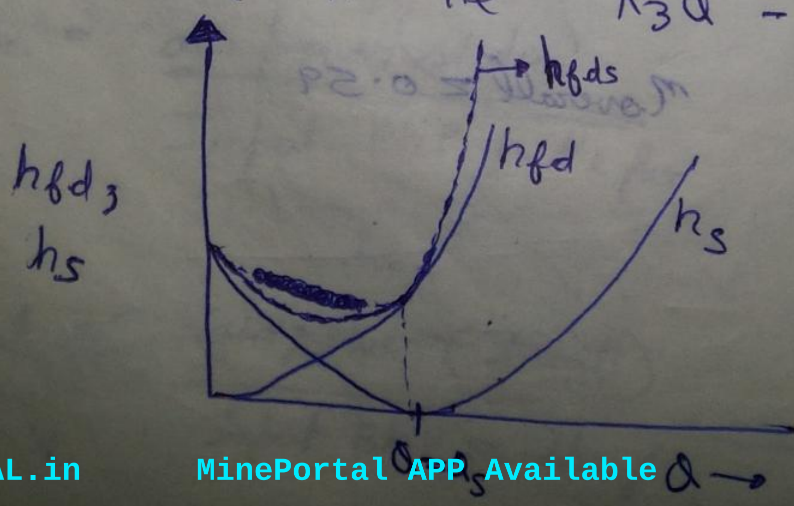
$h_{fd} = (K_1 + K_2) Q^2 = K_3 Q^2$

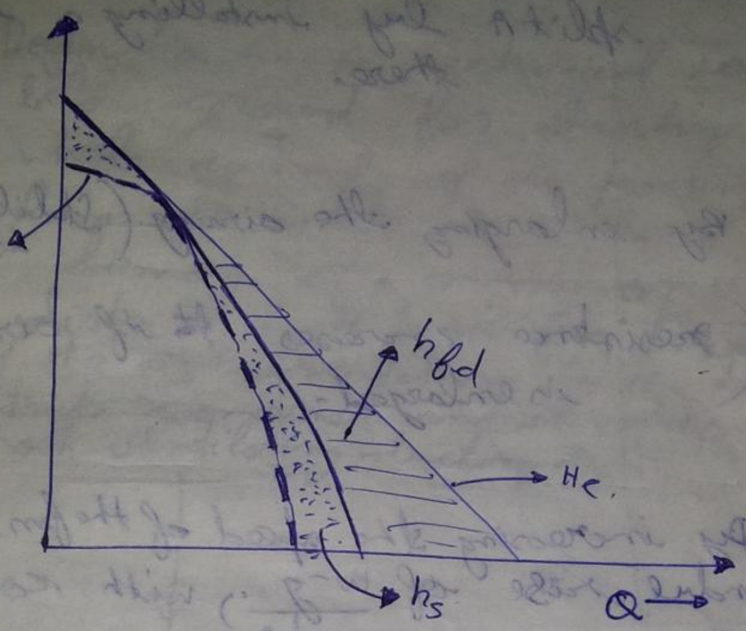
$Q_s \rightarrow$ quantity for which shock loss is minimum (shockless quantity)

$h_s \propto (Q - Q_s)^2$

$\therefore h_s = K_4 (Q - Q_s)^2$

$H_{actual} = H = H_e - K_3 Q^2 - K_4 (Q - Q_s)^2$



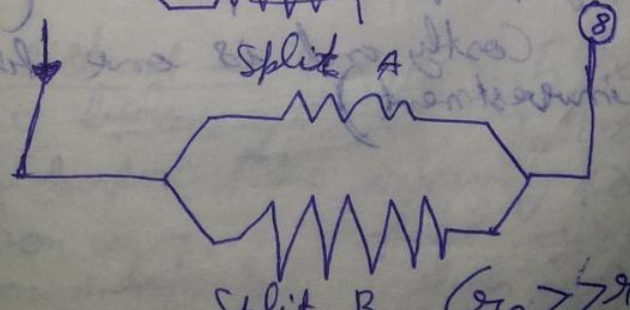


13/08/2013. UME – II (SG Sir)

~~Booster Fan.~~

methods to increase the air quantity :-

1.) By installing a regulator in the neighbouring split (But cost of ventilation is increased due to more resistance)



Suppose we want more air in split B due to working we can increase the resistance of split A by installing a regulator there.

2) By enlarging the airway (Stability problem is there)
(resistance increases ~~it~~ if airway is enlarged.)

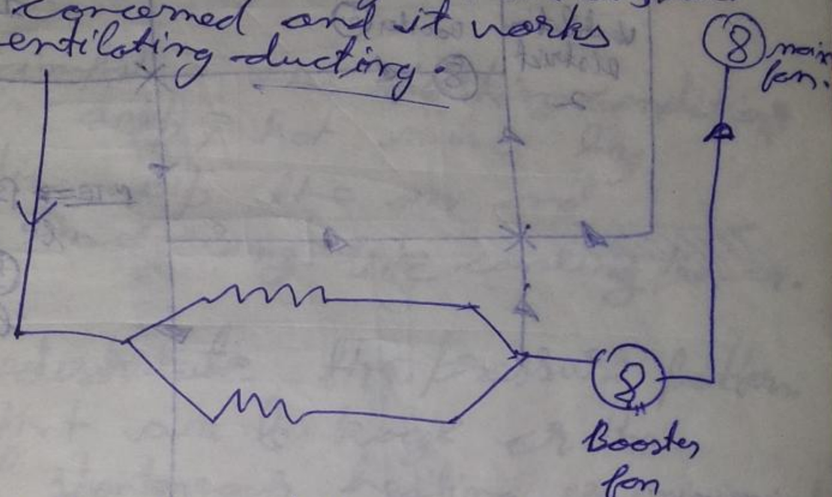
3) By increasing the speed of the fan without undue rise of $\frac{W\text{-}g}{\text{water gauge}}$, with consequent loss of power in regulators of low resistance splits and increased air leakage.

Demerits → due to cracks in rocks and ~~sp~~ small ~~ch~~ spaces in ~~spot~~ stoppings there is short circuit with the return airway (leakage) since the dia of such paths are $< 0.3\,m$ so flow is laminar and it follows that $\Delta P = RQ$
so if fan speed in increased then ΔP increases and leakage(Q) is increased in such ~~air~~ small airways.

4) By installing a new mine fan with a large peripheral speed (Fan is costly and is one time investment)

Booster Fan :-

Defination → A mechanical ventilator used below ground for boosting the whole current of air passing along the intake or return airway of a mine or ventilating district. A booster fan passes the whole of the air circulating in the district or districts concerned and it works without ventilating ducting.

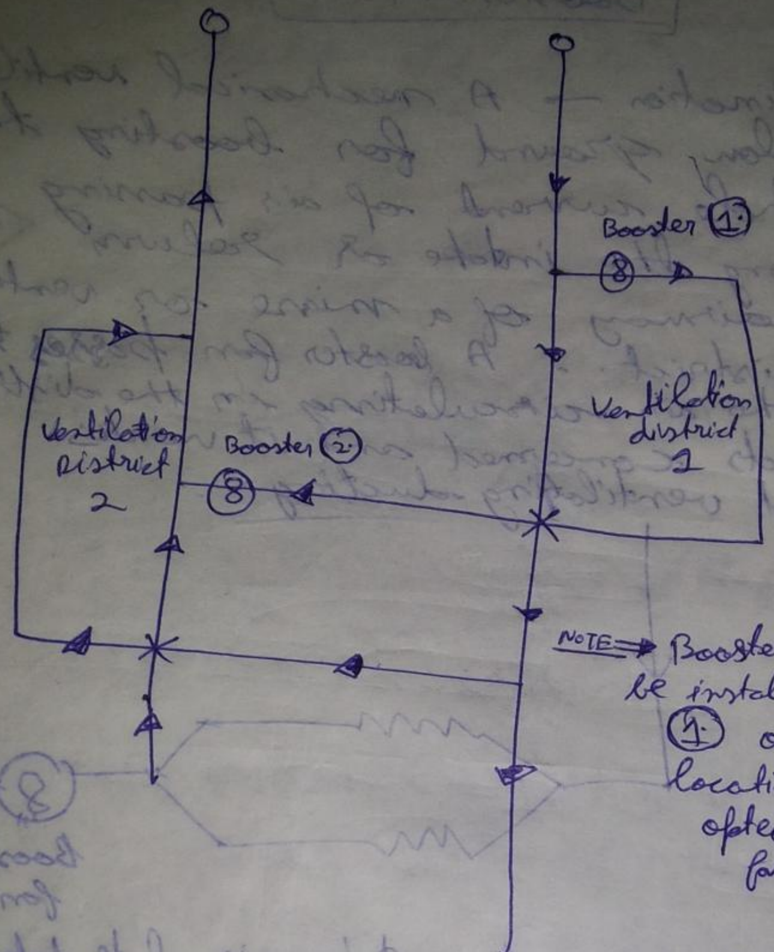


⇒ Demerits of Booster ~~used~~ to circulate total air current of the mine:-

Because it is difficult to maintain the fan underground. Instead we can install a fan at the surface.

⇒ Booster fan is instead used to boosts the total air flow in a ventilating District.

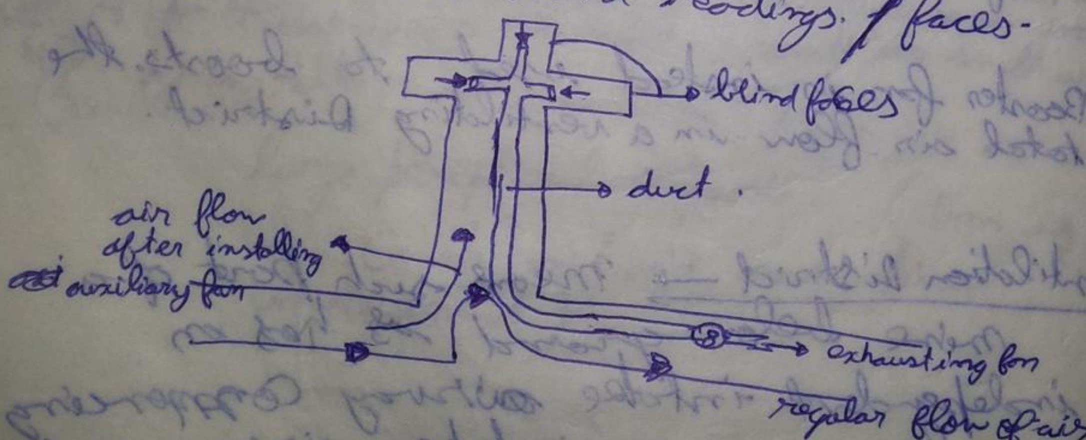
Ventilation District → Means such part of a mine below ground as has an independent intake airway commencing from a main Intake airway and an independent return airway terminating at a main return airway.



NOTE ⟹ Booster can either be installed at location (1) or (2) but location (2) is opted for booster fan installation (why??)

auxiliary fan:-

It is a forcing/exhausting fan used with a duct to ventilate blind headings/faces.



⟹ if fan placed on other side then it acts as a forcing fan

⟹ auxiliary fan only ventilates a number of faces.

Purpose of Booster fan installation:-

The primary objectives of a booster fan are:-

1.) To enhance or maintain adequate airflow in areas of the mine that are difficult or uneconomic to ventilate the main fans.

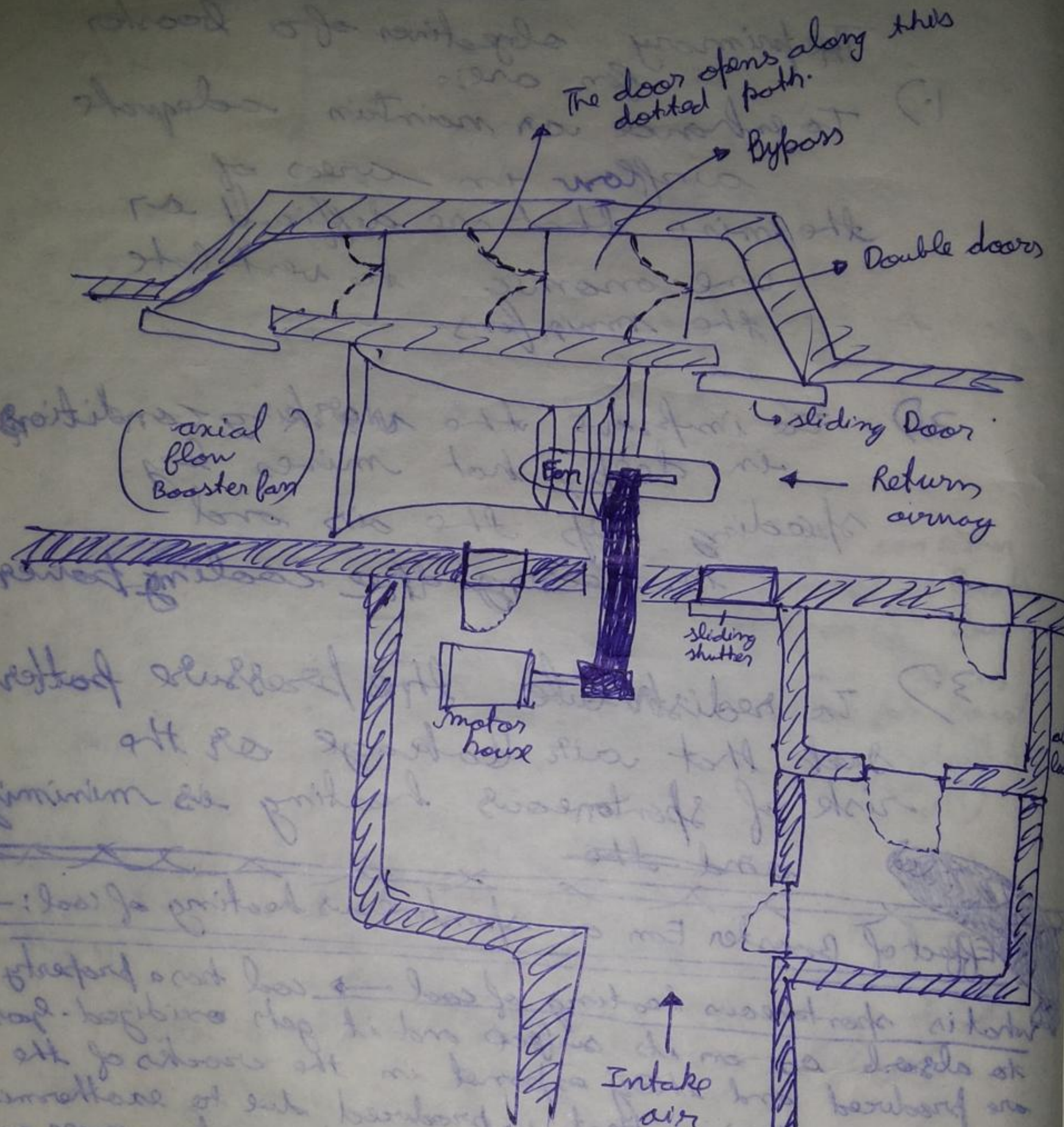
2.) To improve the working conditions in deep, hot mines by speeding up the air and increasing the cooling power.

3.) To redistribute the pressure pattern such that air leakage or the risk of spontaneous heating is minimized. ~~and the~~

Effect of Booster Fan on spontaneous heating of coal:-

What is spontaneous heating of coal → coal has a property to absorb O_2 on its surface and it gets oxidized. Gases are produced and they expand in the cracks of the coal seam and ~~since~~ Heat is produced due to exothermic nature of oxidation. As the cracks widen more and more O_2 enters and more oxidation takes place and at some point the ignition temperature is reached and spontaneous heating takes place.

→ When a booster fan is installed so it may increase the pressure difference across the cracks and leakage may increase. But such ventilation into the cracks is insufficient to remove the heat of the coal seam but provides sufficient O_2 for oxidation. This oxidation further produces heat and spontaneous heating chances are increased. So before installing a booster we have to make a proper ventilation survey of the areas where pressure difference can cause such dangers.



⟹ Booster fan covers the total cross-section of the airway and intake to a district is usually used for haulage and transportation and so booster is alway installed on return airway of a district and But there is a bypass to cross the fan in case haulage is required.

Booster increases leakage in the intake airway.

⇒ multiple doors are used in the bypass area due to the following reasons:-

1) The booster fan creates pressure drop across the bypass so to reduce leakage and proper stopping multiple doors are used.

2) The doors open on high pressure side so if multiple doors are not ~~required~~ installed then it will become difficult to open the door.

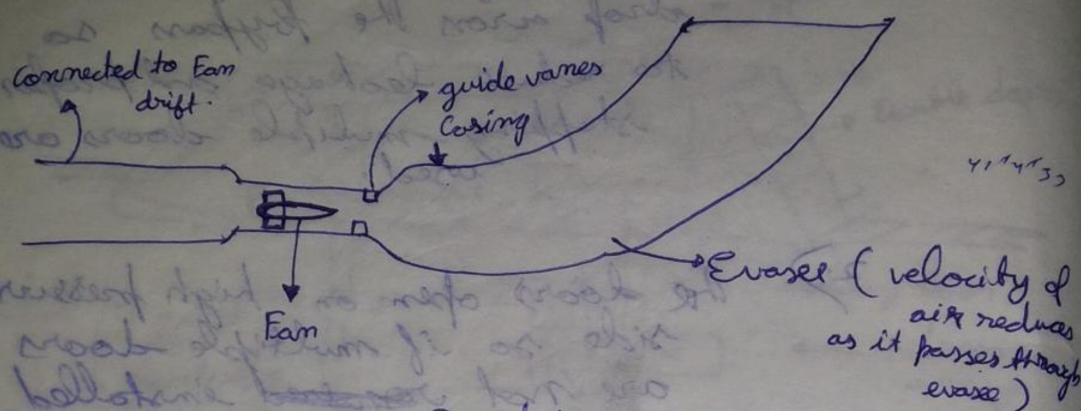
NOTE:- In a case of multiple doors also there is a hole on the doorways so that before opening the doors the hole is opened and pressure on both sides is equalized and then the door is opened easily.

$\boxed{\text{NOTE:-}}$ According to ~~...~~ regulation ~~...~~ the motor should always be ventilated by the intake air because ~~in~~ the return air has lot of inflammable gases so in case of spark in motor during starting of switch off then it may lead to some explosion.

16/08/2013.

NCR Sir

Axial-Flow Fan:-



Fan drift → Passage where fan is installed.

Advantages:-

→ high capacity (Q)
→ low head (Pressure)
→ very high speed.
→ Single-stage

Though for high head, 2-3 stages can be opted.

if one stage is used for high head then it requires:-

1) larger size of fan
2) larger ~~size~~ space
3) larger size of blades

40 41' 53'
41° 43' 55"

⇒ Compared to centrifugal fan axial flow fan head is loss

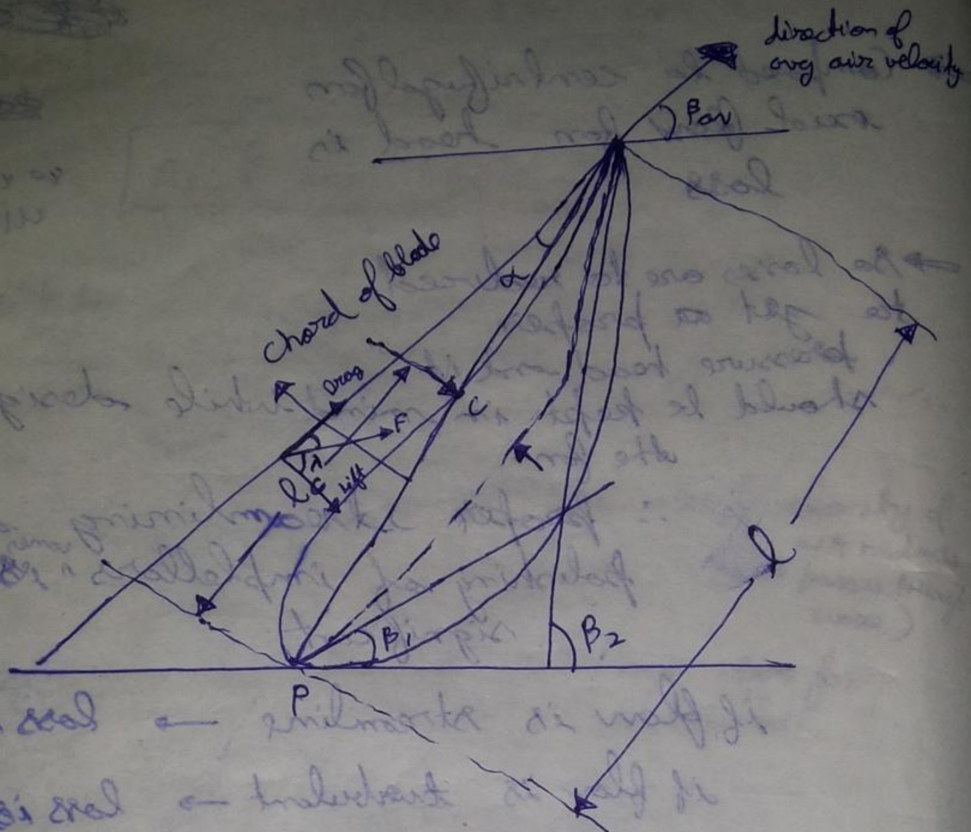
⇒ So losses are to reduced to get a proper pressure head and it should be kept in mind while designing the fan.

∴ proper streamlining and polishing of impellors vanes is very significant.

if flow is streamline → loss is less

if flow is turbulent → loss is more

So vanes ~~are~~ of axial flow fan are of aero foil design for streamline flow.



An aerofoil consist of a certain thickness of material concentrated about a mean line as shown by (- - -). The maximum distance from the mean line to the chord is shown as C.

C: Vane Camber

which is expressed as a percentage of chord length l. The camber is situated at a distance of l_c from the point P

α: angle of attack is the angle between the chord of the aerofoil and the direction of average air velocity

~~of in a craft the~~

The angle λ between F and L is called gliding angle.

$$L = C_L \, b \, l \, \rho \, W_{av}^2$$

$$D = C_D \, b \, l \, \rho \, W_{av}^2$$

$C_L \rightarrow$ coefficient of Lift

$C_D \rightarrow$ " " Drag

$b \rightarrow$ width of aerofoil

$l \rightarrow$ chord length

$\rho \rightarrow$ density of air

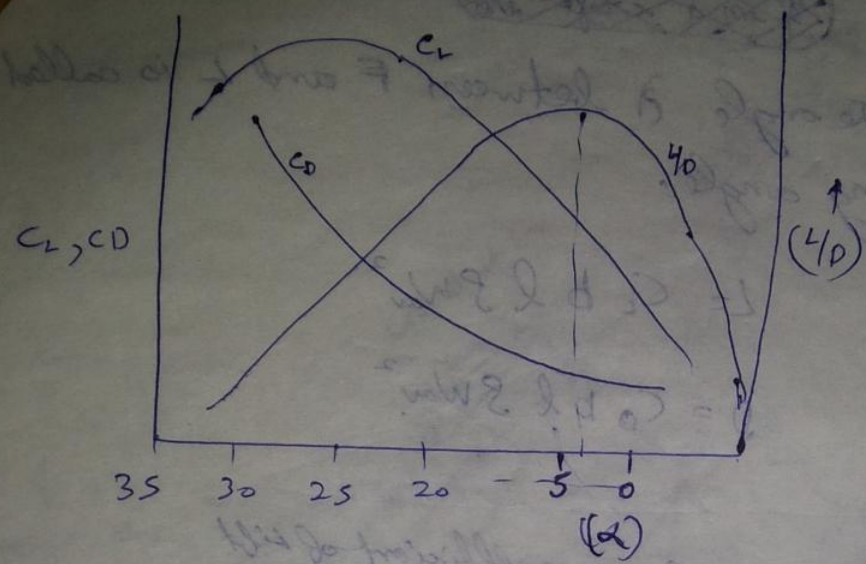
$W_{av} \rightarrow$ rel. velocity of air.

