LECTURE NOTES ON MINE VENTILATION

FOR 4TH SEMESTER MINING STUDENT

ER. GHANSHYAM DHURUA

SENIOR LECTURER IN MINING ENGINEERING

ORISSA SCHOOL OF MINING ENGINEERING,KEONJHAR

1. Natural Ventilation

i. Definition of natural ventilation and factors affecting natural ventilation.
ii. Describe the different types of Thermometer.
iii. Describe the different types of Barometer.
iv. Describe kata thermometer.
v. Describe water gauge.
vi. Calculate ventilation pressure by using piton static tube.
vii. Explain effects of heat & humidity.
viii. Explain natural ventilation motive column, geothermic gradient.
ix. Enumerate laws of mine air friction and solve problems on above.
x. Statutory provision as per CMR 2017,MMR 1961.

2. Air Crossing and distribution

i. Describe ventilation stopping, air crossing, ventilation door, brattice partition.
ii. Describe different types of ventilation.
iii. Accessional & declensional ventilation.
iv. Homotropal & Antitropal ventilation.
v. Boundary ventilation.
vi. Central & combined ventilation.
vii. Explain splitting of air current & solve numerical problems on splitting.
viii. Describe air locks at pit top.

3. Mechanical Ventilation

i. Explain construction & principle of operation of centrifugal flow fans.
ii. State fan laws & calculate fan efficiency and capacity.
iii. Explain installation of mine fan with reversal arrangement.
iv. Describe fan drift, fan drive, evasee and diffusers.
v. Explain fan characteristics and mine characteristics.
vi. Describe methods of output of mine fans.

4. Booster fan and its Effects

i. Describe installation, location and purpose of booster fan.
ii. Solve problems relating to booster fan.

5. Auxiliary Ventilation

i. Describe systems of auxiliary ventilation.
ii. Describe advantages & disadvantages of auxiliary ventilation.

6. Ventilation Survey

i. Describe methods of pressure survey using barometer, gauge and pitot tube with manometer.
ii. Describe the method of measurement of cross-sectional area.
iii. Describe the method of velocity measurements by using anemometer, voltmeter, and pitot- static tube and smoke & cloud method.
iv. Determine percentage of oxygen, methane, carbon monoxide SO_2 & H_2S.

7. Leakage of air in Mines

i. Describe causes and preventive measures of leakage of air in mines.

1. NATURAL VENTILATION

1. i. Definition of natural ventilation and factors affecting natural ventilation.

Air flows from a region of high pressure to a region of low pressure

• The difference of pressure may be caused by – Purely natural means: called natural ventilation, or – By a fan: called mechanical ventilation.

• Small and shallow mines are sometimes ventilated by natural means.

• Ventilation only through natural means is usually – Poor – Fluctuates to a large extent and – Subject to reversal of direction.

• In case of emergency such as fires underground, mechanical ventilation is more effective.

• However, natural ventilation does play a role in all mechanically ventilated mines.

Nowadays, there is no scientific explanation of the reasons of natural ventilating pressure occurrence and regularities of changes in it, as well as its influence on the operation of MFU, which makes impossible to create the methodology of monitoring the ventilating process of underground mines with the account of its operation. It can be noted that two factors influence the natural ventilating pressure – air density and the variation between the spot height of the interconnected mines. We can make a conclusion that the value of the natural ventilating pressure between the interconnected mines is influenced by the spot heights which do not change relative to each other (for example, the shafts), only the air density will have influence in these mines. Three groups of reasons influence the changes in air density, consequently, the magnitude of natural forces causing the displacement of air flows (masses):

1. Changes in air density at constant temperature and pressure, due to changes in gas concentration in the mine.

2. Air density changes due to its temperature fluctuation. The appearing draft in this case is called a "thermal drop of ventilation pressure".

3. Changes in air density due to areas with increased or decreased pressure, which appear due to many reasons, such as: collision of air flows, redistribution in MFU reverso or changes in its capacity, when air flows runs onto artificial obstacles (shaft air bratices, air doors and so on). Thus, to determine the factors influencing the value of the natural ventilating pressure it is necessary to study separately the influence of these parameters .