Both C_D and C_L depend mainly on aerofoil profile (camber, curvature, chord length, etc).

The angle of attack (α) depends on β_1 and β_2.

The lift component helps to generate air pressure and Drag component is responsible for losses.

Our target is to maximize L/D ratio.



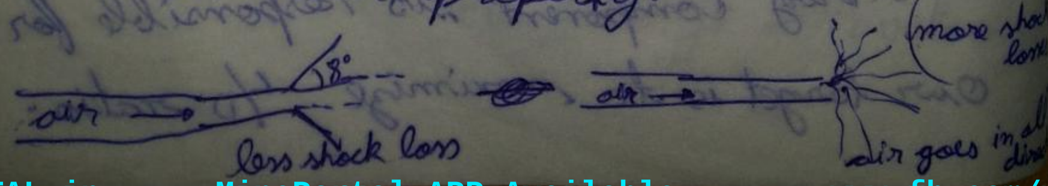
fan Casing are generally provided with fixed guide vanes in opposite orientation, to straighten the outlet air flow (streamlining)

guide vanes help in converting the tangential component of outlet velocity to pressure energy.

⟹ 5-8 fixed guide vanes.

In addition to the provision of guide vanes the casing is having expanding structure. The angle of divergence is maximum 8°

expanding structure helps in reducing the shock losses by directing the air properly.

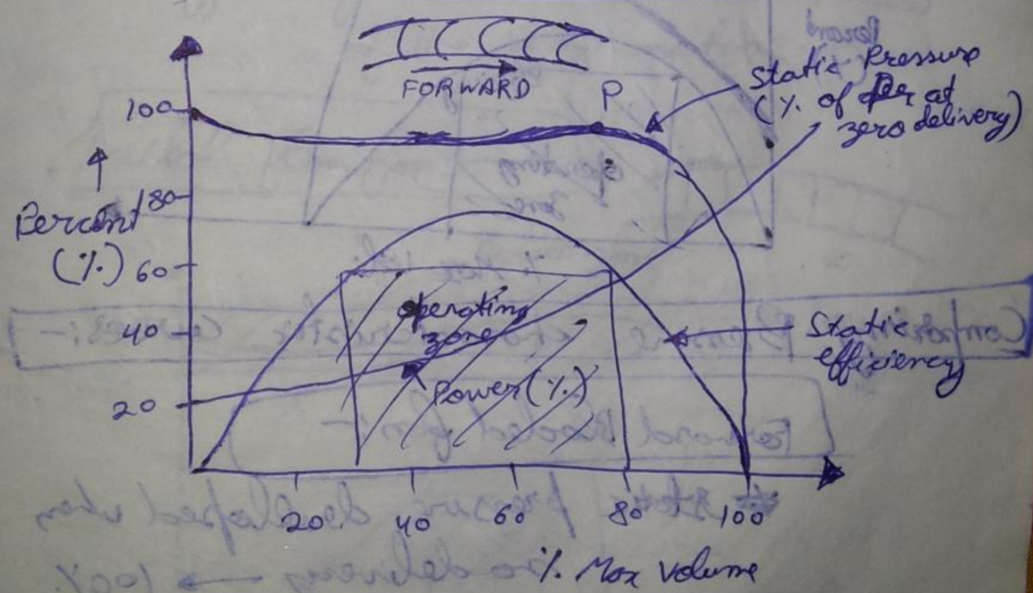


Sometimes instead of fixed guide vanes we can have contra rotating impellor in order to straighten out the flow. In such case the fan should be considered a 2 stage fan and total head is ~~...~~ twice the previous kind of fan.

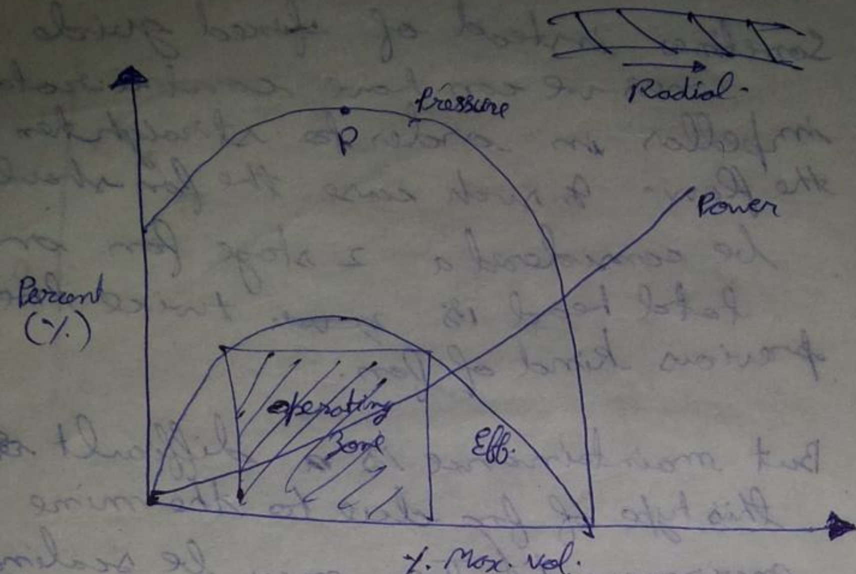
But maintainance is a difficult ~~of~~ for this type of fan due to the mine environment (There may be scaling on the blades) so 2-stage is not used in mines.

19/08/2013. (NCK sir)

Fan Characteristic Curves:-



Radial.



Backward Bladed.

Comparing Pressure characteristic curves:-

Forward Bladed fan:-

~~≠~~ Static pressure developed when no delivery → 100%.

% static pressure ~~&~~ reduces and then remains more or less constant and then falls. The initial loss is less because of FBB fans have large numbers of blades so more dis flow.

Comparing Power characteristic curves:—

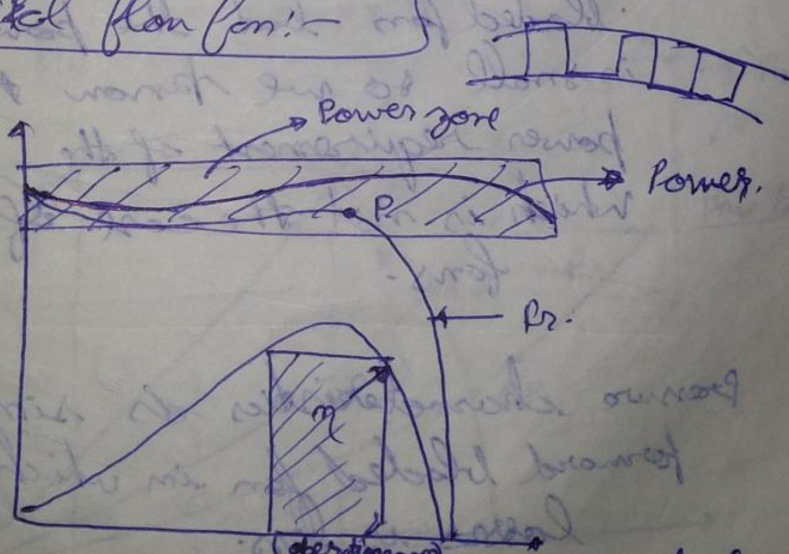
In BB fan ⇒ with increasing quantity beyond certain limit the power delivered reduces and so there is less chances of coil getting burnt (safety feature)

while in FB and radial fans ⇒
The power characteristic curves have an increasing nature

Comparing efficiency curves:—

efficiency curves are more or less of the same nature.

Axial flow fan:—



efficiency in general higher than centrifugal fans but good efficiency zone (80–100% of max efficiency) is narrow so narrow operating zone for axial fan.

This is disadvantageous because in case of improper operation of fan (improper airflow) due to various reasons like :–

① advancement of face
② water logging
③ increasing cross-section

then with a wide operating zone gives us a high efficiency even with large variation in quantity flow.

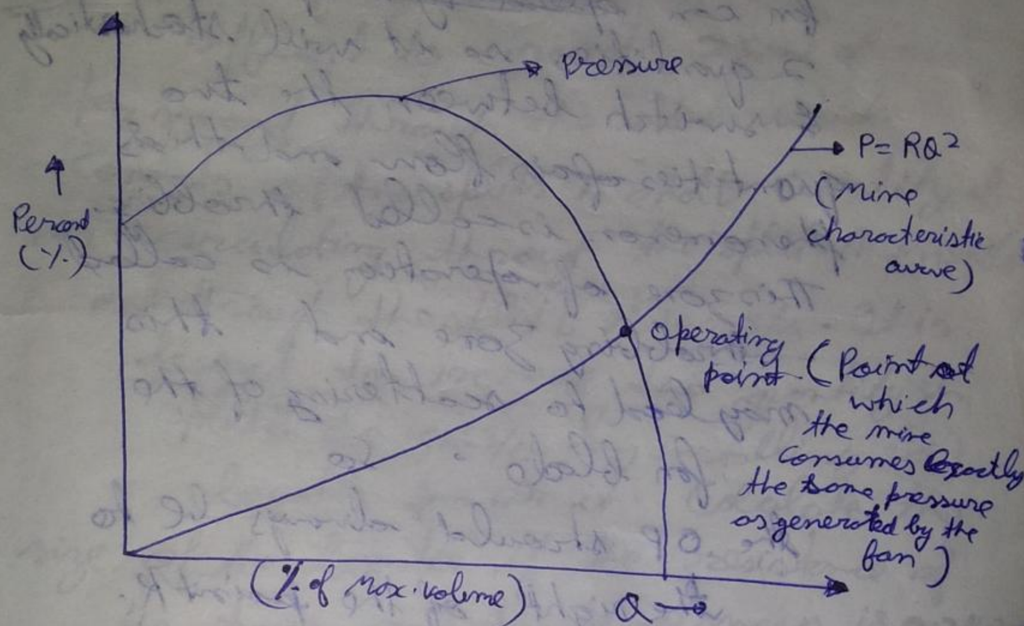
centrifugal fans → have a wide operating zone.

Power characteristics has a non-overloading characteristic similar to backward bladed fan but the power zone is small so we know the exact power requirement of the axial fan which is not the case of centrifugal fans.

Pressure characteristics is similar to forward bladed fan in which initial losses is less.

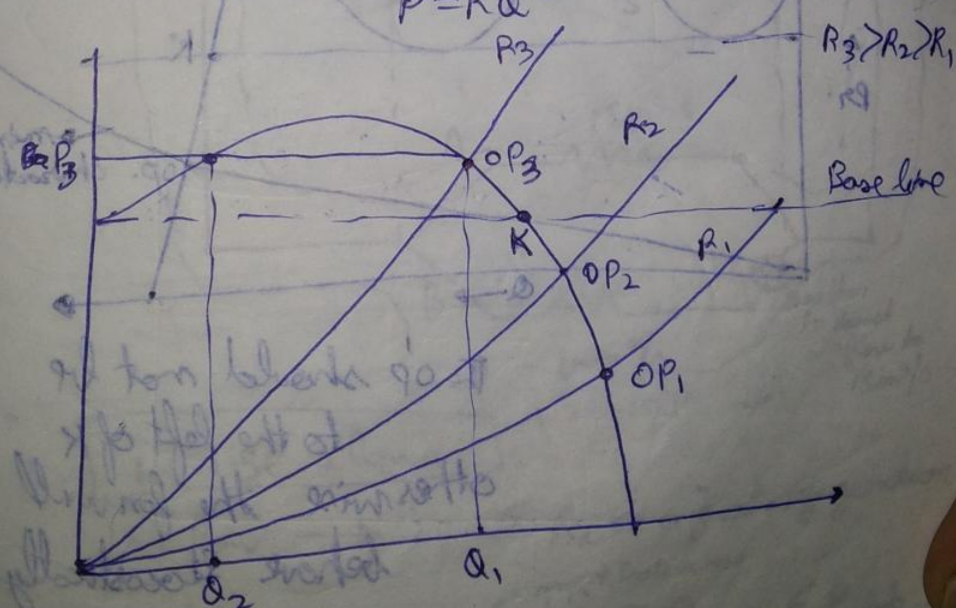
Importance of Pumping limit

In all curves → P is the pumping limit.

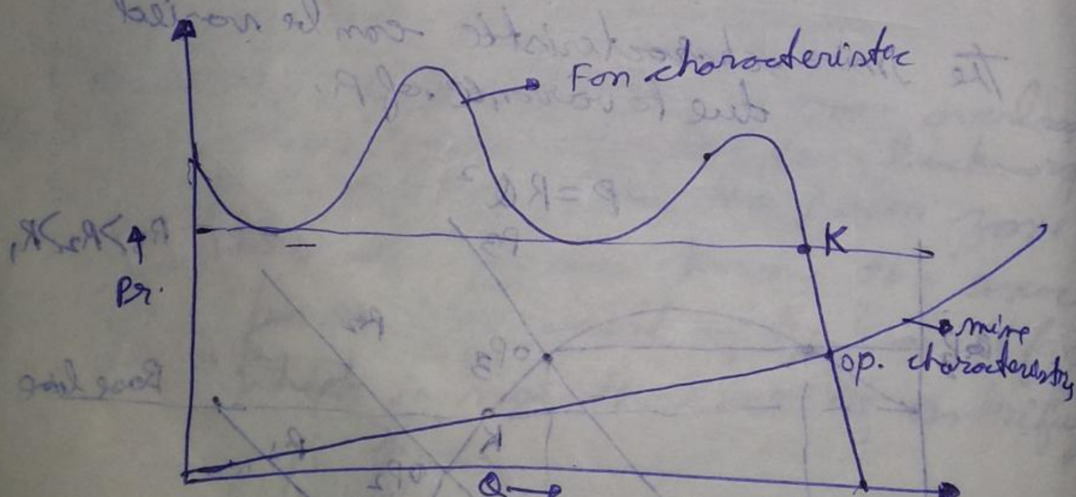


The mine characteristic can be varied due to variance of R.

$P = RQ^2$



If the operating point is above the Base line then for the same pressure the fan can ~~operating~~ & operate on 2 quantities so it will stochastically & switch between the two quantities of air flow and this phenomenon is called throbbing. This zone of operation is called throbbing zone and this may lead to scattering of the fan blade. So the OP should always be to the right of the point K.



The OP should not be to the left of K otherwise the fan will behave stocastically.

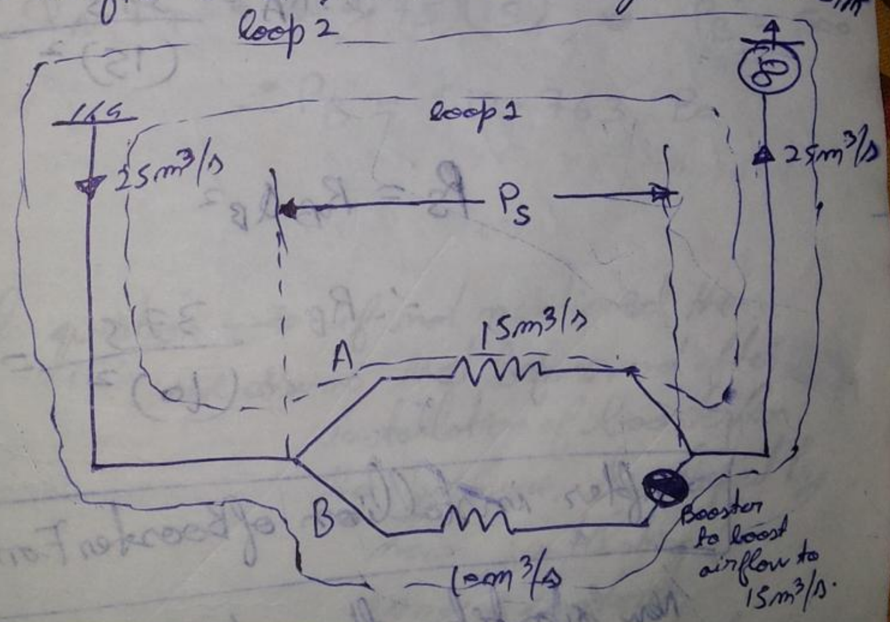
20/08/2013

SG Sir

Examples:-

ex. 1.7 A mine fan generates 500Pa which is sufficient to circulate 25m3 of air per second through the mine which consists of two splits A and B. Quantity of air circulating through the split A is 15m3/s and through the split B is 10m3/s. It is desired to increase the quantity in split B to 15m3/s by installing a booster fan in it. Calculate the size of the booster if the resistance of the shafts and trunk airways is 0.2 Ns^2m^{-8}

A.1.7.



We use 2 laws.

1st law → $\sum Q_i = 0$ } at any junction

2nd law → $\sum H_l = 0$ or $\sum$ Pr.drop $= 0$

Pressure head

closed loop

closed loop

R_A 500 Q_A

$P_{Fan} = 500 Pa.$

P loss in trunk airways $= 0.2 \times (25)^2$
$= R_T \times (Q_{mine})^2$
$= 125 Pa.$

$\therefore$ P across split $= P_{Fan} - P_{loss} = P_S$

$\therefore P_S = 375 Pa$

$625 \times 0.2 = 125.0$

$\Sigma \; P_S = R_A Q_A^2$

$\therefore R_A = \frac{375}{(15)^2} = 1.67 \; Ns^2m^{-8}$

$P_S = R_B Q_B^2$

$\therefore R_B = \frac{375}{(10)^2} = 3.75 \; Ns^2m^{-8}$

After installion of Booster Fan:-

New quantity through mine $= Q_N$

$Q_B = 15 \; m^3/s$

$Q_A = (Q_N - 15)$

loop 1:-

$$500 = 0.2\,Q_N^2 + 1.67\,(Q_N - 15)^2 \rightarrow (1)$$

$$1.87\,Q_N^2 - 50.1\,Q_N + 375.75 - 500 = 0$$

$$1.87\,Q_N^2 - 50.1\,Q_N - 124.25 = 0$$

$$Q_N = 29.07\ m^3/s$$

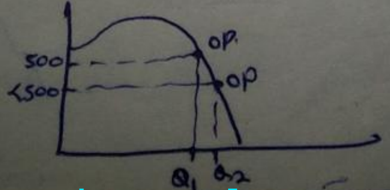
loop2:-

$$\underbrace{Q_N^2 R_T + (3.75)(15)^2}_{\text{Pressure drop}} - \underbrace{P_B}_{\text{Pressure developed}} = 500$$

$$\therefore P_B = 512.763\ Pa$$

In normal question → if not mentioned the we assume that before and after installation of booster fan the pressure developed by main ventilation fan remains constant

But practically pressure developed by main fan reduces with increase in quantity that can be seen from the characteristic curve.



$Q_1 = 25\ m^3/s$

$Q_2 = 29\ m^3/s$

ex 3.7

Two splits A and B pass 40 m^3/s and 60 m^3/s of air respectively with a pressure of 450 Pa across them when the main fan pressure is 850 Pa. (a) Calculate the pressure of the booster fan required to increase the flow in split A to 50 m^3/s and flow in split in split B after installation of the booster (a) assuming the main fan pressure remains constant at 850 Pa.

(b) The main fan pressure follows the equation $\underbrace{P = 1650 - 8Q}_{\text{operating zone equation}}$

P (Pa), Q (m^3/s)

What will be the critical pressure of the booster fan?

$\boxed{\text{Ans.}}$

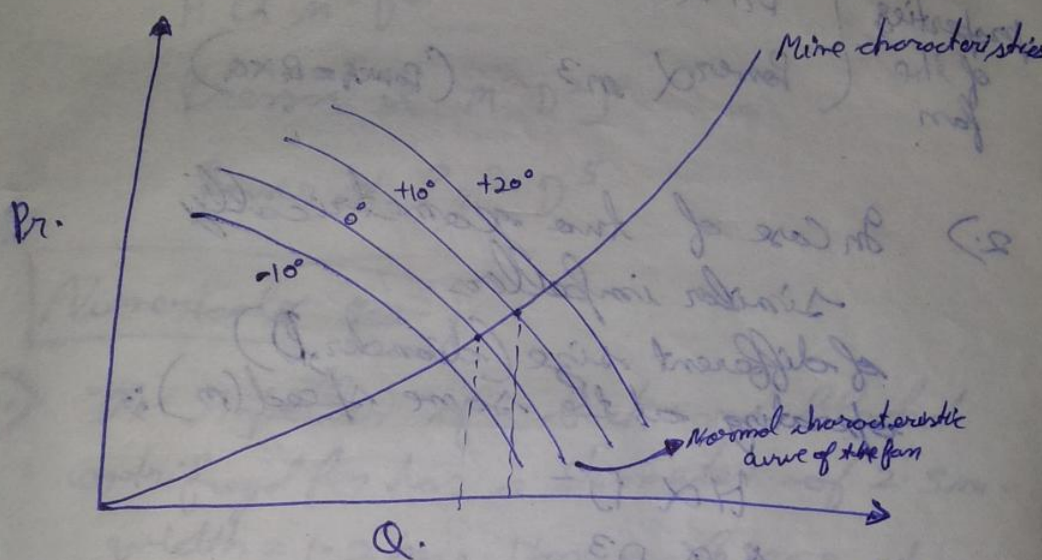
(a) $Q_B = 56.38\ m^3/s$

(b) $Q_B = 54.7\ m^3/s$

23/08/2013.

NCK Sir

Variable Blade angle fan — true in case of axial flow fan. The blade angles can be changed in this case



If ~~if~~ we ~~can't~~ change the blade angle of all the blades then we can have an increase in Quantity and well as pressure

Advantage → this feature of axial flow fan allows us to change the output of the fan by varying the blade angle without having to change the fan. (flexibility of axial flow fan.)

→ In general it is used with ± 15° angle variance

Fan Laws:—

1.) When the speed (n) of a given fan is changed.

Inherent properties of the fan
$$\begin{cases} Q \propto n \\ P_r \propto n^2 \\ \text{Power} \propto n^3 \end{cases}$$ (Power = $P_r \times Q$)

2.) In case of two geometrically similar impellers of different size (diameter, D) operating at the same speed (n):-

$H \propto D^2$

$Q \propto D^3$

$\text{Power} \propto D^5$

3.) If both speed (n) and size (D) of two geometrically identical impellers are varied then

$H \propto n^2 D^2$

$Q \propto n D^3$

$\text{Power} \propto n^3 D^5$

4.) If density (ρ) is also varied in addition to condition 3.)

$Q \propto n D^3$

$H \propto n^2 D^2$

$\text{Pressure} \propto n^2 D^2 \rho$

$\text{Power} \propto \rho n^3 D^5$

$\boxed{\text{Numericals}}$

1.) The impellar of a backward bladed centrifugal fan has a diameter of 2.5m. width = 1.2 m, Vane angle 65° at outlet (a) what will be the theoritical head developed by the fan when it running at a speed of 280 rpm and circulating 5 m³/s of air.
Assume → Meridional Entry
(b.) what will be the maximum theoritical head and max. theoritical capacity.

2.) A fan circulates 50 m³/s of air through a mine having resistance $R = 0.3\ NS^2m^{-8}$. The power input to the fan motor is recorded at 75 KW (a) what is the combined efficiency of the fan and motor system.

(b) It is desired to raise the quantity through the mine ~~through~~ to $65\ m^3/s$ by increasing speed. Examine if the motor rated at ~~to~~ 120 KW will be adequate.

$\boxed{\text{Ans. 2}}$

(a) $$\eta_{combined} = \frac{\text{Air Power}}{\text{Electrical Power}}$$

$$= \frac{(RQ^2)Q}{75\ KW}$$

$$= \frac{0.3 \times (50)^3\ \text{watts}}{75000\ \text{watts}} = 0.5$$

$$\therefore \eta_{combined} = 50\%$$

(b) $$50\% = \frac{0.3 \times (65)^3}{\text{Power input required}}$$

assuming efficiency is same

$$\text{Power input} = 164.77\ KW$$

$$> 120\ KW$$

Conclusion:- So Motor is incapable

Ans 1 (a) given $B = 1.2\,m$

$R = 1.25\,m = \frac{D}{2} = \frac{2.5}{2}\,m$

$\beta = 65^\circ$

$Q = 5\,m^3/s$

$n = 280\,rpm$

$U = \omega R = 36.65\,m/s$

So theoritical head =

$$H_e = \frac{U_2^2}{g} - \frac{U_2 \cot\beta_2\, Q}{2\pi r_2 B g}$$

$$= \frac{(36.65)^2}{9.81} - \frac{(36.65)\cot 65^\circ \times 5}{2\times\pi\times 1.25\times 1.2\times 9.81}$$

$$= 136.924 - 0.924$$

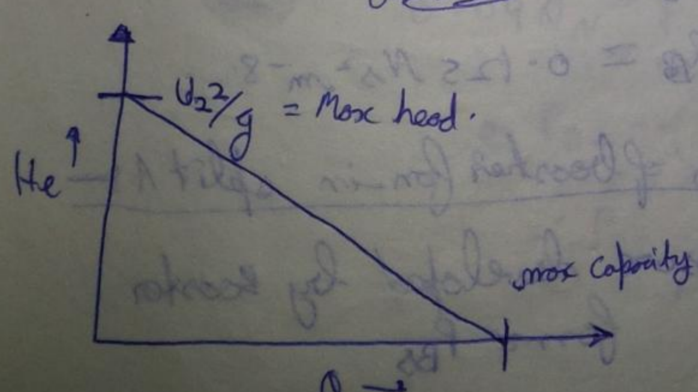
$$\therefore H_e = 136\,m$$

(b)

$$\max H_e = \frac{U_2^2}{g} = 136.924\,m$$

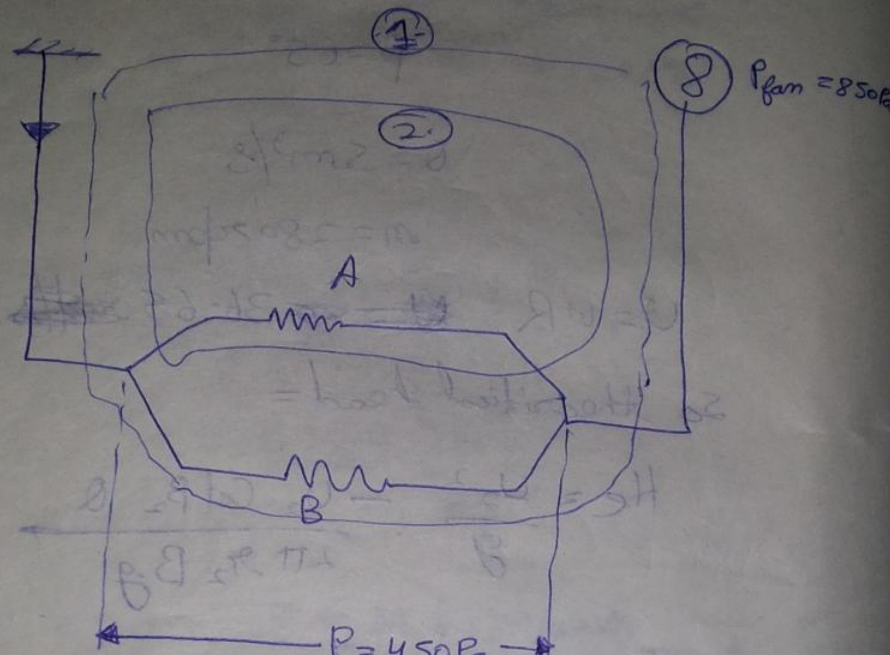
$$Q_{max} = \frac{2\pi r_2 B U_2}{\cot\beta_2}$$

$$= 740.75\,m^3/s$$



Solution of Question given by SG Sir on 20/08/2013:-

A.2.7.



Initially:-

$R_A = \frac{450}{Q_A^2}$

$Q_A = 40\ m^3/s$

$\therefore R_A = 0.281\ Ns^2m^{-8}$

$R_B = \frac{450}{Q_B^2}$ $Q_B = 60\ m^3/s$

$\therefore R_B = 0.125\ Ns^2m^{-8}$

flow through mine

$R_T Q_N^2 = 850 - 450$

$400 = R_T(60+40)^2$

$\therefore R_T = 0.04\ Ns^2m^{-8}$

(a) After installation of booster fan in split A:-

net pressure developed by booster fan = P_{BS}

$$Q_A = 50\,m^3/s$$

$$Q_{mine} = Q_N$$

$$Q_B = (Q_N - 50)\,m^3/s$$

Applying loop law to loop 1:-

$$R_T Q_N^2 + R_B Q_B^2 = 850$$

$$0.04\,Q_N^2 + (Q_N - 50)^2\,0.125 = 850$$

$$\cancel{4Q_N^2 + 0.125Q_N^2 + 2500 - 12.5Q_N = 850}$$

$$\cancel{4.125Q_N^2 - 125Q_N + 1650 = 0}$$

$$\cancel{Q_N = 1.52\,m^3/s}$$

$$0.04Q_N^2 + 0.125Q_N^2 + 312.5 - 12.5Q_N - 850 = 0$$

$$0.165Q_N^2 - 12.5Q_N - 537.5 = 0$$

$$Q_N = 106.38\,m^3/s$$

$$\therefore Q_B = 56.38\,m^3/s$$

$$0.04Q_N^2 + 0.281(50)^2 - P_{BS} = 850$$

$$P_{BS} = -\left(850 - 0.281(50)^2 - 0.04(106.38)^2\right)$$

$$\therefore P_{BS} = 305.168\,Pa$$

$Q_A = 50 m^3/s$

$Q_B = \cancel{56.38 m^3/s}$

$Q_N = \cancel{106.38 m^3/s}$

$P_{BS} = ??$

$P_{fan} = 1650 - 8(Q_N)$

$= 1650 - 8(106.38)$

$\therefore P_{fan} = 798.96 \text{ Pa}$

$\therefore P_{BS} = \cancel{P_{fan}} \; R_T(Q_N^2) + R_A(50)^2 - P_{fan}$

$= (0.04)(106.38)^2 + (0.281)(50)^2 - 798.96 \text{ Pa}$

$\boxed{\therefore P_{BS} = 92.205 \text{ Pa}}$

(b.) $\boxed{\text{Loop 1:-}}$

$R_T Q_N^2 + R_B(Q_N - 50)^2 = 1650 - 8Q_N$

$0.165 Q_N^2 - 4.5 Q_N - 1337.5 = 0$

$\therefore Q_N = 104.7 m^3/s$

$\therefore Q_A = 50 m^3/s$

$\therefore Q_B = Q_N - Q_A = 54.7 m^3/s$

$P_{B\text{-critical}} = \frac{R}{R}$

$= \frac{0.281}{0.04} \times ($

26/08/201

$$\therefore P_{BS} = R_T Q_N^2 + R_A(50)^2 - 1650 + 8Q_N$$

$$\therefore P_{BS} = (0.04)(104.7)^2 + (0.281)(50)^2 - 1650 + 8(104.7)$$

$0.04(Q_N')^2 = 1650 - 8Q_N' \Rightarrow Q_N' = 126.39\ m^3/s$

$$\boxed{\therefore P_{BS} = 328.584\ Pa}$$

$P_{B\text{-critical}} = \frac{R_A}{R_T} \times P_{fan}$

$= \frac{0.281}{0.04} \times (1650 - 8 \times 126.39)$

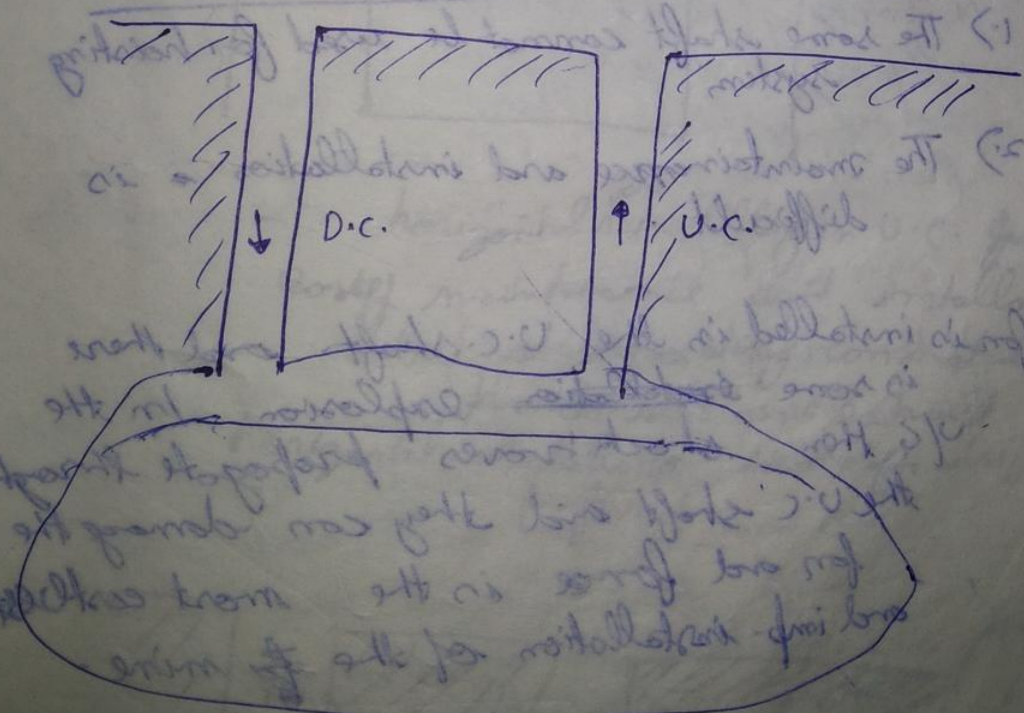
$= 4.48\ KPa$

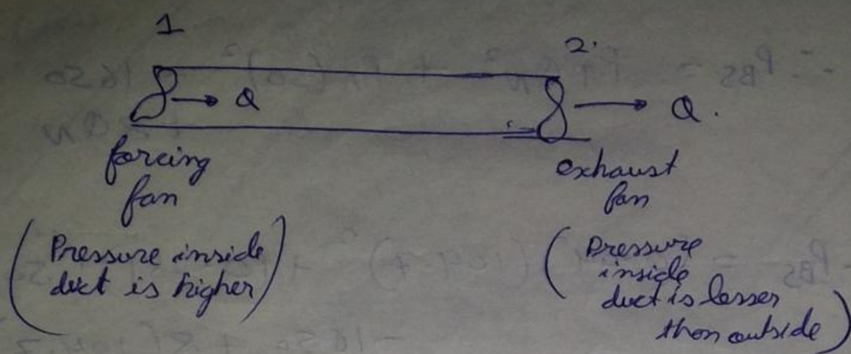
26/08/2013.

NCK Sir

Installation Of Main Fan

Fan → Main ~~Mine~~ fan
Fan → Auxilliary fan
Fan → Booster fan





The same fan can be used as forcing as well as exhaust depending on the place where it is installed.

We can go for forcing installation in D.C. or go for exhaust installation in the U.C.

Advantage of installation in shaft top:-

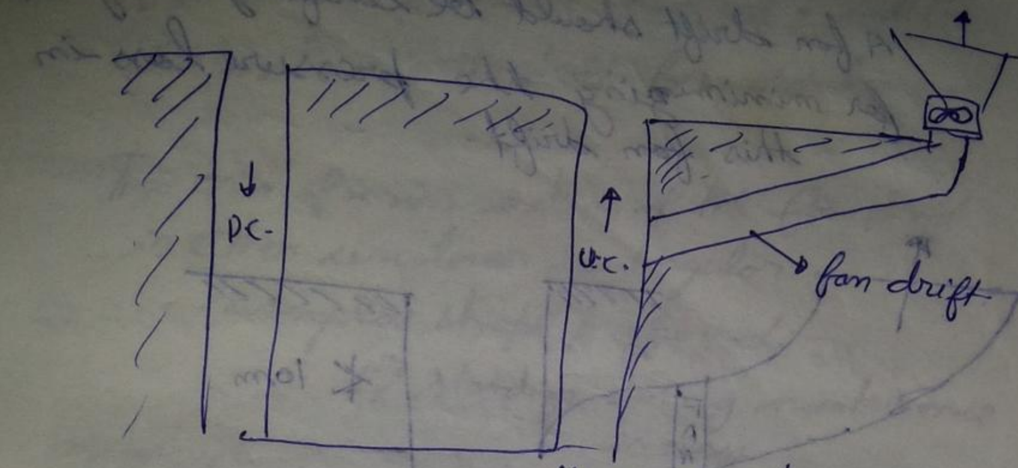
1.) The air is directly ~~moved in the~~ circulated in the airways.

Disadvantage of installation in shaft top:-

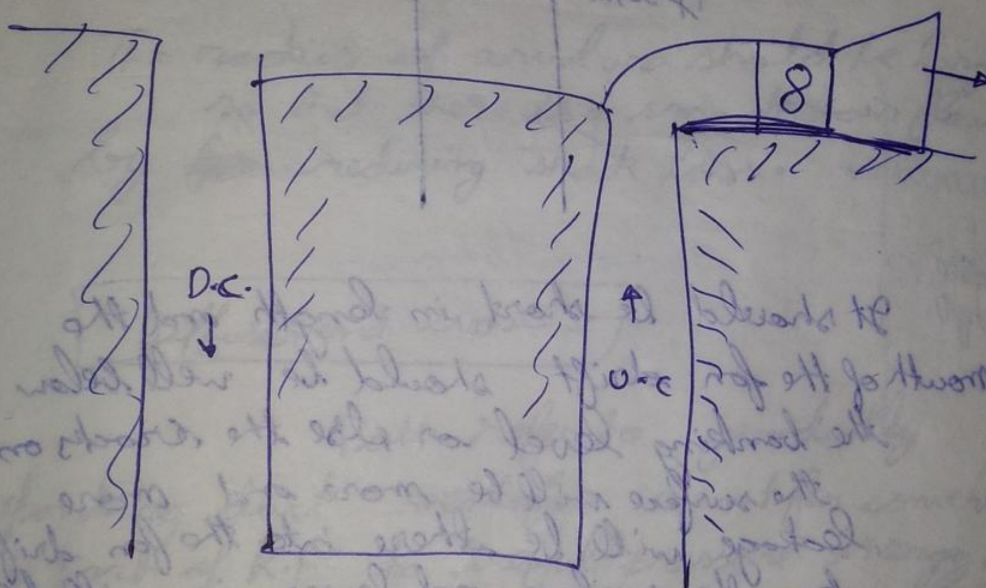
1.) The same shaft cannot be used for hoisting system.

2.) The maintainance and installation is difficult.

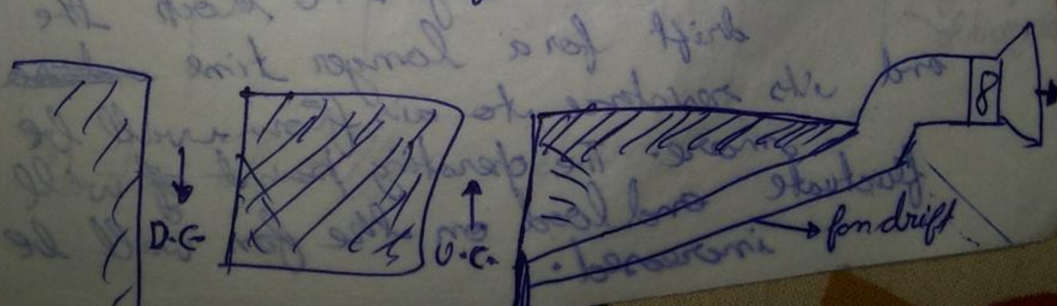
3.) If fan is installed in the U.C. shaft and there is some ~~installation~~ explosion in the U/G then shock waves propagate through the U.C shaft and they can damage the fan and force in the most costliest and imp. installation of the mine.



Here we can have hoisting system, ~~etc~~ in U.C. also

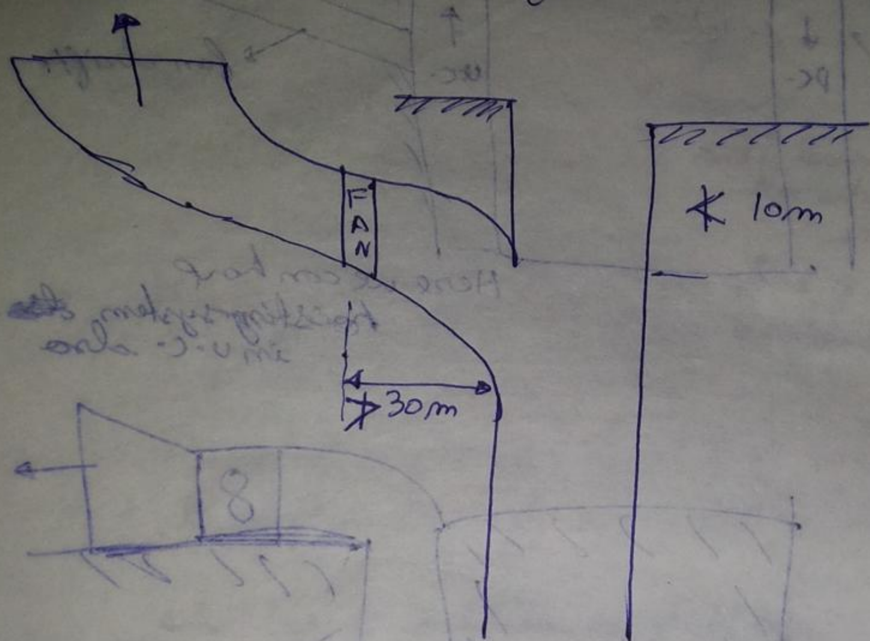


horizontal fan installing in U.C. gives easy maintainance and installation but still hoisting cannot be placed so an exhaust horizontal installation in the fan drift is preferred.



FAN DRIFT

A fan drift should be carefully designed for minimizing the pressure loss in this fan drift.



It should be short in length and the mouth of the fan drift should be well below the banking level or else the cracks on the surface will be more and more leakage will be there into the fan drift from the surface and lesser air will be drawn from the mine. thereby affecting our ventilation.

If the drift is close to the B.L. then then in case of hoisting system as the cage is close to the Banking level its speed is very less and the cage will block the drift for a longer time ~~and so~~ and its resistance to air flow will be more. The operating point of will fluctuate and load on the fan will be increased.

It is a usual practice to have a little flat position in the drift for maintainance.

The area of cross section of the fan drift is either circular or rectangular.
rectangular shape prefferred:-

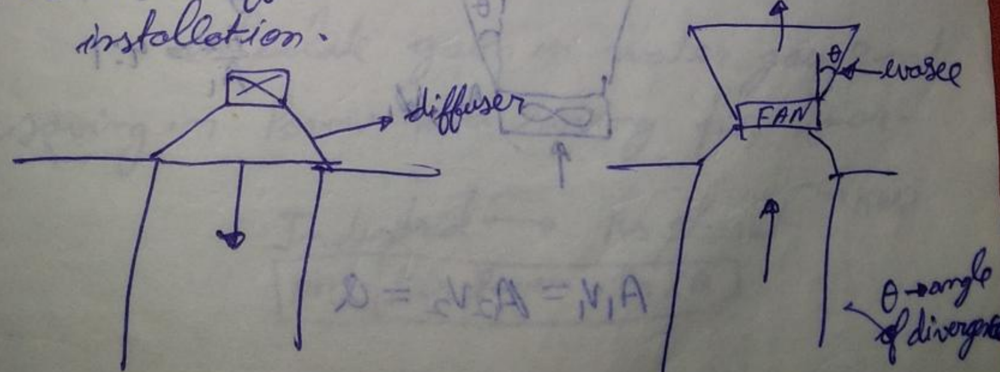
1) standing during maintainance is easy
2) driving a circular opening is difficult.

The radius of curvature should be large so that there is a smooth air flow by ~~for~~ reducing shock loss.

Diffuser and evasee:-

Both refer to gradually expanding duct ~~meant for~~ meant for converting a part of K.E. to useful pressure energy.

The name diffuser and evasee depend on the installation.



Purpose of diffuser and evasee is same.

The increase in area should be gradual to minimize the shock loss. From this point of view a suitable angle of divergence of the side of the evasee should be ~~fixed to~~ 6° to 7°.