1.ii. Describe the different types of Thermometer

Thermometer types

Main Types of thermometer are given in the list below:

Clinical or Medical thermometers

A Medical thermometer is used to measure body temperature. Most thermometers made in the 20th century are mercury thermometers. They are sensitive and accurate, having a narrow place where the level of mercury rises very fast. A kink on the tube stops the mercury level from falling on its own.

These kinds of thermometers are used in the clinics by doctors, so they are also called doctor's thermometers. It is used to measure human body temperature in the range of 35 °C to 42 °C. Medical thermometers are cleaned before and after each use, with alcohol.

Laboratory thermometers

It is used to measure the room temperature of hot solids and liquids in experiments. It measures temperature in the range of 5 °C to 110 °C and on higher temperatures

Digital thermometers

Digital thermometers measure the temperature by means of an electronic circuit. The information they capture is sent to a microchip that processes it and displays it numerically on the digital screen. They are easy to use, fast, accurate, and inexpensive. These are advanced thermometers used to measure the temperature of a body of a high level of accuracy.

How to use Digital or clinical thermometers?

In order for the body temperature to be measured correctly with the digital thermometer, the following steps must be followed:

Turn on the thermometer and check if the number zero appears on the display;

Place the tip of the thermometer under the armpit or carefully insert it into the anus, mainly to measure the temperature in children. In the case of the rectal route, you must lie on your back, inserting only the metallic part of the thermometer in the anus;

Wait a few seconds until you hear the thermometer alarm;

Remove the thermometer and check the temperature value on the screen;

<u>Infrared ear thermometers</u>

The temperature in the ear is also known as the tympanic membrane temperature or eardrum. This is one of the ways to take your body temperature using the inside of your ear. Children like this way of taking temperature because it is taken quickly. The normal ear temperature is 99.5 degrees F (37.5 degrees C) in adults. They should not be over-squeezed or used on ears with a lot of wax.

Infrared thermometers capture body heat in the form of infrared energy given off by a heat source. This type of thermometer is based on the fact that the laws that govern the radioactive emission of bodies allow the precise calculation of the temperature of the radiating object from its emission spectrum, without requiring direct contact with it.

How to uses an Infrared ear thermometer?

To use the thermometer in the ear, also known as a tympanic thermometer, you must:

Place the tip of the thermometer inside the ear and point it towards the nose;

Press the “power” button on the thermometer until you hear a signal;

Read the temperature value, which appears instantly;

Remove the thermometer from the ear and clean the tip with cotton or alcohol gauze.

The infrared ear thermometer is very fast and easy to read, so it requires you to regularly buy plastic protective caps, which makes using the thermometer more expensive.

See Also: Best Touchless Digital infrared Thermometers

Some Other Types of the thermometer on the basis of Technology

An ideal thermometer shall have an infinite temperature range. Since no thermometer is ideal, therefore we have a large number of thermometers.

Mercury thermometers

It has linear expansion property and has a temperature range of -35°C to +500 °C(with compressed nitrogen).

How To use a mercury thermometer?

The use of the mercury thermometer is contraindicated due to health risks, such as respiratory problems or skin damage, but there are also currently glass thermometers similar to the old mercury, called analog thermometers, which do not have mercury in their composition and can be used safely.

To measure the temperature with these devices, you must:

Check the temperature of the thermometer before using it, observing if the liquid is close to the lowest temperature;

Place the metallic tip of the thermometer under the armpit or in the anus, depending on where you intend to measure the temperature;

Keep the arm that has the thermometer still next to the body;

Wait 5 minutes and remove the thermometer from the armpit;

Verify the temperature, observing the place where the liquid ends, which will be the value of the measured temperature.

This type of thermometer takes longer to measure the temperature than the others, and the reading is usually more difficult to do, especially for the elderly or the visually impaired.

- **Pyrometer Thermometers**

This measures the temperature from the heat radiation emitted by the objects. These thermometers allow them to be used without having to touch objects, allowing them to be measured when they are moving or far away, as well as when their temperatures are very high.
This thermometer work on the principle of radiation. It measures a temperature greater than 2000 k. It uses Stefan's law:

- **Pacifier thermometers**

They are suitable instruments for infants since they take the temperature of the same without causing any discomfort. Use the same as the standard digital thermometer for oral temperature.

- **Plastic strip thermometer**

Certain plastic strips applied to the baby's forehead can measure temperature changes at a given moment by giving a colorimetric scale that tells us, after putting it on a child's forehead for a minute, whether a child has a fever or not. However, such measurement is not reliable but indicative.

1.iii.Describe the different types of Barometer.

Fortin's Mercurial Barometer & Aneroid Barometer

Air pressure is simply the mass of air above a given level. As we climb in altitude above the earth's surface, there are fewer air molecules above us; hence, atmospheric pressure always decreases with increasing height. Most of our atmosphere is crowded close to the earth's surface, which causes air pressure to decrease with height, rapidly at first, then more slowly at higher altitudes.

Construction

Fortin's Mercurial Barometer

A Fortin's barometer consists of a narrow glass tube of length about 90 cm. This tube is closed at one end. The tube is completely filled with mercury and kept inverted in a cistern filled with dry mercury. Usually, the glass tube is protected by enclosing it in a brass tube. The upper part of the brass tube has a slit that enables the level of the mercury in the glass tube to be seen.A scale graduated in millimetres is attached to the brass tube. This functions as the main scale.For accurate measurement, a vernier scale that can slide over the main scale is also fixed to the barometer.

The vernier scale can be moved up and down using a screw.The bottom of the cistern is like a bag made of flexible leather. The mercury level can be adjusted by means of a screw provided underneath. There is an ivory pointer in the cistern, placed at the top. The tip of this pointer coincides with the zero of the main scale. The level of the mercury column in the cistern can be changed with the screw under it. It is so adjusted that

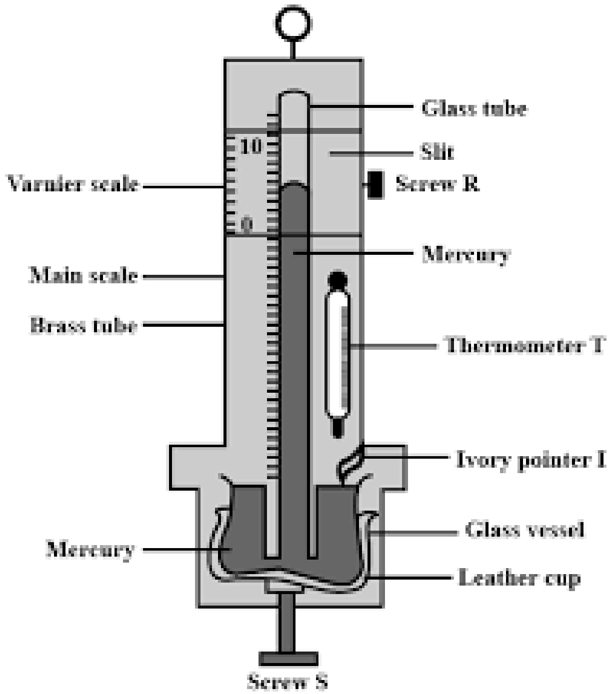
the ivory point is exactly at the surface of the mercury in the cistern. The whole apparatus is fixed in a vertical position.

Working

Any change in the atmospheric pressure is accompanied by an immediate change in the level of the mercury in the glass tube. As the height of the mercury column in the barometer changes, mercury flows between the tube and cistern. As a result, the level of the mercury in the cistern also changes. To determine the length of the mercury column in the barometer, it is necessary to know the position of the free surface in the cistern as well as in the tube.

The first step in measuring atmospheric pressure using Fortin's barometer is to set the mercury level in the cistern. Using the adjustment screw, set the level of the mercury in the cistern such that the ivory pointer just touches the mercury. The reading of the top of the mercury column is then measured using both the main scale and the vernier scale. Before the readings are noted, the vernier scaleneeds to be positioned properly.

The vernier scale is to be adjusted so that its edge and the corresponding reading in the main scale just set tangentially to the meniscus. Now, the readings on the main scale and the vernier scale are noted, and the atmospheric pressure is calculated.



Advantages

Fortin's barometer is widely used in laboratories and in meteorological departments.

The main advantages of Fortin's barometer are:

• Itis portable.

• It allows the mercury level in the cistern to be set to zero. This makes the reading more accurate.