As the length of the evasee increases :-

1.) K.E. tends to zero

But ~~at~~ at the same time

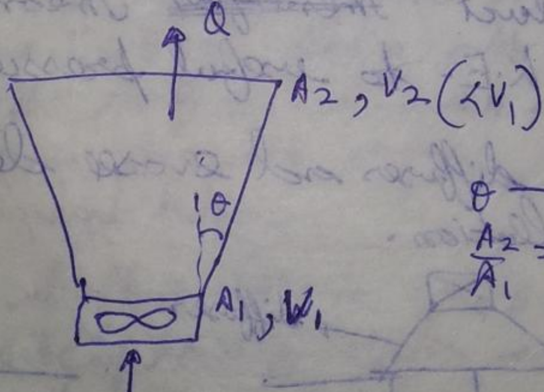
2.) Skin friction also increases

OPTIMIZATION OF evasee length

So $\frac{A_2}{A_1} \not> 4:1$ to get the maximum benefit of the evasee

$A_2 \rightarrow$ outlet area

$A_1 \rightarrow$ fan outlet area



$\theta \rightarrow 6°-7°$

$\frac{A_2}{A_1} = 4:1$

$A_1V_1 = A_2V_2 = Q$

$$\left(\frac{\rho V_1^2}{2} - \frac{\rho V_2^2}{2}\right)\eta_c = h \quad (Pa)$$

$\eta_c \to$ efficient of conversion of KE to Pr energy is about 70% for $A_2 : A_1 = 4:1$

$$h = \left(\frac{\rho V_1^2}{2} - \frac{\rho V_2^2}{2}\right)\eta_c$$

$$= \frac{\rho}{2}\left(\frac{Q^2}{A_1^2} - \frac{Q^2}{A_2^2}\right)\eta_c$$

$$= \frac{\rho Q^2}{2}\left[\frac{1}{A_1^2} - \frac{1}{A_2^2}\right]\eta_c$$

$\boxed{A_2 = 4A_1}$

$$= \frac{\rho Q^2}{2}\left(\frac{15}{16 A_1^2}\right)\eta_c$$

Q. The area of the base $A_1 = (2 \times 2)\,m^2$

$A_2 = (3 \times 3)\,m^2$ $\boxed{\eta_c = ??}$

$Q = 4000\,m^3/min$

Calculate gain in water gauge and saving in Power and saving per year.

Industrial $\to$ Rs 5/unit $\to$ KWH

$\boxed{\text{NOTE: Air Power} = Pr \times Q}$

27/08/2013 SG Sir

Joint operation of Main and Booster Fans

Depending on the power of the booster fan, the result of its installation may be:-

→ The required distribution of the air between the splits

→ An excessive increase of the flow in one split at the expense of the others.

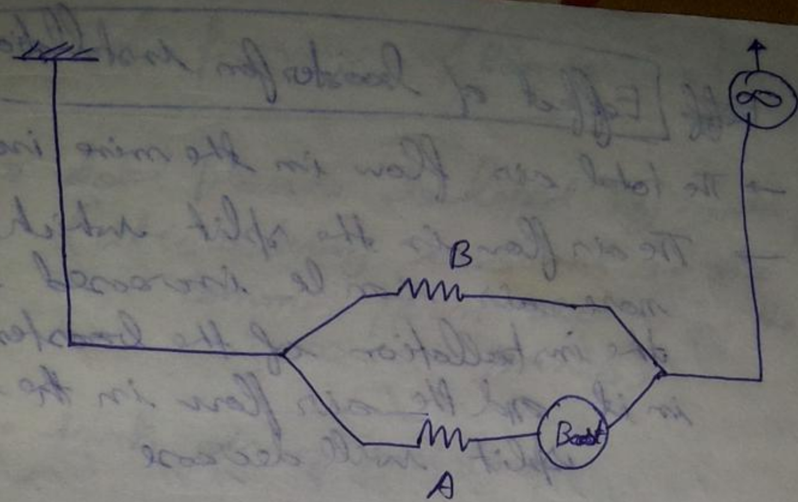
→ A reduction or even a reversal of the air flow in the splits which have no booster.

In both the last instances, it is necessary:-

(a) to reduce, if possible, the resistance of the common sections

(b) to increase the resistance of the split containing booster (not economical)

(c) to reduce the rpm of the booster or to increase that of the main fan.



As the air flow in A is increased by Booster but the air flow in B is decreased and as the airflow in A is further increased the airflow in B is further reduced.

The overall ~~i~~quantity of air flow in the entire mine increases.

The increase in split A is due to:-

1.) reduction in split B

2.) increase in total quantity through the mine

If R_T is the resistance of the common/trunk airways then as the pressure of Booster is increased the flow through mine is increase and pressure drop in the trunk airways increases. As the size of booster is increased the Q through mine increases and pressure loss in the trunk airways is increased and a point comes when the entire pressure developed by the main fan is consumed in the trunk airways. This pressure is called the critical pressure of the Booster fan. At this critical pressure the total airflow through the mine passes through the boosted split and no air flow through the unboosted split takes place.

If the size of booster is further increased then the recirculation of air in the split A takes place (i.e. whatever airflow passes through A, it moves back into the split B in the reverse direction causing reversal of airflow in split B and again enters into split A causing a complete circulation of A). Such a situation is very dangerous.

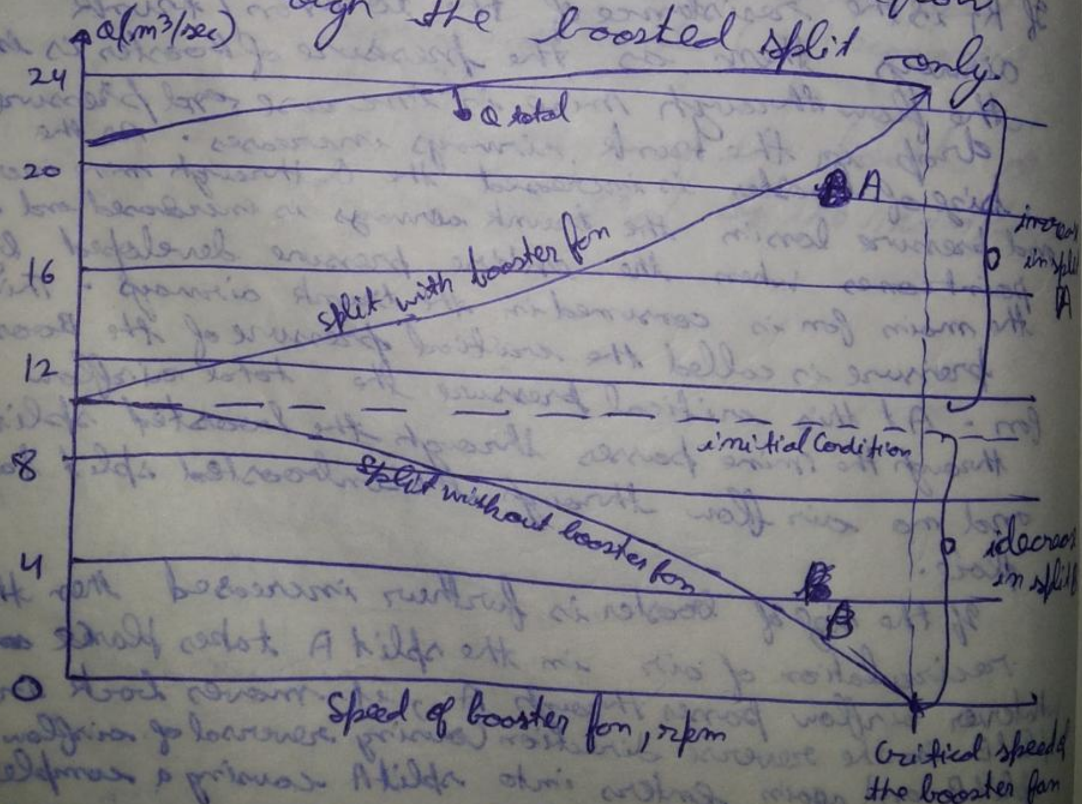
Effect of booster fan installation :-

→ The total air flow in the mine increases

→ The air flow in the split which needs more air can be increased through the installation of the booster fan in it and the air flow in the other split will decrease

→ The increase in the air flow of the booster split is much more than the reduction in airflow in the unboosted split.

→ If we go on increase the speed of the booster fan hence the pressure developed by it, time will come when all the air will flow through the boosted split only.



Critical pressure of Booster Fan

P → total pressure developed by main fan (it is entirely consumed in the common / trunk section of the mines)

R_T → trunk airway resistance

R_S → resistance of the boosted split

$$P = R_T Q^2$$

$$\underbrace{P_{B-critical}}_{\text{Critical Pressure of Booster}} = R_S Q^2$$

$$\therefore P_{B-critical} = \frac{R_S}{R_T} \times P \quad (10)$$

If the booster fan selected is of such high capacity or operates at a high pressure that the whole of the ~~fan~~ main fan ~~f~~ quantity is drawn into the booster split, the ~~[illegible]~~ whole of the main fan pressure is consumed to overcome the resistance of the shafts and trunk airways. The flow in the parallel/split or splits then becomes zero. The pressure of the booster fan in this situation is known as the critical pressure ~~of~~ for the booster fan.

If the booster fan operates at higher than the critical pressure, the flow in the parallel splits will reverse with the booster causing recirculation of the air in these splits.

The critical pressure of a booster fan

$$P_b = \frac{R_a}{R_t} \times P$$

Where:-

R_a is the resistance of the high resistance split A.

R_t is the resistance of the trunk airways.

P is the pressure developed by the main mine fan

Q.1) The ~~resistances~~ resistances of two districts A and B of a mine in parallel are 0.15 weisbach respectively and 0.25 WbA while the resistance of the shaft and trunk airways is 0.08 Wb. Pressure due to the main ventilating fan is 75 mm of W-gauge. Calculate the critical pressure of the booster fan to be installed in district B.

Note:

- Weisbach (german unit) = 9.8 Ns^2m^{-8}
- Kilomurg (russian unit) = 9.8 Ns^2m^{-8}

Q.2.) The main surface fan of a mine develops a pressure of 1.2 KPa. Of this 0.8 KPa is consumed in the shaft and trunk airways and rest is used up in ventilating 2 splits A and B. Airflows in split A is 15 m³/s and in split B is 10 m³/s. What should be the critical pressure of the booster fan to be installed in split B. What quantity will flow through A at this pressure.

Q.3.) 2 splits pass 20 and 30 m³/s of air respectively with a pressure of 600 Pa across them. The pressure drop in trunk airways being 1000 Pa. Calculate the pressure of the booster fan in the longer (high resistance) split that will cause complete stoppage of flow in the other split. Assume main fan pressure to remain constant.

A.1.)

$R_B = 0.25 \ Wb$ (Booster installed in split B)

$R_T = 0.08 \ Wb$

$\therefore P_{B\text{-critical}} = \frac{0.25}{0.08} \times P_{fan}$

$= \frac{0.25}{0.08} \times 75$

$\therefore P_{B\text{-critical}} = 234.375$ mm of w-g

$= 2.3$ KPa

$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

A.2.

$P_{fan} = 1.2\, KPa$

$P_T = 0.8\, KPa$

$P_{across\ split} = 0.4\, KPa$

$Q_A = 15\, m^3/s$

$Q_B = 10\, m^3/s.$

$$R_A = \frac{0.4 \times 10^3}{(15)^2} = 1.778\, Ns^2m^{-8}$$

$$R_B = \frac{0.4 \times 10^3}{(10)^2} = 4\, Ns^2m^{-8}$$

$$R_T = \frac{P_T}{(Q_{mine})^2} = \frac{0.8 \times 10^3}{(25)^2} = 1.28\, Ns^2m^{-8}$$

$\Rightarrow$ Booster installed in split B

$$\therefore P_{B\text{-}critical} = \frac{R_B}{R_T} \times P_{fan}$$

$$= \frac{4}{1.28} \times 1.2\, KPa$$

$$\therefore P_{B\text{-}critical} = 3.75\, KPa$$

At this pressure of Booster flow through split A is zero.

A.3.

A.37

1) longer split ⇒ higher resistance split.
2.) quantity of air flow is lower.

Split A → $20 m^3/s$ (Booster installed here)
Split B → $30 m^3/s$

$Q_{mine} = 50 m^3/s$

$P_T = 1000 Pa$

$P_{across\ split} = 600 Pa$

$$R_T = \frac{P_T}{(Q_{mine})^2} = \frac{1000}{(50)^2} = 0.4\ Ns^2m^{-8}$$

$$R_A = \frac{600}{(20)^2} = 1.5\ Ns^2m^{-8}$$

$$\therefore P_{B\text{-}critical} = \frac{R_A}{R_T} \times P_{fan}$$

$$= \frac{1.5}{0.4} \times (1000+600)$$

$$\therefore P_{B\text{-}critical} = 6000 Pa = 6 KPa$$

Solution of Question given by NCK Sir on 26/08/2013

A>

$$P = \frac{\rho Q^2}{2}\left[\frac{1}{A_1^2} - \frac{1}{A_2^2}\right]\eta_c$$

$$P = \rho_w g h$$ → head of water gauge

$\rho_{air} = 1\ kg/m^3$

$\boxed{\text{But take}}$ $\rho_{air} = 1.2\ kg/m^3$ and then solve in the same procedure

$\rho_w = 1000\ kg/m^3 = 1\ kg/l = 1\ gm/ml$

$$h = \frac{\rho_{air} Q^2}{(\rho_w)\, 2g}\left[\frac{1}{A_1^2} - \frac{1}{A_2^2}\right]\eta_c$$

$$= \frac{(4000)^2}{1000 \times 60 \times 60 \times 2 \times 9.81}\left[\frac{1}{4^2} - \frac{1}{9^2}\right]\eta_c$$

NOTE ⟹ Here taken $\eta_c = 100\%$ but actually it should be mentioned in the question. It is impossible to have $\eta_c = 100\%$

~~h = 40 900.57 mm of w-g.~~

$h = 11.36$ mm of w-gauge
(gain in water gauge)

$$P_r = \rho \times g \times h = 1000 \times 9.81 \times \frac{11.36}{1000}$$

$$= 111.442\ Pa$$

$$Q = \frac{4000}{3600}\ m^3/s = 66.667\ m^3/s$$

$\therefore$ Power saving $= P_r \times Q = 7.43\ KW$

1 Industrial Power unit = 1 KWH

$$= \frac{1000 \times 3600}{10^6}$$

$= 3600$ K

Power units saved per second of fan use = $\frac{7.43\ kW}{3600\ kS}$

$\approx$ ~~2 units~~

$\approx 2.06 \times 10^{-3}$ units/sec

Power units saved per year $= 2.06 \times 10^{-3} \times 24 \times 3600 \times 365$

~~= 65086800 units~~

$= 64964.16$ units

If industrial rate = Rs5/unit

$\therefore$ yearly savings = ~~65086800 x 5~~ 64964.16×5

$= 3,24,820.8$ rupees

~~= 32,54,34,000~~

$\boxed{30/08/2013.}$ $\boxed{\text{NCK Sir}}$

Forcing Vs Exhaust system:-

Fan remains the same. It depends on how you install it.

1) Both exhaust and forcing system are used in metal mines mainly.

1.81

But in coal mines $\rightarrow$ exhaust system is used invariably

Advantages of exhaust:-

1) It avoids necessity of providing air locks on main shaft if it is D.C. (hoisting is there in D.C. shaft)

If hoisting in U.C. then during hoisting air doors on top of the shaft should be closed.

2.) greater Power saving possible because of evasee installation in exhaust shaft.

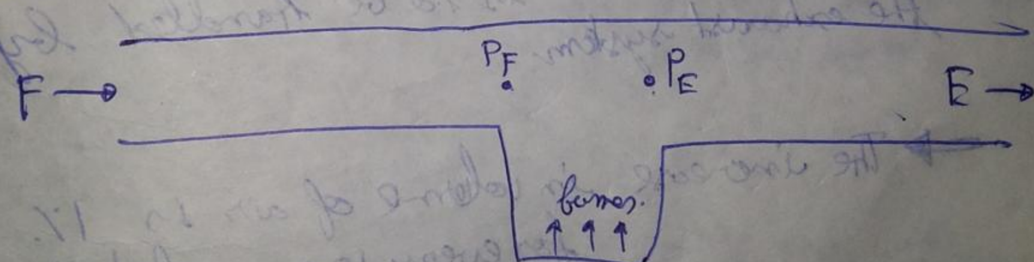
3.) In exhaust system P inside mine is less than Patm.

Due to Power failure, mechanical failure or fan maintainance. if fan is not working.

Then pressure inside mine increases and the methane emission from the coal bed (culprit of explosion) will be restricted and the methane will be pushed towards the goaf area and methane concentration at working faces will be less for the initial instant. Later on the when pressure is balanced (between atm and ~~the~~ mine) then emission of methane will normal after a long time.

while if a forcing installation is there then pressure inside mine is more than atm. on sudden stoppage of force, so the pressure at the faces reduces and release of methane at the faces increases than before. This is the main reason why exhaust installation is used in coal mines.

4:) gas and fume clearance is better in exhaust system



$$\text{Pressure inside mine} \begin{cases} P_F > P_{atm} & \text{if forcing} \\ P_E < P_{atm} & \text{if exhaust.} \end{cases}$$

so fumes have a tendency to move towards lower pressure, and so fume clearance while forcing system will be better at the face will restrict the fume movement at the face

Advantages of forcing fan

1.) The fan handles fresh air (non-corrosive air) so fan life i.e., ~~fan~~ fan blade is better. while exhaust fan has a high maintained cost due to encounter with impure mine air.

2.) To get a quantity Q at the mine working a forcing fan handles less capacity of air but exhaust has to handle a greater volume of air

Reason:- In the mine heat, moisture and gases are added to the air so ~~volume~~ temperature of air increases and volume of air is increased from Q to Q + ΔQ. This increased volume is to be handled by the exhaust system.

⟹ The increase in volume of air is 1% for every 100 m depth due to geothermal gradient.

Fan Control:-

For Centrifugal fan we have 3 systems of control:-

1) Constant speed drive and fan with capacity control devices which modify the fan characteristics. Such devices are damper control and inlet vane control

2) Constant speed drive with provision of for variation of speed by intermediate devices such as hydraulic coupling (fluid drive) or electrical coupling (magnetic drive) and also by V-belt/gear system

3) Variable speed drive directly coupled to the fan. ex:- (a) d.c. motor (speed control is smooth but costly)
(b) Slip-ring induction motor
(c) multi-speed AC motor

For axial flow fans:-

All these systems above are applicable with axial flow. In addition some other facilities are there. This is:-

(*) Variable blade angle fan

By varying the Blade angle of the fan the operating point of the fan can be changed.

9/09/2013

NCK Sir

Selection of Main Fan:-

Major factors to be considered:-

1.) Q required at various periods during the life of mine → we have to consider the range of Q required during the life of the mine.

2.) Head required to deliver the quantity

3.) Possibility and range of variation of Mine characteristics

4.) Altitude and temperature of fan site

4.5.) NVP

5.) Reversal of air current → Sometimes we require a reversal of ~~the~~ air current. In case there is a fire near the DC shaft then if the reversal of air current is not there then smoke will spread throughout the mine so reversal of air current helps the smoke to be released to the atmosphere easily.

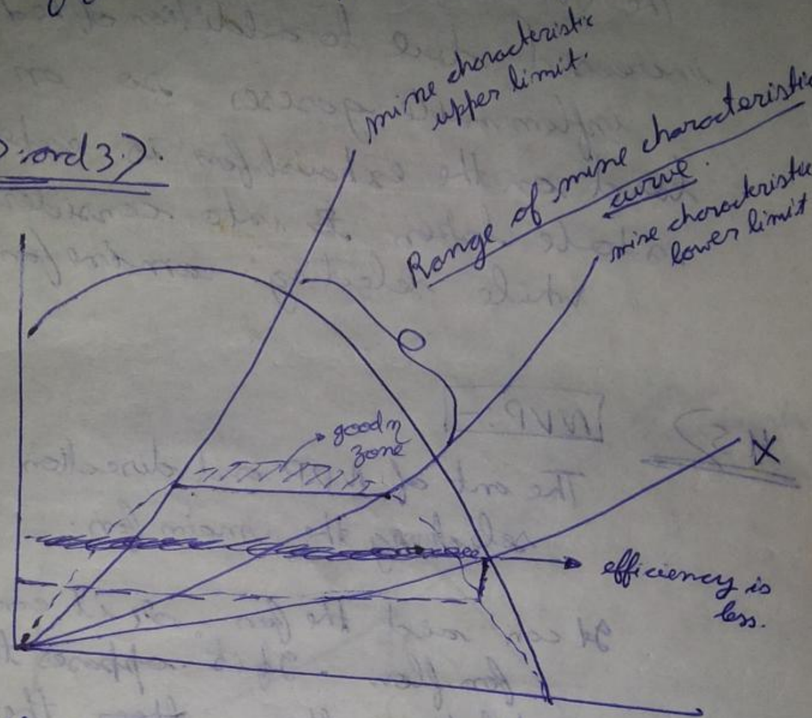
6.) Type and speed of motive power available.

7.) Noise → The noise should be within the permissible limits.

8.) Initial running cost

9.) ~~Size~~ Size of fan and space occupied.

1.) and 2.) and 3.)



The pressure and Q is selected on the basis of ventilation requirement of the mine. A fan should be so selected that it operates at high efficiency as possible during major part of the operation. High η minimises running cost as well as keeps the noise low. Usually fans are installed with constant speed drives so that variation in mine resistance shifts the OP along the fan characteristics. Variation in Mine ~~characteristic~~ resistance/characteristic should be as small as possible.

when great variation in mine ~~characteristic~~ resistance/characteristic do occur → other means of fan control should be used (speed, blade angle)

Hence we can conclude that Axial flow fans are better.

The value of Q at the working district is increased due to addition of heat and inflammable gases so an additional load on the exhaust fan is expected. This is to be taken ~~t~~ into consideration while selecting main fan capacity.

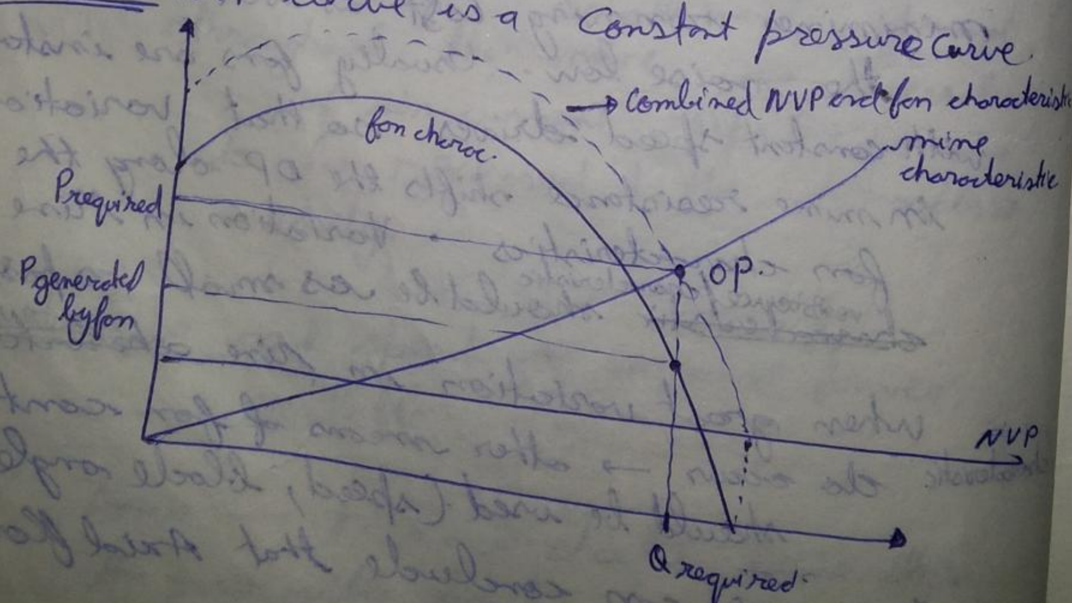
4.5) NVP:-

The amt of NVP and direction is imp. while selecting the main fan.

It can aid the fan or it can oppose the fan flow. If it opposes the fan ventilation then ~~then~~ the fan has to generate additional pressure to overcome the NVP.

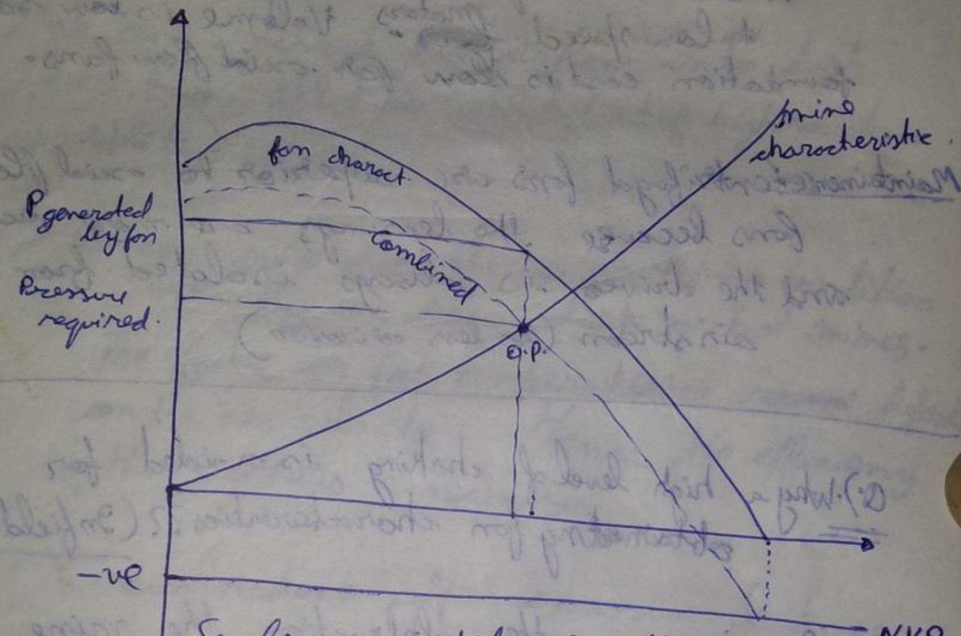
If NVP aids fan ventilation:-

NOTE:- NVP curve is a Constant pressure curve.



So for Q flow through the mine we require a lesser P to be generated by the fan.

If NVP opposes fan ventilation:-



So for a quantity Q through the mine a greater pressure is required to be generated by the fan.

⇒ So the fan should be placed in that shaft such that is aids to the NVP

7) Noise → ~~axial~~ is a function of rotational speed, (should be within the permissible limits)

Axial flow fan → high speed → more noise

But these days the design is sophisticated to keep noise in permissible limits.

Least noise is produced when efficiency is high.

8.) and 9.)

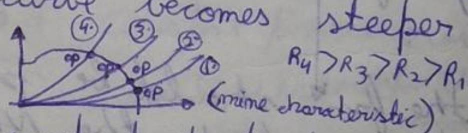
Axial flow fans:-

Because of complicated design and Composite material (light, durable, etc) they have high initial cost. But running cost is less due to high speed so high speed motor is required which is cheaper compared to low speed motors. Volume is low so foundation cost is low for axial flow fans.

Maintinence: Centrifugal fans are superior to axial flow fans because the bearings are more accessible and the drive is always isolated from the airstream (so less corrosion)

Q.) Why a high level of choking is avoided for obtaining fan characteristics?? (In field test)

By increasing the obstruction the mine resistance increases and the mine characteristic curve becomes steeper and steeper.



For a fan with constant speed drive, the operating point shifts along the fan characteristic curve towards the aerodynamic stall point.

But as the OP points shifts towards the pumping limit. It enters into the zone of throbbing. So to avoid the event of throbbing the resistance of the main airway should not be increased ~~to~~ a very high value.

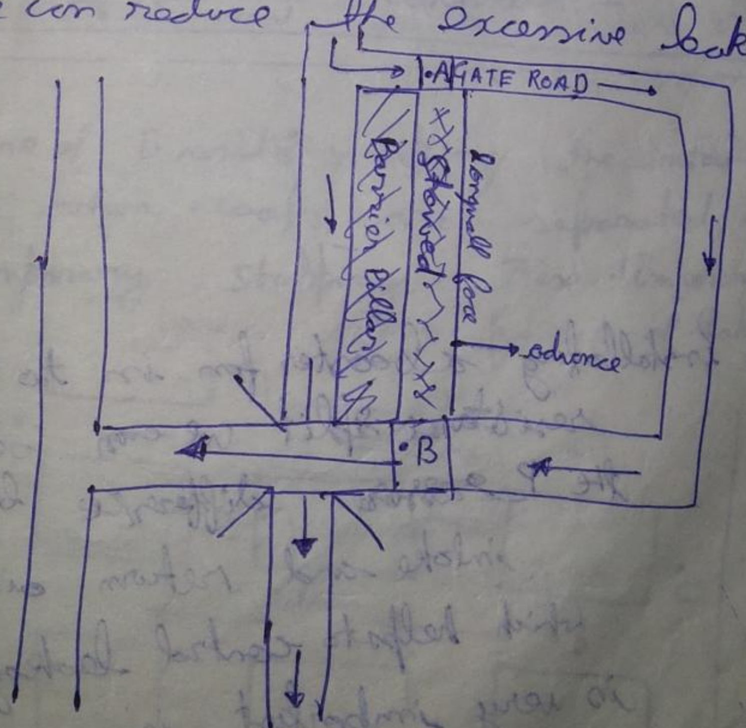
10/09/2013	SG Sir

Advantages of Booster fan installation:-

1.) We can increase the airflow into high resistance split or splits (set of high-resistance splits)

2.) We can improve the working condition specially in the deep or hot mines. The effective or feel temperature ~~remai~~ depends on the air velocity. Hence the efficiency of the workers increases.

3.) We can reduce the excessive leakage



leakage → unwanted shortcircuiting of air

As the Longwall face advances, stowing is done but stowing is not perfect so voids are left which are paths for leakage of air current

As there is a pressure difference between A and B which allows air to flow through ~~the~~ gate roads but this pressure difference causes leakage through the stowing area.

(Continued later)

4.) By installing a booster fan in to the high resistance split we can adjust the Pressure difference between intake and return airways which helps to control leakage which is very important in seam liable to spontaneous heating

Disadvantage:-

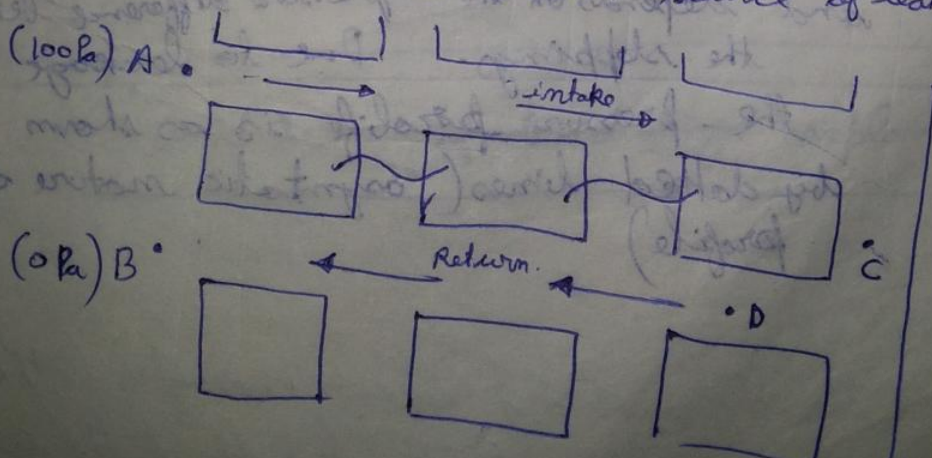
1.) Maintainence of the fan in U/G is difficult due to lack of space and visibility problem.

2.) In case of Booster fan we have to ensure an uninterrupted power supply because in case of power failure the methane can cause a dangerous concentration which can cause an event of explosion in the due course of time → In Coal mines.

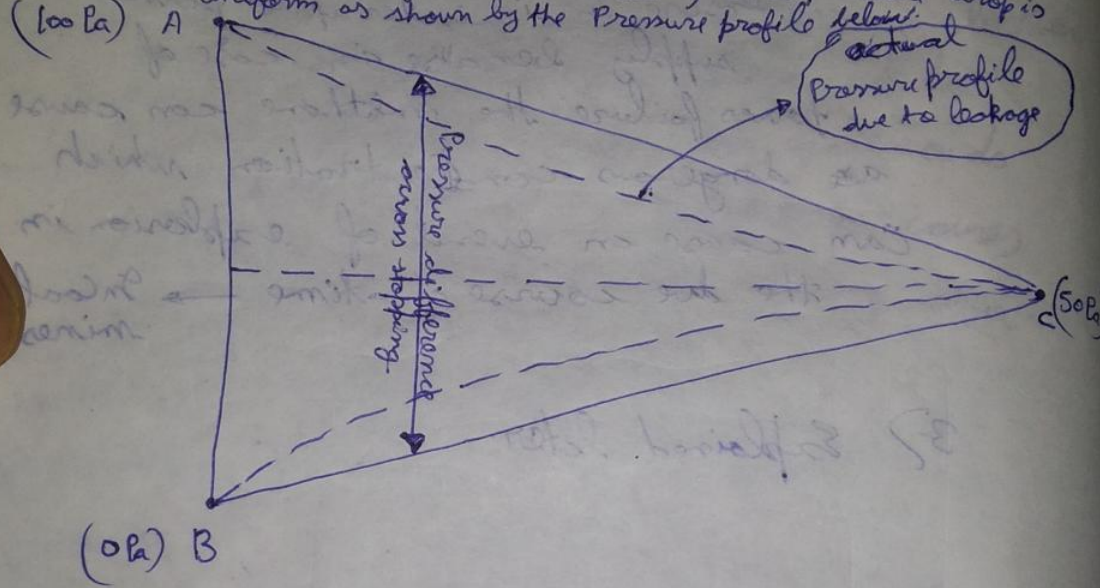
3.) Explained later.

Point 3.) of advantage continued:-

In case of B and P working the intake and return roads are separated by temporary stoppings. These temporary stoppings are a main source of leakage of air.



As we move from A to B via C
we see that the pressure difference across the temporary stoppings changes.
If the airways are of uniform crossection then drop in pressure per unit length is constant, hence pressure drop is uniform as shown by the Pressure profile below.



The pressure difference across stoppings decreases as we move towards C.

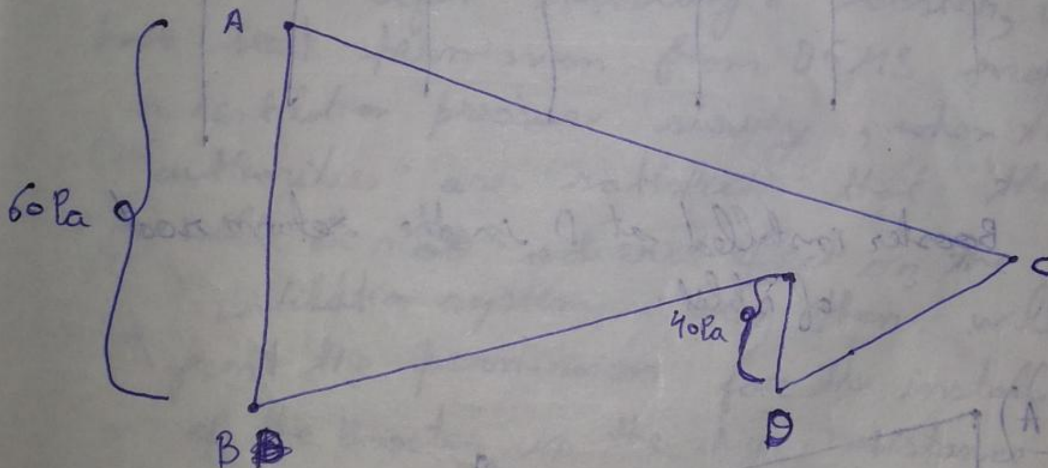
And leakage through stoppings is laminar in nature (i.e. $\Delta P = RQ$ is followed since the diameter of leakage paths $< 0.3 m$) and depends on the pressure difference between the stoppings. Due to leakage the pressure profile is as shown by dotted lines (asymtatic nature of profile)

By installing a booster there may be redistribution of pressure such that the pressure differend decreases, therby decreasing the leakage through stoppings.

Hence a Booster alters the pressure profile for a benefit.

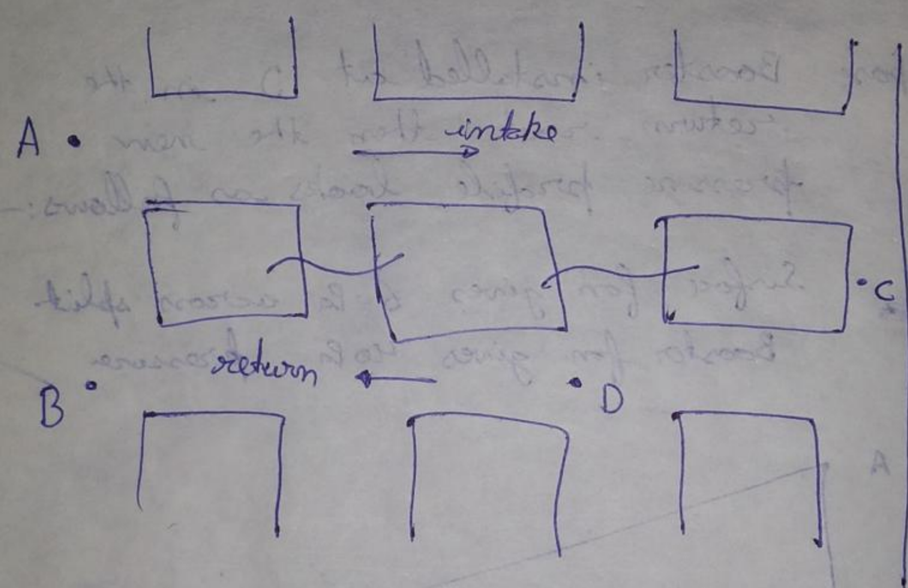
Suppose Booster installed at D in the return root then the new pressure profile looks as follows:-

~~A~~ Surface fan gives 60 Pa across split.
Booster fan gives 40 Pa pressure.

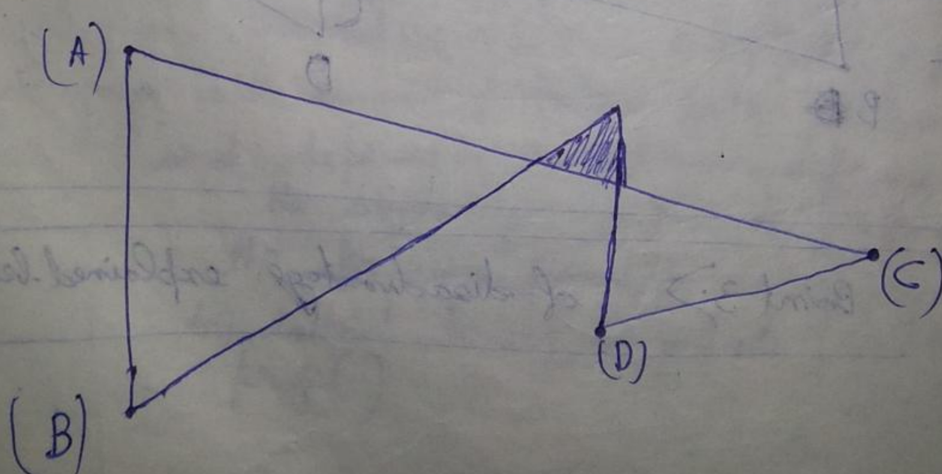


Point 3:> of disadvantage. explained below:-

By installing a Booster in the return path of high resistance split a situation may come as indicated ~~&~~ by the pressure profile curve below.



Booster installed at D in the return root of split.



The region shaded above indicates the ~~?~~ area in the return path of the air where the pressure in the return root is higher than the pressure on the other side of the stopping in the ~~intake~~ intake road.

In Such a situation there is a leakage of foul ~~air~~ return air (containing obnoxious gases, heat, ~~impuri~~ dust) into the intake road through the ~~lea~~ leakage paths in the stoppings.

And this situation is more dangerous than the situation in which there is insufficient flow of air through the split

Hence before installing a Booster, we have seek permission from DGMS and after a Ventilation pressure survey, when the authorities are satisfied that there will be not adverse effect on the ventilation system, only then will they grant the permission for the installation of the Booster in the high resistance split.

3/09/2013

[NCK Sir.]

Series and Parallel operations of Fans:-

1.) When mine resistance is higher than what can be negotiated by a single fan. The second fan will be installed in series.

2.) When quantity requirement of the mine has increased (resistance change is not significant) we go for parallel connection.

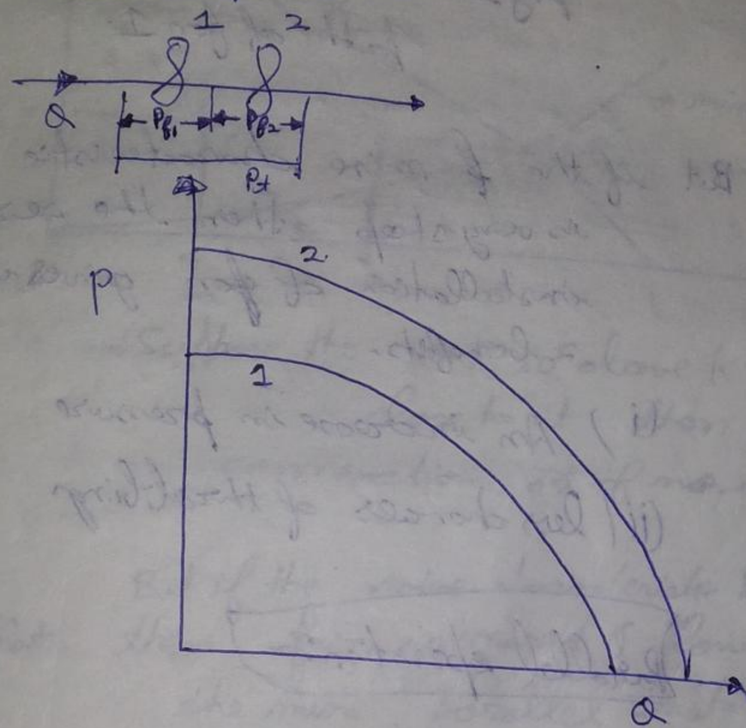
Primary Conditions:-

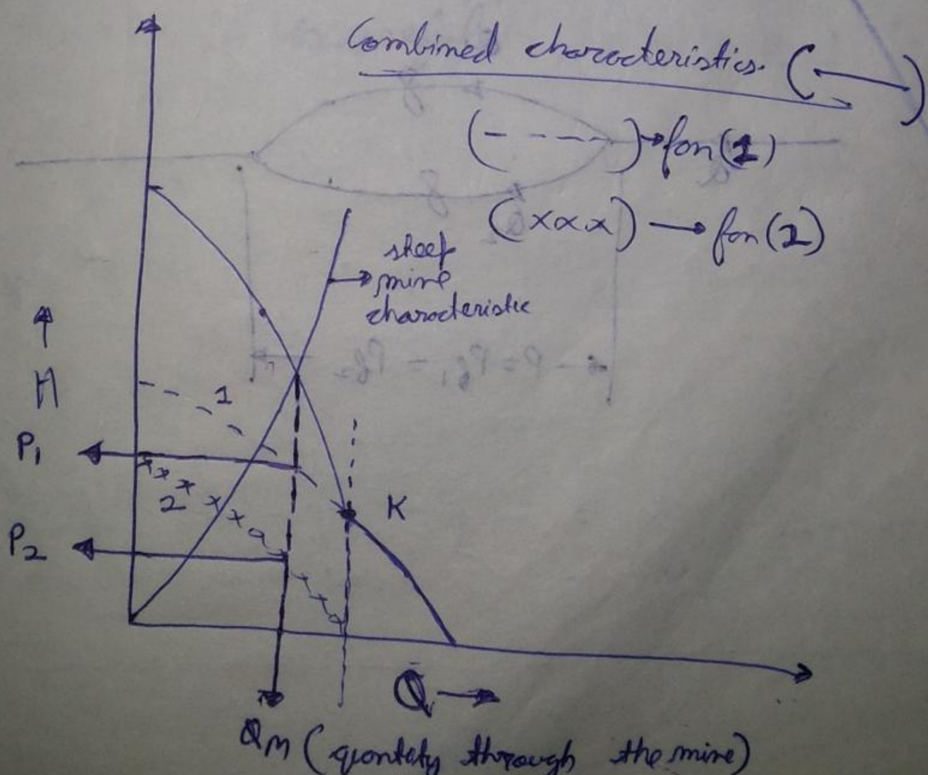
1.) When fans operating in series, each fan handles total Q. ; each fan generates a portion of the overall head required for that particular quantity of airflow.

2.) When fans operating in parallel, at the same point in the system, each fan will develop the overall head required to overcome the mine resistance and each will handle a portion of the total quantity.

In both the cases, the combined characteristics is obtained graphically.

Series operation:-





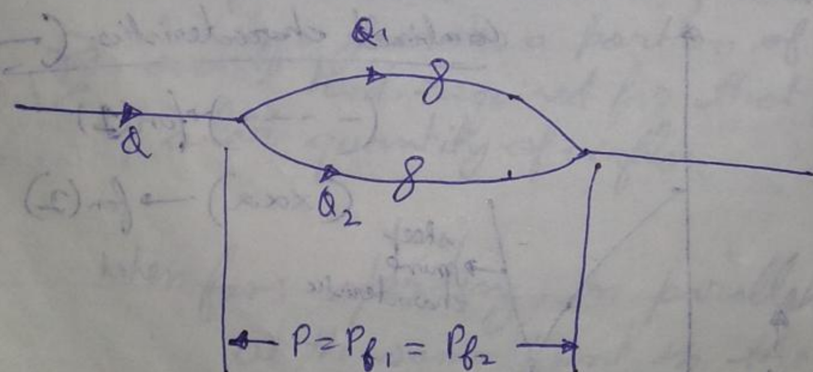
If our operating point is below K or close to K the series installation is not justified and ~~the~~ the second fan ~~...~~ just acts as a physical obstruction in the path of fan 1.