Aneroid Barometer

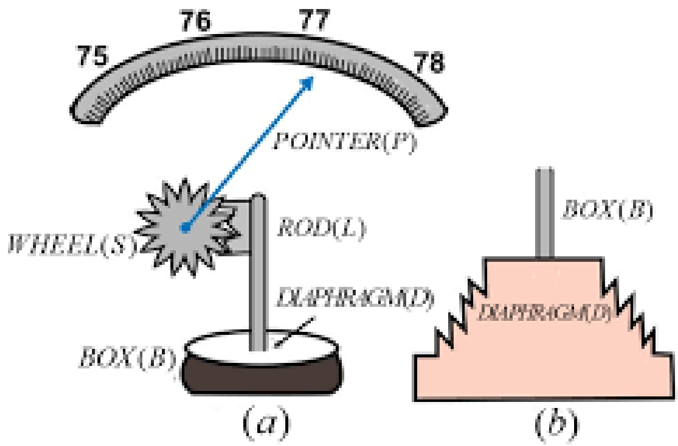
An aneroid barometer is an instrument for measuring pressure as a method that does not involve liquid. Invented in 1844 by French scientist Lucien Vidi. Inside this instrument is a small, flexible metal box called an aneroid cell. Before the cell is tightly sealed, air is partially removed, so that small changes in external air pressure cause the cell to expand or contract.

The size of the cell is calibrated to represent different pressures, and any change in its size is amplified by levers and transmitted to an indicating arm, which points to the current atmospheric pressure the aneroid barometer often has descriptive weather-related words printed above specific pressure values.

These descriptions indicate the most likely weather conditions when the needle is pointing to that particular pressure reading. Generally, the higher the reading, the more likely clear weather will occur, and the lower the reading, the better are the chances for inclement weather.

This situation occurs because surface high-pressure areas are associated with sinking air and normally fair weather, whereas surface low-pressure areas are associated with rising air and usually cloudy, wet weather. A steady rise in atmospheric pressure (a rising barometer) usually indicates clearing weather or fair weather, whereas a steady drop in atmospheric pressure (a falling barometer) oft en signals the approach of a cyclonic storm with inclement weather.

The altimeter and barograph are two types of aneroid barometers. Altimeters are aneroid barometers that measure pressure, but are calibrated to indicate altitude. Barographs are recording aneroid barometers. Basically, the barograph consists of a pen attached to an indicating arm that marks a continuous record of pressure on chart paper. The chart paper is attached to a drum rotated slowly by an internal mechanical clock



1.iii. Describe kata thermometer.

The Kata Thermometer :-

The Kata Thermometer consists of an alcohol thermometer with a large bulb A 4 cm. long and 2 cm. In diameter and a stern 20 cm. long. graduated only at two points namely 38°C and 35°C

It may be used for dry or wet. For wet Kata Cooling power reading the bulb Is first placed In hot water so that the liquid rises and partly fills the upper reservior C. It Is then exposed to the air. The bulb is surrounded by a wet muslin thimble D and time In seconds taken for the liquid to fall from 38°C-35°C Is observed.

In case column is broken, keep the bulb in cold water till the whole column of red Alcohol collects In the bulb.

The wet cooling power is then found by dividing the factor marked by the number of seconds observed.

The dry Kata reading gives only the cooling power due to radiation and conduction, but the wet Kata reading Includes the effect of evaporation and is thus a more useful guide as to the cooling power In reference to the human body.

1.vi. Calculate ventilation pressure by using piton static tube.

THE PITOT-STATIC TUBE:

The pitot-static tube, often erroneously referred to as the pitot tube consists essentially of a pitot tube or a total-head tube placed concentrically inside a static tube. It comprises a head which faces the air-stream and a stem bent at right angles to it. The pitot tube is nothing but a tube with an open end facing the air-stream so that it measures the total head whereas a static tube is one with its nose (which faces the air-stream) closed and with a few holes on the side of the tube there are two concentric tubes, the outer of which has a few holes on the sides. The annular opening between the two tubes at the nose end is sealed so that the inner tube records the total pressure and the outer, the static pressure only. The nose is total pressure and the outer, the static pressure only. The nose is suitably shaped so as to avoid undue turbulence and hence offer the least resistance to flow. The two component tubes of the pitot-static tube are connected to the two limbs of a manometer which reads the velocity pressure. The velocity can be obtained from the velocity pressure by using the relation