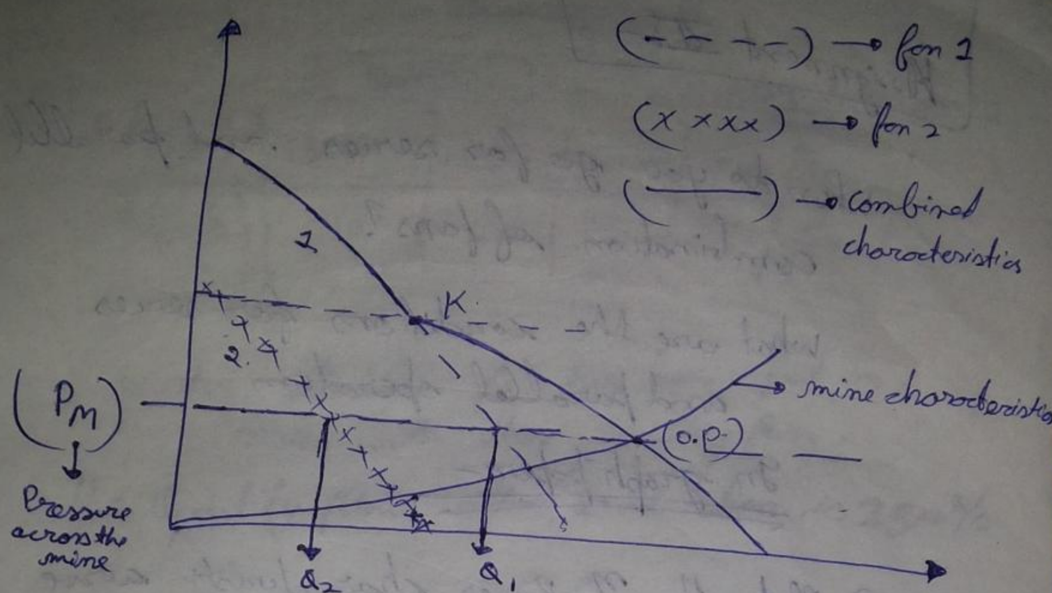
~~*~~ But if the ~~f~~ mine characteristic is very steep then the series installation of fan gives us 2 benefits.

(i) An increase in pressure

(ii) less chances of throbbing

Parallel operation:-





Suppose the O.P. is above K or close to it then parallel connection is of no use

But if the mine characteristic becomes flat then for increased Q flow through the mine, parallel installation is useful

Assignment II:-

When do you go for series and parallel combination of fans?

What are the conditions for series and parallel operation

In graph paper:-

(a) Plot H, η, Power characteristic curve of the main fan operating in the mine.

Plot a suitable mine ch. curve on the same graph.

(b) Another fan H, η, Power. in another graph.

(c) Find H charact for series operation

(d) Take a suitable charact. curve for series opera.

(e) Determine graphically :H, η, power of individual fans.

⇒ Repeat the same for parallel operation of same 2 fans.

16/09/2013 | NCK Sir

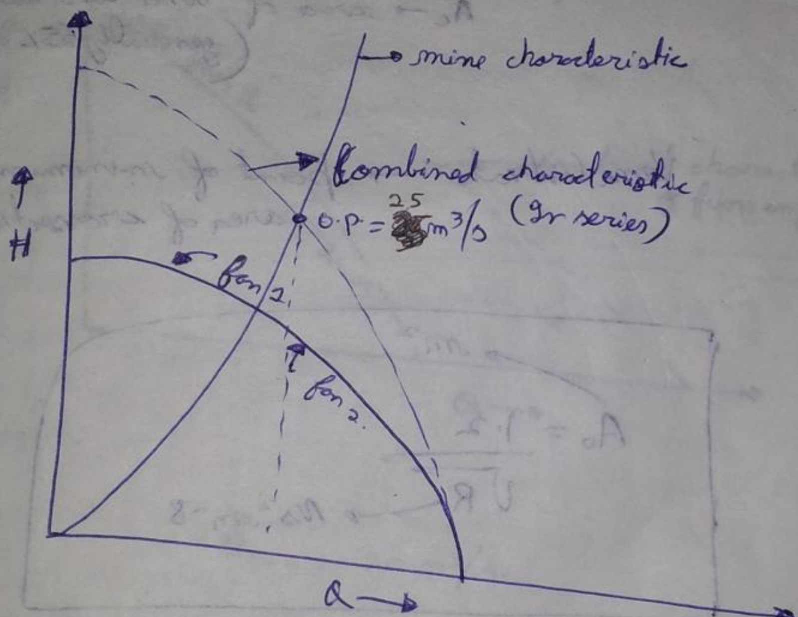
Q.7.

Fan 1:- characteristic is given below:-

P(Pa)	1370	1270	1000	740	150
Q(m^3/s)	10	20	30	40	50

Another identical fan has been put in series with this existing fan.

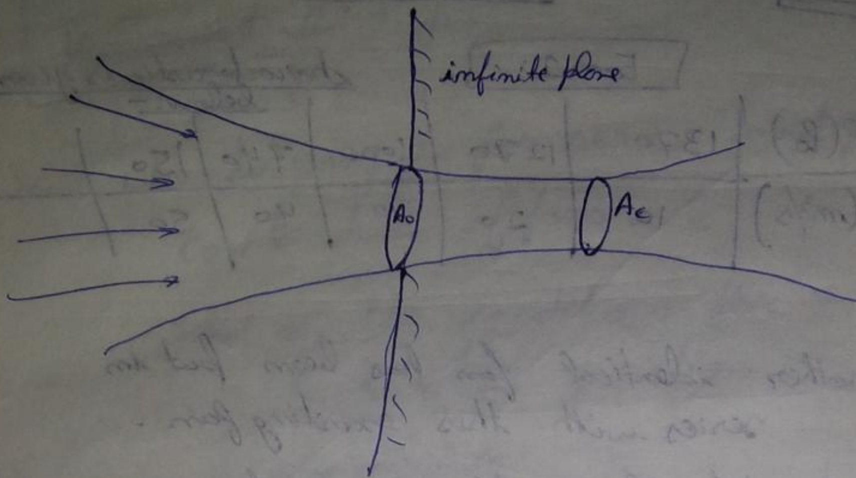
The Quantity flow after Combination is 25 m^3/s



find the equivalent orifice of the mine??

~~Ans~~

equivalent orifice → for the same air flow and resistance of the mine, we imagine a circular opening in an infinite plane which represents the resistance of the entire mine.



$A_c \rightarrow$ area of Vena Contracta
(generally 65% of A_o)

Vena Contrata $\rightarrow$ point of minimum area of crossection.

$$\boxed{A_o = \frac{1.2}{\sqrt{R}}}$$

$A_o \rightarrow m^2$

$R \rightarrow Ns^2 m^{-8}$

Sol-1:

$Q_{mine} = 205\ m^3/s$

$P_{combined}$ = we get from graph.

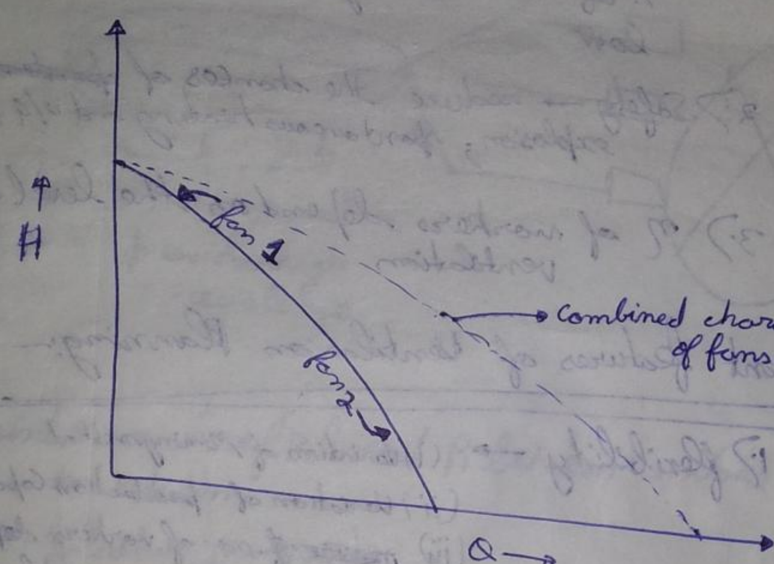
$P_{combined} = R_m Q^2_{mine}$

$\therefore R_m \rightarrow$ can be determined

Q.27. The same 2 identical fans as before.
Q_{mine} after installation of fans in parallel $= 70\ m^3/s$

Find the equivalent orifice of the mine??

Ans.2.



$Q_{mine} = 70\ m^3/s.$

$P_{combined}$ = From combined characteristic of the fans we get P.

$\therefore R_m = \dfrac{P_{combined}}{Q_{mine}^2}$

$$\boxed{A_{orifice} = \frac{1.2}{\sqrt{R}}}$$

20/09/2013.

NCK Sir.

VENTILATION PLANNING:-

Requirements for Ventilation:-

1.) Health → O_2% should be enough for breathing, % of obnoxious gases (CO, CH_4) should be low

2.) Safety → reduce the chances of ~~spontaneous~~ explosion, spontaneous heating and u/g fire.

3.) η of workers depend on the level of ventilation

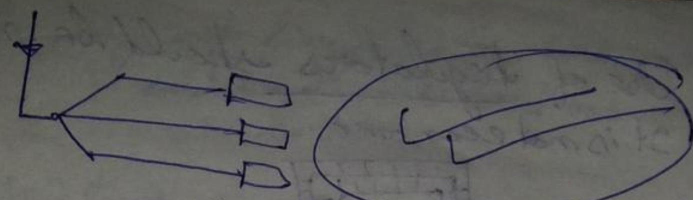
Salient features of Ventilation Planning:-

1.) flexibility → (i) Variation of Mining method
(ii) Variation of production capacity
(iii) ~~nature of~~ no. of workers ~~dep~~ and machines employed
(iv) in case of emergency (UC becomes D.C)

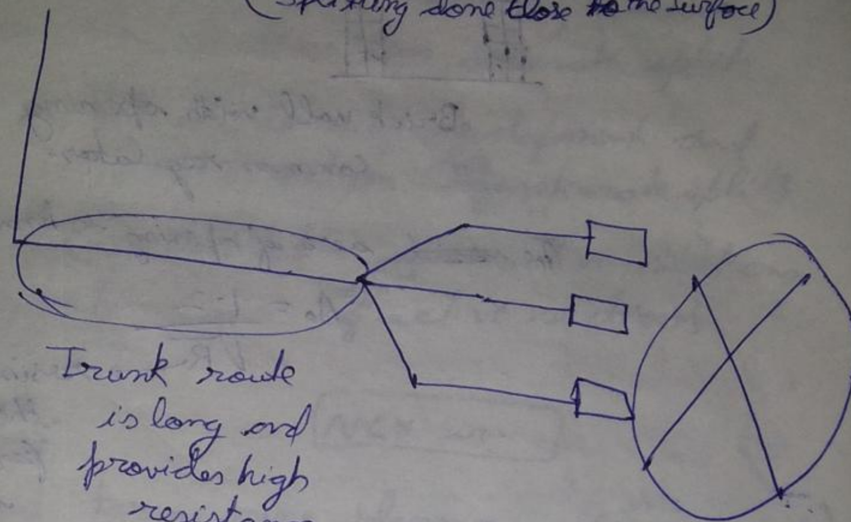
2.) travelling roadway and emergency exits should be the intake
→ return air is foul air (with dust, gases etc)

3.) Utilisation of all/enough surface opening for reducing resistance

4.) Fresh air should be directly coursed to active workings through shortest route (less strata heat added). Splittings of air current should be done as close to surface as possible



(Splitting done close to the surface)



Trunk route is long and provides high resistance

5) Maintenance of Balanced R between intake and Return.

In return airway.

1) Maintance is less so there is dust accumulation, roof fall and side fall which reduces Crossectional area

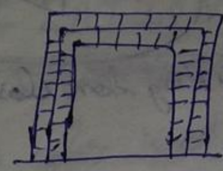
2) All unused material is thrown in the return route.

Due to the above reasons the resistance of the return route is very very high compared to the intake route

This should be avoided.

6.) Use of Regulators should be minimised.

It is not economic.



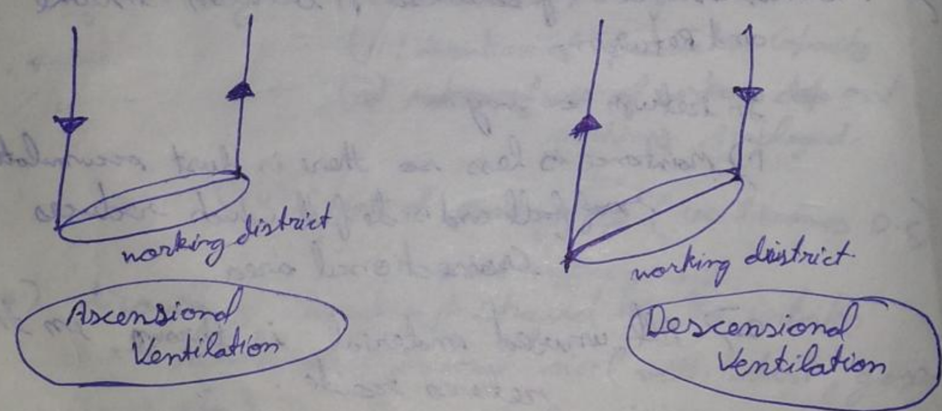
Brick wall with opening is a common regulator.

The ~~~~ area of opening is known by:-

$$A_0 = \frac{1.2}{\sqrt{R}}$$

$R \rightarrow$ resistance of the regulator for which it is designed.

7.) Maintenance of Ascensional Ventilation



Ascensional ventilation is aided by NVP. The air in working district becomes hotter and humid and so is low density air moves better in an ascensional Ventilation.

8.) Minimizing leakage / recirculation

minimised.

is a

own by:-

tance of regulator which it designed.

tilation

ict

d tion

rict

nsity Ventilation.

9) In gassy and fiery coal mine some additional considerations are to be taken:-

(a) ~~Positionining~~ Positioning of active sections on separate splits

(b) Ventilation of development and extraction via ~~by~~ separate splits

(c) Ventilation of inactive sections by return air from ~~of~~ active sections.

23/09/2013. NCK Sir,

short term mine planning:- (Assignment)

Major Steps for long term Ventilation planning →

1) Selection of Ventilation norms and calculation of air quantity requirement based on these norms:-

- Manpower 'N'
- Production 'X'
- Heat and Humidity
- Dry Bulb and Wet Bulb temperature

We go for the highest quantity obtained from above norms.

2) Estimation of extent of air Conditioning:

coal mine — 30-35m → 1°c } geothermal
metal mine — 80-100 m → 1°c } gradient.

∴ for 3000m deep mine:-

3000m < coal (120°c), metal (50°c)

Thus the problem of heat in Cool mines more compared to metal mine as depth increases

3) Selection of feasible ventilation system

4) Show detailed air distribution and various control devices for each ventilation system.

5) Estimate total air quantity requirement taking due consideration for leakages at various parts

6) Calculate resistance of all the branches

7) Solve the ventilation network for all the feasible system

8) Estimate the pressure requirement and draw mine characteristic curve for different periods of the mine

9) Selection of fan/ fans to suit varying mine characteristics taking due consideration of NVP as well as evasee head recovery.

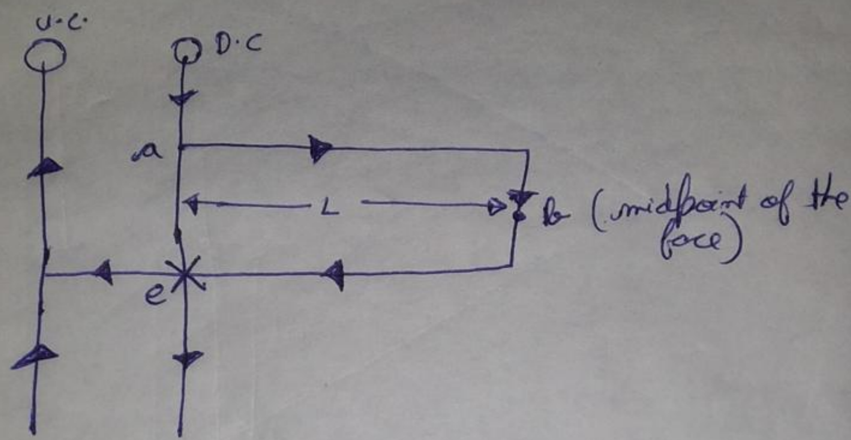
10) Estimate total cost of ventilation for each system and select the most economic one

11) Work out the schedule of implementation of the ventilation plan (they can be for 25-30 years).

24/09/2013.

SG Sir.

Proper Siting of a Booster Fan:-



The Booster is installed in the return because intake is used for men and material transport so if Booster is installed in the intake it will affect the faster operation of the haulage.

Factors of selecting proper site of Booster in return airway:-

1.) It should not result in recercalation of air.

2.) leakage should be minimum.

Assumptions:-

1.) Uniform crossection of airway
2.) Uniform friction factor

So ~~drop in pressure~~ resistance per unit length of airway is constant.

~~But due to leakage~~

So for quantity flow Q through the panel the pressure drop per unit length is uniform.

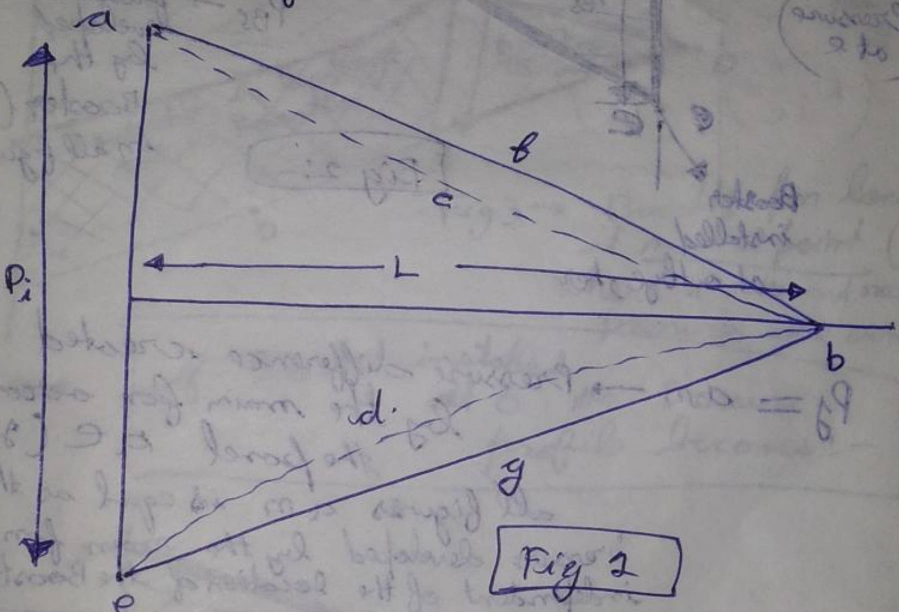


Fig 1

But the actual profile is asymptotic because there is leakage through doors, stoppings and cracks, so quantity flow is not uniform so pressure drop per unit length is not uniform anymore

When Booster is ~~that~~ installed at the outbye point e .

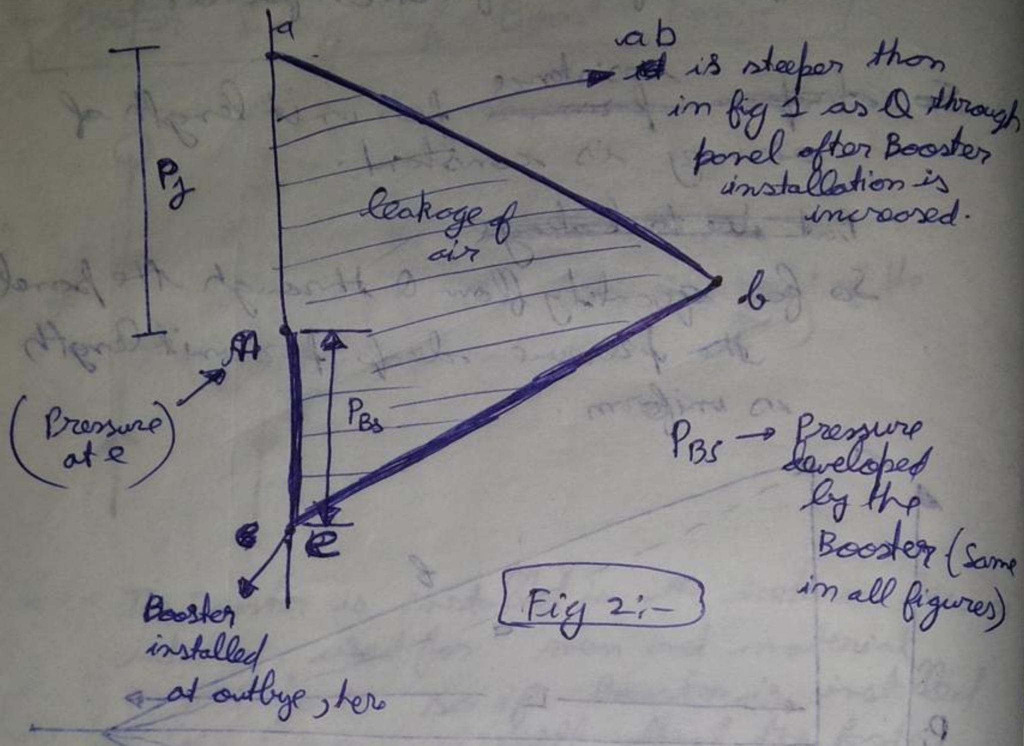


Fig 2:-

P_J = am → Pressure difference created by the main fan across the panel a e (In all figures a m is equal as the pressure developed by the main fan is independent of the location of the Booster)

We can quantify the total leakage quantity through all leakage paths as follows:-

NO Booster:-

The pressure difference between a e = P.

Pressure difference at b = 0

avg pressure difference between leakage path = $\frac{P+0}{2} = \frac{P}{2}$

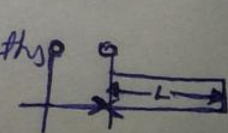
Q_L → leakage quantity total.

$\boxed{P = RQ}$ → in leakage paths

$\therefore \frac{P}{2} = RQ_L$

$R \propto \frac{1}{L}$

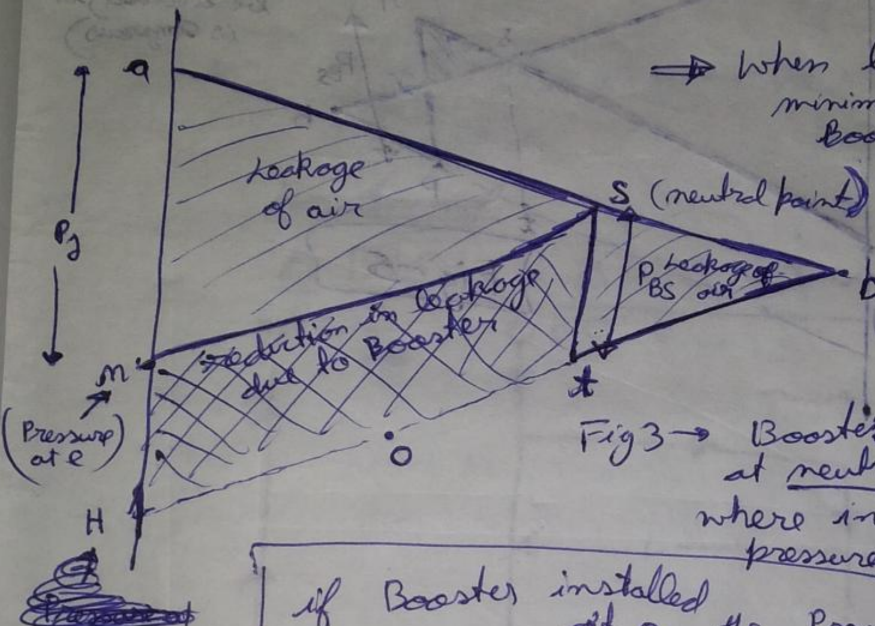
L → length of panel.