K 2p

Pv =

2

Where

V = velocity in m s-1

Pv = Velocity pressure in Pa, P = density ofairin kg m-3

K = correction factorforthe particularpitot-static tube (forstandard designs, K = 1)

Fornormal density ofairof 1.2 kg m-3, equation 8.11 reduces to

V = 1.29 √Pv

1.7 Explain effectsofheat & humidity.

It has been said earlier that the human body produces a lot of waste heat by the process ofmetabolism which has to be dissipated into the surrounding mine air.

The major part of the heat produced by the body is dissipated from the surface of the skin by radiation, convection and evaporation of sweat, though a very small part is dissipated from the lung through exhaled air. The heat transferfrom the innerparts of the body to the skin is through the blood circulatory system, although conduction accounts for a minorpart.

When the temperature of the atmosphere is 298 K or less, the normal blood circulation of the body along with conduction is sufficient to transfer the heat from the inner parts of the body to the surface of the skin. The heat transfer from the skin to the ambient air at these temperatures is mainly by convection and radiation. But above 298 K, the heat transfer to the skin has to be faster. Here, the vaso-motor control comes into operation, dilating the size of blood vessels and thus ensuring larger blood circulation to the skin. As the temperature rises above 302 K, the sweat glands start functioning and now the heat transferfrom the skin is mainly by the evaporation ofsweat.

When the dry bulb temperature of the mine air exceeds the body temperature (310.05 K0 the body can give away heat to the surrounding atmosphere by the evaporation of sweat only.

Explain effects of heat & humidity.

It has been said earlier that the human body produces a lot of waste heat by theprocess ofmetabolism which has to be dissipated into the surrounding mine air.
The major part of the heat produced by the body is dissipated from the surface ofthe skin by radiation, convection and evaporation of sweat, though a very small part is dissipated from the lung through exhaled air. The heat transferfrom the innerparts of thebody to the skin is through the blood circulatory system, although conduction accounts for a minor part

When the temperature of the atmosphere is 298 K or less, the normal blood circulation of the body along with conduction is sufficient to transfer the heat from the inner parts of the body to the surface of the skin. The heat transfer from the skin to the ambient air at these temperatures is mainly by convection and radiation. But above 298 K, the heat transfer to the skin has to be faster. Here, the vaso-motor control comes into operation, dilating the size of blood vessels and thus ensuring larger blood circulation tothe skin. As the temperature rises above 302 K, the sweat glands start functioning and now the heat transfer from the skin is mainly by the evaporation of sweat.

When the dry bulb temperature of the mine air exceeds the body temperature (310.05 KO the body can give away heat to the surrounding atmosphere by the evaporation of sweat only.

Explain natural ventilation motive column, geothermic gradient.

<u>Motive column and N.V.P.</u>

• In case of natural Ventilation it is the excess weight of air in D.C. air column which gives to the Natural Ventilating Pressure (N.V.P.).

• The height of this excess weight of air column of DC shaft 1 m2 in cross section which gives rise to N.V.P. is called motive column.

• In other words, it is the unbalanced part of the whole DC column, 1 m2 in cross section, i. e. that part of the DC column which is not balanced by the UC air column.

• Motive column is given by h = Where TU = average temperature in upcast shaft, K TD = average temperature in downcast shaft, K D = depth of column between top of the higher-level shaft and bottom of the deeper shaft, m N. V. P. = Motive column × density of air in DC shaft,

Determination of N.V.P. from thermodynamic considerations

• The thermodynamic approach developed by Hinsley (1950-51).

• The mine-ventilation system can be compared to a heat engine with the following cycle:

a. Air descending the downcast shaft undergoes auto-compression, as a result of which its pressure and temperature increase and specific vol. decreases.

b. As air travels through the mine workings, heat is added from rocks to the hot and compressed air, thus increasing its temperature. As a result, its specific vol. increases, but pressure decreases.

c. In upcast shaft, auto-expansion leads to increase in its specific vol., but pressure and temp. fall.

d. Finally, heat is rejected by the air to the atmosphere and the air returns to the atmospheric condition of pressure, specific volume and temperature thus completing the cycle.

2. AIRCROSSING AND DISTRIBUTION

2.1 Describe ventilation stopping, aircrossing, ventilation door.

VENTILATION STOPPING:

Stopping may be temporary or permanent. Temporary stopping, though commonly used in coal mines (particularly with bord-and-pillar method of working), are rare in metal mines where most stopping or bulkheads are oaf permanent nature.

Temporary stopping's in coal mines are usually made of brattice cloth, tarred paper or plastic cloth with wire netting reinforcements. They can be hung as curtains for allowing access through the roadway or nailed to a framework, the former allowing more leakage. Even the latter can allow substantial leakage at the periphery of the airway. Inflatable plastic stopping have been designed to minimize such leakage

.

These materials are, however, rarely used in metal mines where the stronger blasting concussion might damage them easily. Besides, they make a poor fit against the rough walls of the drives in metal mines and hence cause a lot of leakage.

Temporary bulkheads in metal mines are usually made of wooden boards nailed on to a skeleton frame of wood, the gaps between different boards as well as those between the boards and the rock wall being closed air tight by stuffing them with rags and plastering with clay.

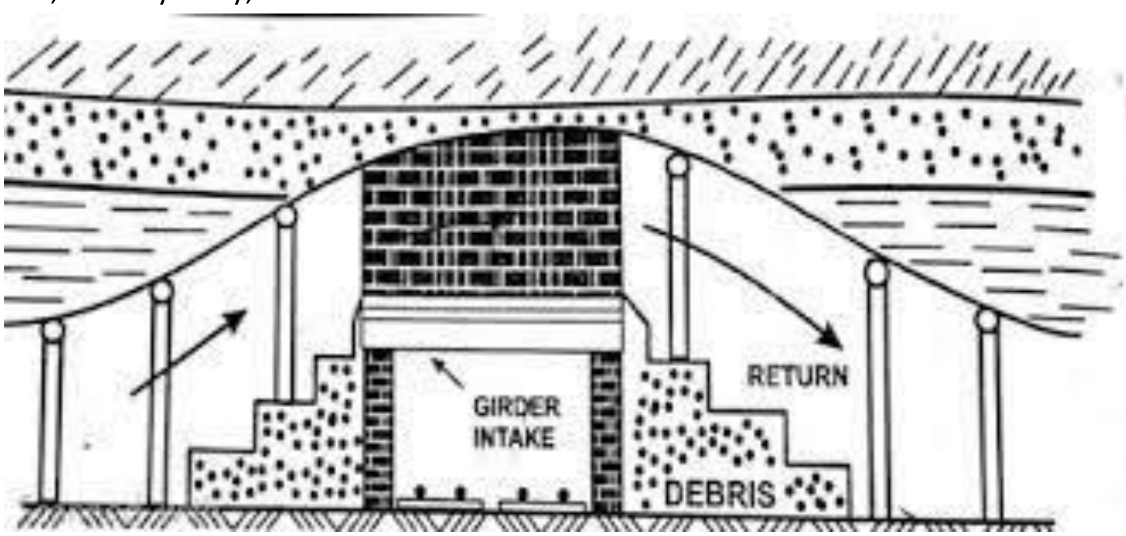
Permanent stopping in coal mines are usually made of brick or cement-concert walls. A good foundation reaching up to solid unfractured ground surrounding an airway is essential for preventing leakage, particularly in case of stopping erected to seal off fire areas.

According to Indian coal mines regulation, all stopping between main intakes and returns should be either of brick work or masonry of a minimum thickness of 250mm and suitably plastered by lime orcement mortar. They should be accessible forinspection.

AIR CROSSING:

Air crossing become necessary when return air has to be taken across intake. In metal mines, the system of ventilation is usually such that air crossings are rarely required, but in coal mines where main return and intake airways run close together, their use becomes essential.

Air crossing must be thoroughly leak proof since they generally involve main returns and intakes. They are usually made of brick or concrete walls covered with a reinforced concrete roof. Wooden roofs, though sometimes used, are very leaky, and are inflammable.