$\boxed{\therefore Q_L \propto \frac{PL}{2}}$

Here we can conclude that the leakage from intake to return is given by the area under the pressure profile curve.

Here in Fig3 → ⊛ area of ΔabH is the maximum leakage. ⊛ area of $StmH$ is the reduction in leakage due to installation of the booster fan



⇒ When leakage is to be minimized then the Booster should be installed at the neutral point St

Fig3 → Booster fan located at neutral point (Point where intake and return pressures are same)

If Booster installed at O the Pressure profile becomes:-

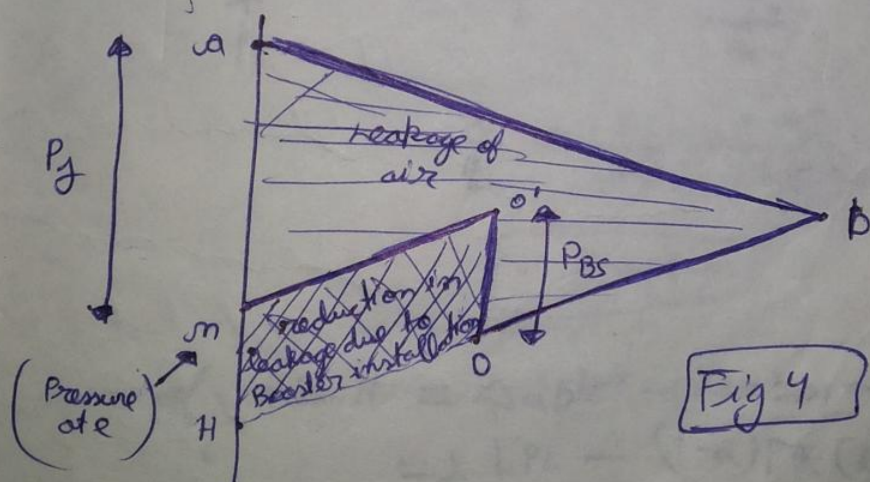


Fig 4

if Booster installed at a point to the ~~staft~~ right of t (near the face) in the return road:-

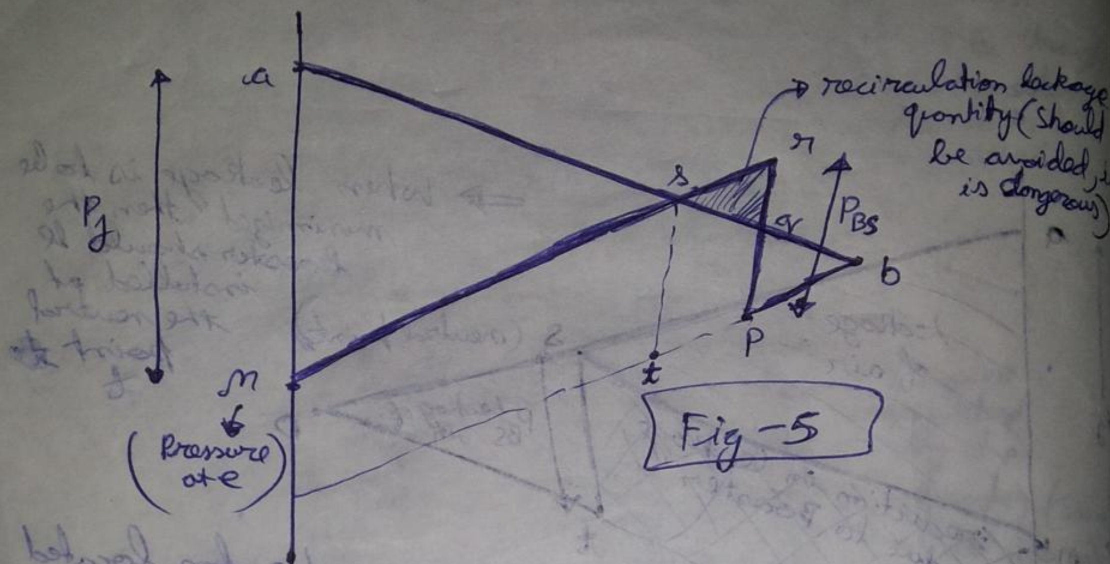


Fig -5

circulation leakage quantity (should be avoided, it is dangerous)

Determination of position of neutral point :-

In Fig 3:-

$aH = P \rightarrow$ Total pressure.

$\alpha \rightarrow$ fraction produced by Booster

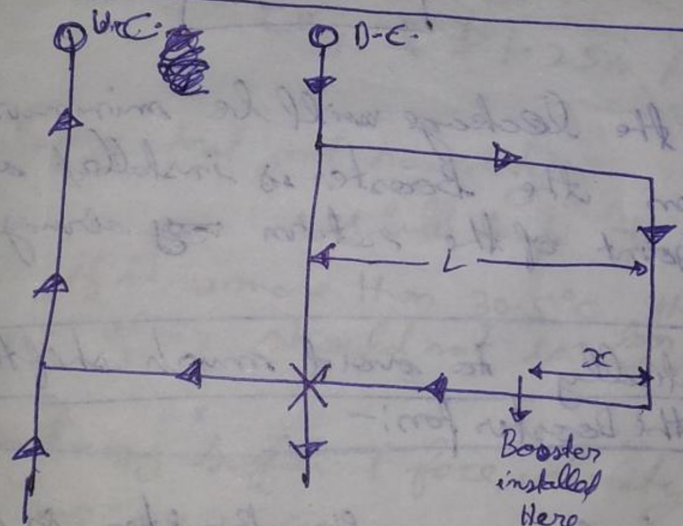
$$P_{BS} = \alpha P$$

$(1-\alpha)P \rightarrow$ developed by the main fan

$\alpha P = mH \rightarrow$ developed by the Booster.

~~Area of~~

ΔBtS and ΔBHa as similar triangle :-



$$\frac{x}{L} = \frac{tS}{aH} = \frac{\alpha P}{P} = \alpha$$

$$\boxed{\therefore x = \alpha L}$$

Area of $tSmH = \Delta abH - \Delta aSm - \Delta Sbt$

$$= \frac{1}{2}\left[PL - (1-\alpha)P * (L-\alpha L) - \alpha P * \alpha L\right]$$

$$= \frac{1}{2}PL(1-1+2\alpha-\alpha^2-\alpha^2)$$

$$= \frac{PL}{2} * 2\alpha(1-\alpha) = PL\alpha(1-\alpha)$$

~~Total~~ Total possible leakage = $\frac{PL}{2}$ = Area of ΔabH

leakage saved = Area of ΔsmH

$$\frac{\text{Leakage saved}}{\text{Total leakage}} = \frac{PL\alpha(1-\alpha)}{PL/2} = 2\alpha(1-\alpha)$$

This will be maximum when $\frac{d}{d\alpha}\left[2\alpha(1-\alpha)\right]=0$

$$\boxed{\therefore \alpha = 1/2}$$

Hence the leakage will be minimum when the Booster is installed at the midpoint of the return airway.

But practically to avoid much shifting of the Booster fan:-

<u>advancing face</u> → the Booster is installed inbye of the neutral point (towards the face)

<u>retreating face</u> → the booster is installed outbye of the netral point (away from the face)

27/09/2013. NCK Sir.

Air Q requirement :-

Purpose:-

(a) To supply the workers breathable air $O_2 \nless 19\%$

$CO_2 < 0.5\%$

(b) dilution of impurities such as inflammable and noxious gases and respirable dust. (Causes pneumoconiosis)

$NO_x \rightarrow 5 ppm$
$CO \rightarrow 50 ppm$ } TLV

$CH_4 < 0.75\%$ in return air

$CH_4 \ngtr 1.25\%$ in any place in the mine

(c) diluting heat and humidity

wet bulb temp $\ngtr 33.5°C$

if it is more than 30.5°C then velocity of air should not be less than 1 m/s

(d) producing sufficient face velocity

⇒ CMR 136(A) gives minimum vel of air at various parts in the mine

(e) Calculate the Q of air separately on the basis of production and manpower.

2.5 m³/min per TPD of output

6 m³/min per person in the largest shift.

Maximum value out of these two values is taken into consideration.

To this value, you have to add:-
(i) air requirement at other ports.

Long headings → high quantity air is required to dilute the blasting fumes and high quantity of dust if the heading is stone drift.

$\boxed{\text{DGMS Circular 30 of 1973 states:-}}$

Ventilation of drives > 50m in length be such that dilution of NO_x and CO after blasting comes down to 5 ppm and 50ppm respectively within 5 minutes

$$Q = \frac{Mq}{C \cdot t}$$

Q → additional quantity required for dilution.

where M → Mass of explosive

q → Volume of gas per unit mass of explosive

C → permissible/allowable concentration of gas under consideration (in decimal)

t → time by which the concentration has to come down

⇒ Calculate the additional quantity for each gas and take the max. quantity value and add it to the value of previous section obtained.

- Internal hoist/haulage/pump house etc →

Thumb rule ~~2.5 m~~ Add 2.3 m^3/s for each of the above

- Battery charging station →

~~while~~ While charging H_2 gas is evolved which is highly inflammable so proper ventilation is required.

⇒ Add 4.7 m^3/s

- Diesel locomotive →

⇒ Add 0.1 m^3/s ~~for~~ KW of Diesel engine

CO evolved %age < 0.2 %

Home Assignment

- risk involved in deisel locomotive and what are the precautions to be taken
- Abnoxious gases in Battery charging

~~Mining~~ Environmental engineering → Sengupta (Vol I and II)

(ii) Leakage: Total quantity supplied ~~to~~ the mine will not be going to the face due to leakage.

Leakage paths are through: stoppings, airlocks, fan drift

There is no standard, it depends on the type of construction and maintainence.

10 – 20 m^3/s – fan drift

1.4 m^3/s — air locks.

1.4 m^3/s — stoppings.

(iii) Exhaust fan in upcast shaft handles a larger quantity ~~##~~ of air than required at the face.

⟹ expansion of air due to geothermal gradient is 1% ~~per~~ for every 100 m depth

After Total Q requirement calculated through the mine we have to check ~~wether~~ weather our roadways are capable of handling such quantity flow. ~~of a high quantity~~.

i.e. (we have to check on the maximum permissable velocity at various parts in the mine)

→ $\boxed{\text{The maximum velocity of air given in DGMS circular 42 (1974):-}}$ → From GB Mishra

If ~~our~~ velocity is higher than the amt. specified then we have to reduce the Q requirement by either reducing TPD ~~one~~ or reducing Manpower deployed.

A very high velocity → causes high dust formation

~~Maximum permissible velocity:~~

~~i) Ventilation shaft not provided with winding equipment, fan drift = 15 m/s~~

~~(ii)~~

CMR Reg 136(A) → Minimum velocity of air at different locations in the mine.

30/09/2013

NCK Sir

Minimum Air vel. at various points

Degree of Gassiness	Place where vel. is to be measured	vel (m/min)
First degree	Immediate outbye ventilation connection from the face	30
Second	(i) 4.5 m from any face ~~the~~ wether working or discontinued ~~from lattice~~ on the intake side of any partition (brattice)	30
	(ii) 7.5 m outbye of the discharge end of any air pipe	15
	(iii) at the maximum span of longwall face	60
Third	(i) same as above	45
	(ii) same as above	25
	(iii) same as above.	75

Pressure ~~required~~ Requirement :-

$$P = RQ^2$$

Q^2 → known

R ↓

Theoritical method → can be determined by geometry of the opening.

Practical method (Better way) → By Press – Quantity survey of any roadway :-

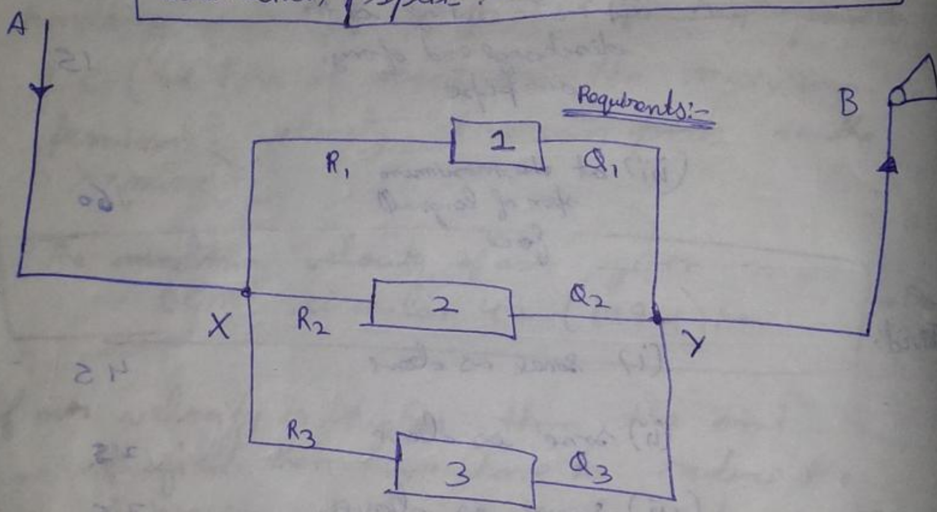
1.) Measure pressure drop across the roadways.

2.) Measure Quantity flow through the airway.

⇒ For each and every branch the resistance is determined and if we have the total resistance of the mine and Q flow through the mine, the pressure requirement of the Mine can be determined and a fan of desired capacity is installed.

⇒ Pressure loss in shaft should be considered by calculating the average Q flow through the shaft (especially for deep shafts where there is a large difference in Q at the top and bottom ends)

⇒ Estimation | Pressure requirement across split :-



$\therefore P_{XY \text{ required}} = (P_{XY})_1$

$(P_{XY})_2$

$(P_{XY})_3$

The pressure requirement across split is the maximum of $(P_{XY})_1$ or $(P_{XY})_2$ or $(P_{XY})_3$.

and install regulators in other splits where pressure required across XY was less.

But if resistance of regulators is high and no. of regulators is also high then we go for an alternate decision.

Problem of regulators:–
1) increases resistance
2) hinders haulage

Alternative:– → (Preferred)

We can install one booster so we can choose the Pressure requirement across split as the mean value of $(P_{XY})_1$; $(P_{XY})_2$ and $(P_{XY})_3$ and install a booster in the ~~low resi~~ high resistance split and a regulator in the low resistance split.

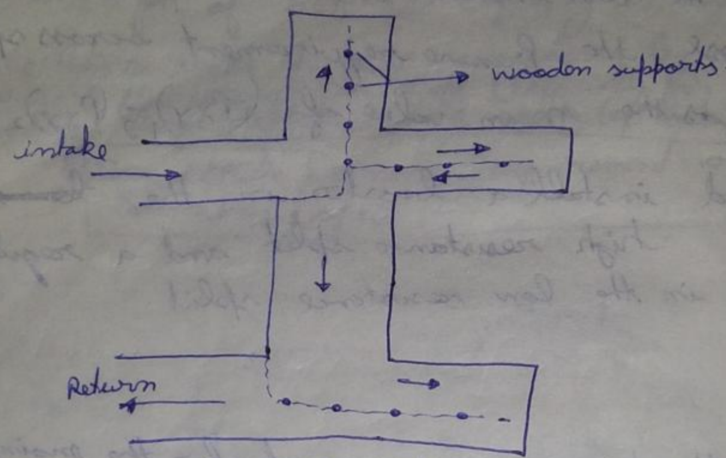
⇒ If the pressure requirement for the main fan is very high then we can go for a low capacity fan on the surface and install a booster fan U/G in the return trunk airway

SG Sir

01/10/2013

Use of Auxiliary Ventilation:–

Auxiliary Ventilation systems are used to supply air to the sinking shafts, drifts, tunnels and other working faces of blind drivages, particularly in metal mines where the small size of opening does not permit bratticing. They are also used in short headings of coal mines where large scale mechanization prohibits the use of brattices. Ventilation of dead-end working places is the most important application of auxiliary ventilation since the auxiliary ventilation systems are the primary means of assuring the standards of air quality and quantity in the faces. The dilution of dust and gases and the removal of heat ~~and the~~ are the primary reasons for applying auxiliary ventilation.



Ventilation ~~by~~ of heading by Brattice

Brattices:-

Hessian cloth nailed against the wooden props placed around (1.5) m apart. So we are ~~the~~ practically dividing the headings into two parts so that one half behaves as intake and other behaves as return. It is used for ventilation of short headings in coal mines.

Disadvantages:-

1.) Reduces the cross-sectional area of the airways, so high scale mechanization cannot be used in such ways.

2.) They are very leaky. We have observed that at a distance of 30m inbye of the

headings, only 5% of air entering is reached, 95% leaks to the return.
~~So it is used in coal mines~~

3.) They increase resistance of airway:-

(A) Cross-section area reduced

(B) Effective length of heading is doubled by dividing of heading into 2 halves.

Earlier Used in coal mines:-

1.) Because heading are only 20m long (short headings)

2.) galleries are wide (upto 4m)

3.) Coal is soft so we get smooth faces so brattice fit properly against the roof.

Not used in metal mines:-

1.) Heading are very long (can go upto 1.5km) and efficiency of ventilation by brattice reduces due to high leakages.

2.) galleries are narrow (1.5-2m wide) so dividing the gallery is not possible

3.) Rock is hard and worked by by drilling and blasting so we do not have a control on the smoothness of the roof and so the brattice is not fitted tightly against the roof and so leakage is very high.

Brattice is not used with high mechanization:-

1.) wide galleries are required for mechanization

2.) Due to high leakage the brattice ventilation was not sufficient to clear the blasting fumes and obnoxious exhaust gases of the machines at a fast and efficient manner.

3.) The rate of face advance was faster with mechanization and brattice could not be extended at this pace of face advance

Installation of Auxiliary fan:- and characteristic

* A axial flow type fan (compact, lighter in wt. and good fit against the co-axial duct) with a duct

* hangs in one corner of the ~~f~~ roof so gives free ~~f~~ area for movement of mechanization.

* Ducts ~~are~~ circular generally but sometimes can be rectangular in case of wooden ducts.

* Ducts are of pieces of 2-3m. Depending on the length of heading the length of duct is decided. As the duct length changes, the resistance ~~to~~ for fan to overcome changes so the fan has to negotiate a high range of resistances of the duct. So the axial flow fan is specially designed to have a continuously decreasing head characteristic with no point of ~~~~ contraflexure (stall point) so the fan can operate with high resistance of the duct without any unstable operation.

(P) Since the ~~axi~~ fan has to operate over a wide range of resistance so it has a very flat efficiency curve so that it has a wide operating zone with good efficiency

Characteristics of auxiliary fan:-

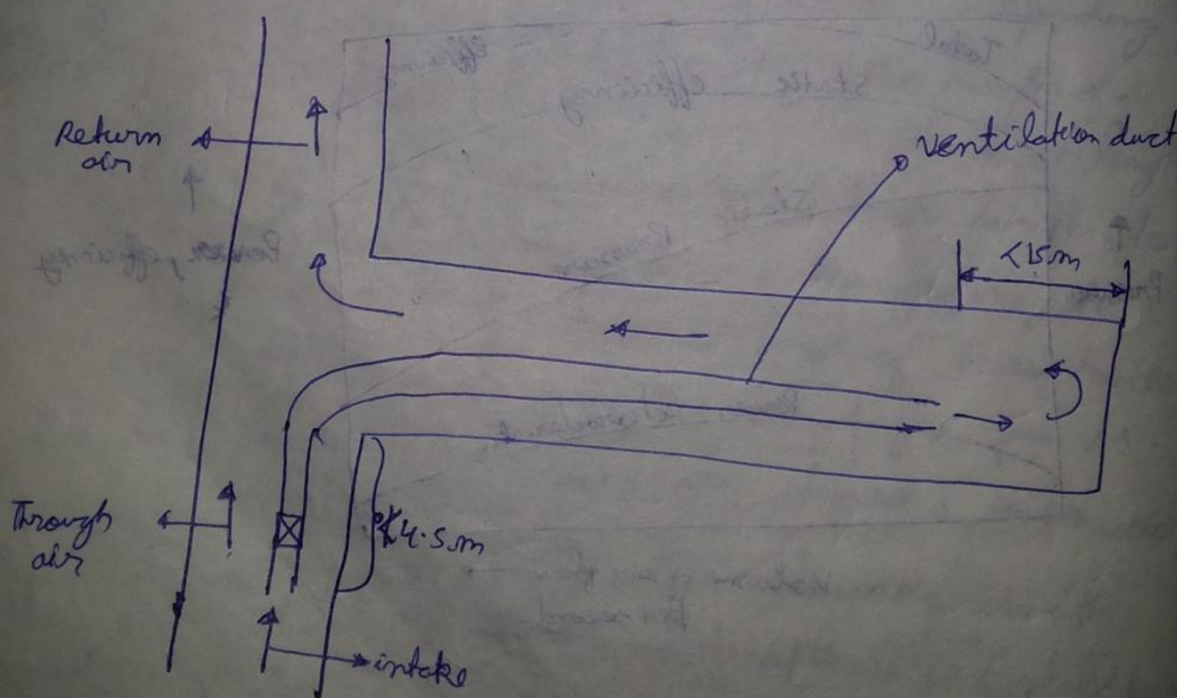
The pressure required for an auxiliary fan depends on the length of the drift. The fan should be so selected that it should operate to the right of the stall point ~~and~~ when used with the longest duct i.e. the max. system resistance. For this reason it is preferable to have a continuously dropping pressure characteristic of the fan. When operating with short duct ~~so~~, the fan will have a tending to overloading and so that is why it is essential to select a type of fan for auxiliary ventilation which not only has a non-overloading but also have a fairly flat power characteristics.

Classification of Auxiliary Ventilation:-

- Forcing or blowing system of ventilation
- Exhaust system of auxiliary ventilation
- overlap System
  - forcing system with exhaust overlap
  - Exhausting system with forcing overlap

Forcing system of Ventilation:-

→ To prevent recirculation of air in the fan, the opening of duct of auxiliary fan should be atleast 4.5m in the upstream side of the fresh air stream.



of ventilation
ventilation

haust overlap

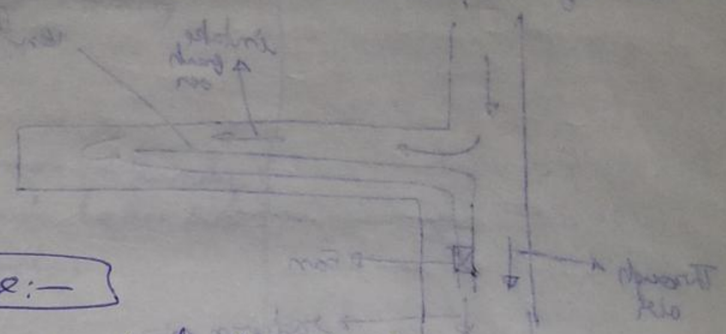
orcing overlap

the
auxiliary
e upstream

ilation duct.

15m

→ ~~which~~ with ~~fo~~ this system ⊖ the fresh air from the through airway is forced into the face through a ventilation duct by a fan and this air returns via the development face end. The intake to the duct must be extended well into the upstream portion of the fresh air stream (at least 4.5m) otherwise there is a danger of the used air ~~when~~ which flows out of the face entering the duct and thus being recirculated. The fan should be in the part of the duct which extends into the fresh air.



Advantage:—

1.) intake air inside the duct so there is no chances of it picking up moisture from the drains in the ~~duct~~ drive and it will not gain heat from the walls of the heading.

2.) For a fixed volume flow rate the speed of intake air in duct is very high so it does not get time to pick up heat from the surrounding temprature.

⇒ Hence it supplied cool, dry fresh air get at the face.

Disadvantage:—

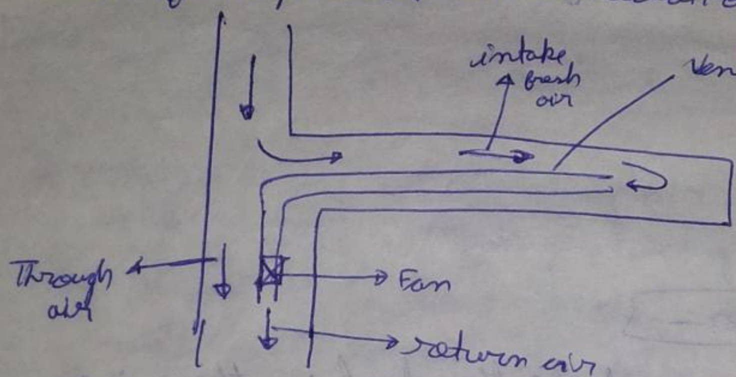
1.) The return air has a very slow speed so fume clearance at the face takes hours.

2.) The blasting fumes move through the entire length of heading there by polluting the whole airway.

Exhaust system of auxiliary ventilation:-

→ The exhausting duct is kept much closed to the face for effective face ventilation compared to the forcing duct.

→ The heading in this case is used as the intake and the air duct as the return. The ventilation duct discharge the return air well beyond the entrance of the development end, on the down side of to prevent recirculation.



disadvantage:-

1.) The intake air is slow, and picks up enough moisture and heat from the headings.

advantage:-

1.) faster cleaning of the face from blasting fumes is possible in this case

2.) The fumes at the face are cleared near the face due to the suction duct and the entire length of heading is not polluted due to blasting.

NCKSir

DGMS circular 42 of 1974 gives maximum velocity in different locations:-

Locality	Max. vel (m/s)
ventilation shafts not provided with winding equipment, for drifts	15
Ventilation shafts where man-winding is not carried out, or mineral hoisting shafts only	12
Shafts used for man-winding and haulage roads (other than conveyor roads)	8
other roadways	6
conveyor roads, loading points, transfer points	4
Working faces, in development or depillaring / stoping areas including longwall faces	4

21/10/2013. | WCK Sir

Ventilation Survey:

- Q survey
- pressure survey
- Temperature Survey (Heat and Humidity)

Importance of systematic and regular ventilation survey:-

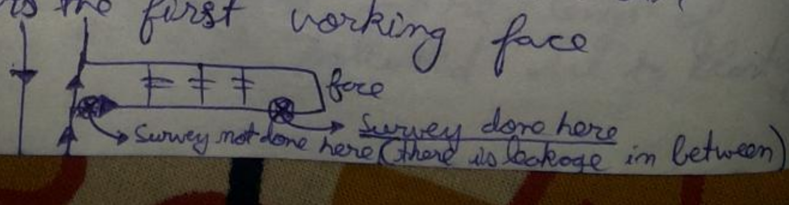
1) Checking and supply of adequate Q of air to any working face
2) Detection and remedial of leakage
3) Determining the size of airway
4) Determining the size and location of fan for future ventilation planning
5) Planning suitable ventilation for control of mine fires.
6) Suggesting possible modifications in the magnitude and direction of air current, airway resistance, control devices, etc for improving the ventilation in the mines.

CMR 133(4)(a) → All mechanically ventilated mines, Q measurement in important areas is to be done in every 14 days (30 days if degree I)

In MMR → Every 30 days.

Location of surveys:- → (Q measurement)

- intake and return
- splits (as near as possible to the starting point of the split)
- ventilation district where the air enters the first working face



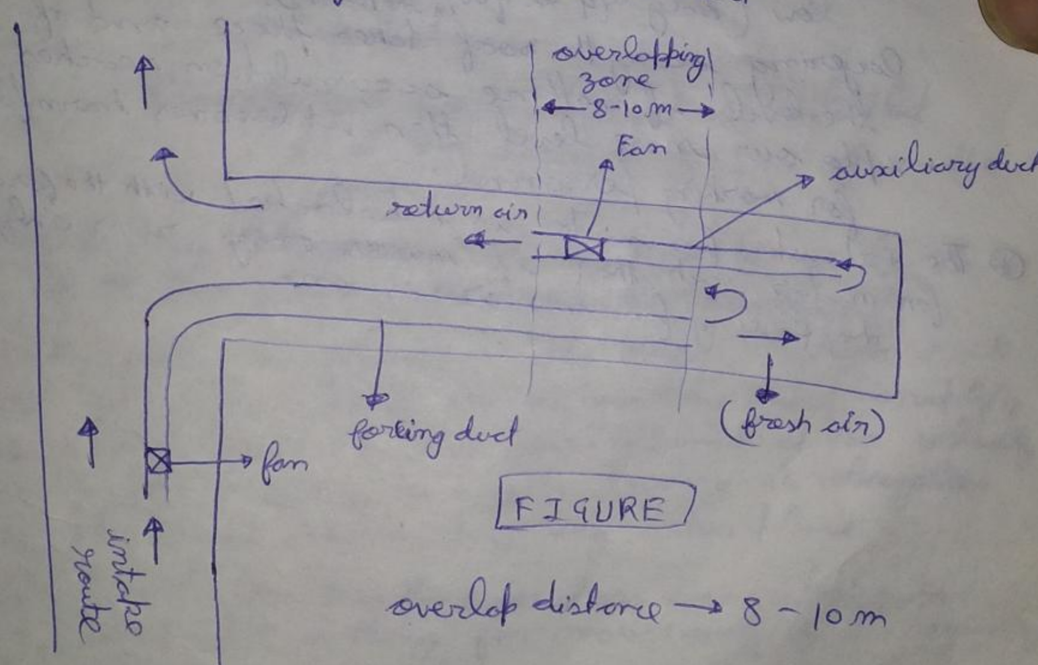
22/10/2013

Forcing System with exhaust overlap :-

In this system, the forcing fan sends a quantity of air, a part of which goes to the exhaust overlap duct and the rest travels outbye through the heading. After the overlap zone, the exhaust fan delivers the air in the heading (directly or through a dust filter) and the combined air now goes out through the rest of the heading, the exhaust overlap duct has to be extended periodically to keep up with the progress of the face but the exhaust fan (and the dust filter, where fitted) and the forcing fan duct may be advanced less frequently

main duct → forcing duct

auxilliary duct → exhaust duct



FIGURE

overlap distance → 8 - 10 m

~~A dust filter~~.

dust filter just before the fan → removes the dust due to coal blasting and so improves the air quality in the heading. It has to be cleaned from time to time or replaced from time to time or else the filter pores are choked and the

" exhaust fan has to develop greater pressure to allow air flow through the exhaust duct.

The position of exhaust fan and dust filter is fixed but the exhaust overlap duct has to extended periodically as the face advances.

The forcing duct is not extended so frequently as the face advances ~~as~~ ~~upto~~ until a certain limit of face advance.

As per regulation each duct can handle only 50% of the total air flowing. ~~through the heading~~.

If Q is the air flowing in the intake stream then Q/2 ~~is of~~ flows through the forcing duct and only Q/4 of it is handled by the exhausting duct so the velocity of air in the ~~exhausting duct is very low~~ overlapping zone is very low (only Q/4 ~~&~~ quantity flow in the heading) so methane layering along the roof takes place and if the level of methane accumulation reaches upto our nose level then it becomes harmful for working personnel.

⊛ The exhausting fan motor is interlocked with the forcing fan motor such that it ~~moves only~~ runs only if the forcing fan motor is on.

| Exhaust

⊛ ex

1.) forcing face met expos

2.) ~~If~~ ~~fo~~ system fum it is operatio on air turbul remov t

3.) Polle

⊛ As per of th

If Q is then Q/ is handl of air in abnormally

⊛ The forcing such th fan is

In this sys type. A short with the e the face. The drawn by the circulation. Th

Exhausting system with forcing overlap :-

* main duct → exhaust duct
* auxiliary duct → forcing duct.
* exhausting fan provided with dust filter.

Advantages:-

1.) forcing duct gives a brisk air velocity at the face which gives a turbulent mixing of the methane emitted at the coal face ~~&~~ freshly exposed and of the blasting fumes with air is allowed.

2.) ~~It forcing duct provides a~~. the exhausting system cannot effectively removes the blasting fumes unless it is extended upto the face but it is not possible ~~to the~~ due to the blasting operation taking place so the forcing duct ~~was~~ provides an air jet which swifts across the face and allows turbulent mixing of air and blasting fumes and removes them from the face and guides them towards the exhausting duct.

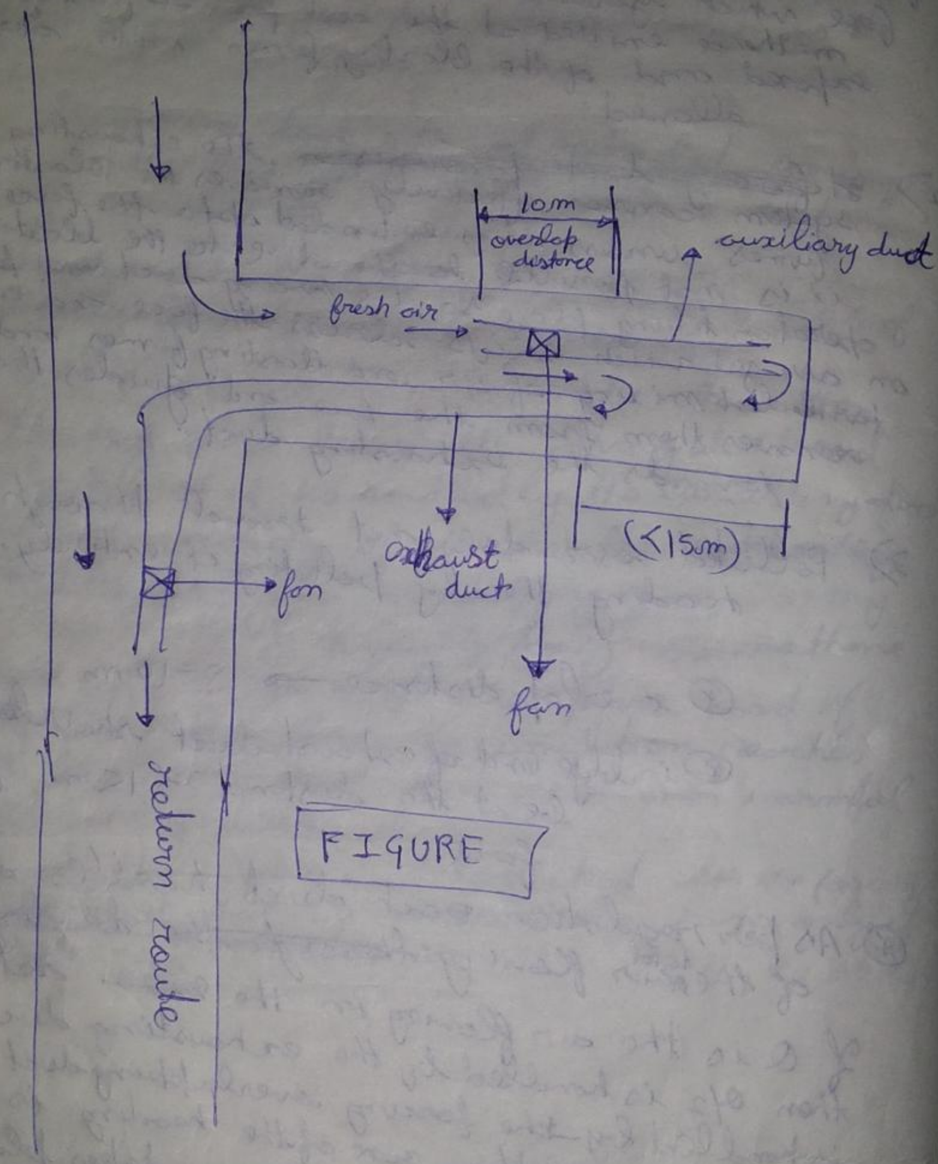
3.) Polluted air does not travel through the heading thereby polluting it entirely.

* overlap distance → 8-10 m
* inbye end of exhaust duct should be at the distance < 15 m from the face
* As per regulation each duct handles only 50% of the total ~~main~~ air flowing ~~through the heading~~.

If Q is the air flowing in the ~~exha~~ return route then Q/2 is handled by the exhausting duct and Q/4 is handled by the forcing overlapping duct so velocity of air in the overlapping zone of the heading is ~~very low~~ abnormally low so methane layering takes place.

* The forcing and exhausting fans. motors are interlocked such that the forcing fan moves only if the exhausting fan is on.

In this system the basic auxiliary fan is of exhausting type. A short forcing duct, having an overlap of 8-10m with the exhaust duct extends to within 3m from the face. The forcing fan handles less than half the air drawn by the exhaust fan to avoid the risk of re-circulation. The exhaust fan is usually fitted with a dust filter at its outlet end. Quick cleaning of shot firing fumes where blasting is adopted and a brisk air velocity at the face is the 2 advantages of the system.



FIGURE

Choice of Auxilliary Ventilation System :-

3 pollutants in headings:-

1) fire damp and methane
2) ~~fire damp of~~ heat
3) blasting fumes / dust.

The pronounced problem decides the Ventilation system.

1) The higher velocity air stream emerging from the face end of a forcing duct gives a scouring effect as the air sweeps across the face. This assists in the turbulent mixing of any methane that may be emitted from fragmented rock or newly exposed surface. It also helps to prevent the formation of methane layers at roof level. In hot mines, the forcing system provides cooler air at the face. This results in a cooling effect by lowering the effective temperature.

2.) The major disadvantages of a forcing system is that pollutants added to the air at the face affect the full length of the heading as air passes back, relatively slow, along it.

3.) Where dust is the main hazard, an exhaust system is preferred. The polluted air (containing firedamp, dust and blasting fumes) is drawn directly into their duct at the face end allowing fresh air to flow through the length of the heading and the heading is kept clear for person working and travelling therein.

4) With the forcing system, the methane emitted out bye in the heading is carried away from the face. With an exhausting system, it is taken into the face area where there is the greatest danger of ignition.

5.) With the forcing system the air reaching the face usually takes up less heat, moisture and as the air is carried to the face end at high velocity by a duct therefore it cannot pick up heat, moisture or dust on its journey to the face, Therefore forcing system of auxiliary ventilation is particularly suitable for wet headings where the rock temperature is high.

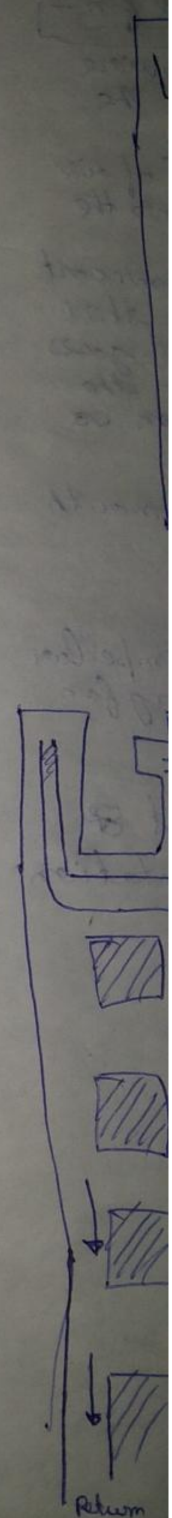
6.) Leaks in the ducting are more easily detected and deleted in a forcing system.

U and W auxiliary Ventilation Systems:—

1.) In case methane emission from rib pillars (corner) is more then the polluted air is carried to the faces which is harmful in U system of ventilation but in W system the rib pillars are in the return routes so the methane is carried out efficiently off the panel

2.) In case of U system the same air from one face is carried on to the next face (of the ventilation route) so the faces at the end ~~are~~ receive highly polluted and unusable air while in W- system of ventilation the central ~~pillars~~ galleries divide the ventilation headings into 2 equal halves so the quality of air in the headings at the ends of the ventilation route ~~is not so poor~~ is also good.

3.) But a problem with W- system is that the no. of stoppings in this case is double that number in U- system so leakage is more in W- system of ventilation.



Auxiliary Ventilation Systems for B and P Panel:-

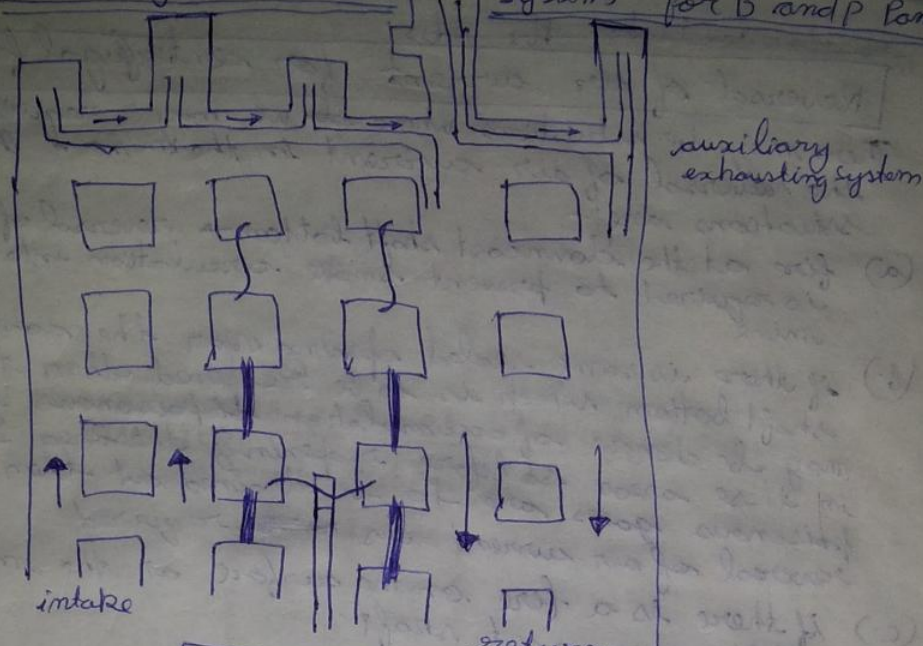


FIG: U-System

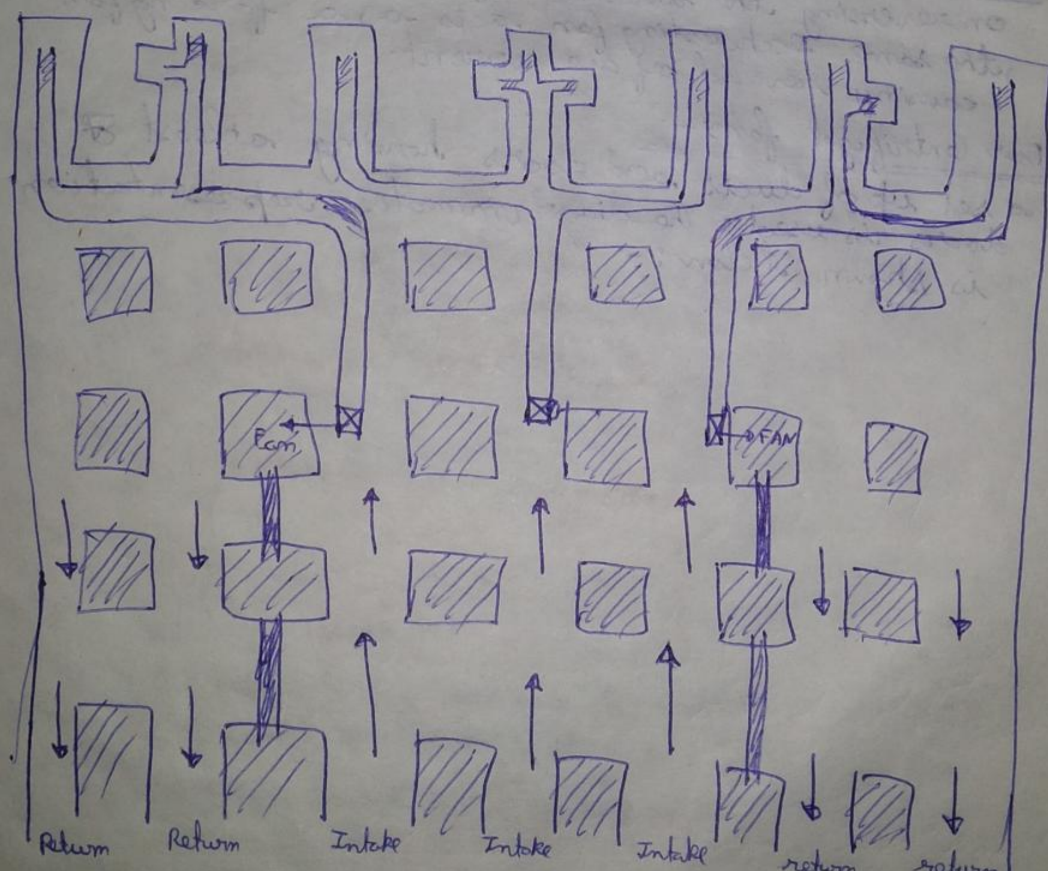


FIG:- W-System

~~which controls the dis.~~

Reversal of air current for centrifugal fan:-

There may be situations where ~~do~~ we may require the reversal of air current in the mine & the situations are:-

(a) fire at the downcast shaft bottom → reversal of air is required to prevent smoke circulation into the mine

(b) if there is some sealed opening near the downcast shaft bottom which is to be reopened then there may be chances of accumulation of poisonous gases in these areas so before reopening the area the poisonous gases are to be drained out then a reversal of air current is ~~to be~~ required

(c) if there is a fire on the surface at the mouth of the downcast shaft.

For axial flow fans:-

on reversing the direction of rotation of the impeller, the same exhausting fan acts as a forcing fan causing reversal of air current.

For Centrifugal fans:-

a set up of ducts and doors having atleast 8 doors is used. The diagrammatic representation is shown below:-