According to Indian regulations, air crossing should be fireproof and in gassy coal mines, explosion proof too. They should be of a minimum thickness of 250mm if constructed of brick or lightly reinforced concrete or of 150mm if constructed of properly reinforced concrete. Sometimes brick or concrete arches may be used instead of the rectangular construction.

Natural air crossing, where there are a few meters of rock separating the intake from the return, are the best from the point of view of leakage and are definitely explosion proof though they are costlier. Air crossings can be overcast or undercast, the former being more common. Undercast air crossing can be made by digging up the floor, but are less common because of their quantities of return air can be taken across the intake through one ormore large diameterpipes orducts.

VENTILATION DOOR:

Where access through stopping's is essential, doors are used. The term door usually means the assembly of both door and frame. The frames are set in suitable air-tight stopping's, made usually of cement concrete and the doors hung from them vertically by means of two to three strap iron hinges, Indian coal mines regulations require that the thickness of the masonry or concrete wall in which the door frame is set should not be less than 250mm.

single doors are most common in use though double doors are sometimes installed where a wide opening is required. Most double doors close in one plane though double V-doors operated manually or by compressed air or electricity are sometimes used on rope-haulage roads. In some cases automatic sliding doors have been used on rope haulage roads.

The size of doors is often as large as that of the stopping itself except in airways which are infrequently used for the passage of men only ; in such cases small doors of 0.6 X 0.9m size may serve the purpose. Doors range in size from about 1.5 X 2m in metal mines up to 2 X 4m in coal mines, depending on the width of cars that have to pass through the door.

Doors should preferably open on one side, i.e. the high-pressure side, opening in the other direction being checked by the frame. They should be so installed that they close automatically if left open. In coal mines, this is commonly achieved by installing the frame at a small angle of about 0.175 rad (10°) with the vertical so that the door closes by its own weight.

In metal mines, counter-weights or springs along with manually operated catches are usually relied upon for keeping the doors, they are often blocked open by irresponsible trammers so much so that in gassy coal mines it becomes necessary to place special operators at the doors. In coal mines, regulations provide that when a door is frequently used for the passage of men or material, an attendant shall always be placed at the door.

2.ii Define splitting of ai rcurrent.

SPLITTING:

When a mine has several working districts, it is preferable to divide or split the air required for the mine to the repective quantities needed in these districts and supply them through separate ventilation routes or circuits in parallel.

Just as combination of airways in parallel reduces their resistance, splits reduce the overall resistance of the mine and increase the fan quantity. Control of quantities delivered to different districts to suit their needs can be done easily by controlling the resistance of the splits.

Besides, splitting helps in providing fresh uncontaminated air to each district. Explosions or fires occurring in one district can be easily confined to that district by suitable ventilation control measures.

Splitting helps in keeping down air velocities in roadways by distributing the quantity through several opening instead of one.

However, splitting has its disadvantages such as (a) the necessity of maintaining a larer number of airways and (b) addition of a greater amount of heat to the air by virtue of its low velocity and contact with a larger rock surface in the splits.

For ideal air distribution, (a) the splits should have resistances commensurate with their air requirements ; (b) they should be fairly long so that the trunk airways connecting them to the shafts at both ends are as short as possible, as these trunk airways are usually overloaded and can cause large friction losses ; and (c) the number of splits cause a large number of faces to be ventilated by a single split whereas too many splits may produce sluggish ventilation at the face.

3.0 MECHANICAL VENTILATION

3.1 Explain construction & principle of operation of centrifugal flow fans.

A centrifugal fan essentially consists of an impeller, rotor or wheel rotating inside a volute casing. The impeller, in turn, consists of several blades or vanes mounted on a central hub over the driving shaft. When the impeller rotates, air is drawn into it at the hub and is discharged at the periphery into the casing. Following figure indicates an impeller of a centrifugal fan in which
U= the peripheral velocity ofthe impellerin m s-1 V= the absolute velocity offlow in m s-1

W= the relative velocity of flow in m s-1, i.e. velocity of air relative to that of the impellerso that V is the resultant of W and U
VR= radial component ofthe absolute velocity offlow
VU= tangential component ofthe absolute velocity offlow r1= radius ofthe impellerinlet in m,
r2= radius ofthe impelleroutlet in m,
and subscripts 1 and 2 indicate the flow conditions at the entrance and dischare of the impellerrespectively.