Underground Mine Ventilation – A Case Study

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Abstract – *In view of mining, Ventilation is a major aspect of an underground mine, in which it is to control the atmosphere to support miner's life and improve their efficiency. It leads to an increase the productivity and also to flush out the harmful and noxious gases to their permissible levels. This study is carried out to know the static conditions of mine which relates to the ventilation (i.e., Air velocity at roadways in mine, the existence of humidity in particular areas of the mine, the efficiency of fans at a rate of ventilating air into the mine, equivalent orifice (or) resistance of a mine, method of ventilating the air into mine, the ventilation distribution in mine and some other conditions). For ventilating the working faces, the proper controlling devices are used for coursing of air and sufficient ventilation survey techniques are to be developed to maintain the quality and quantity of air. This present paper covers a detailed view of the underground mine ventilation system, ventilation survey and different parameters that contribute to provide ventilation effectively.*

Keywords*: *Mine Ventilation*; *Ventilation Survey*; *parameters; controlling devices;

1. INTRODUCTION

Generally, as we all know that mining operations usually create a negative environmental impact both mining activity and also after the mine has abandoned this is because of, we are going averse to the environment there will be a lot of problems (or) difficulties occurs during the Mining operation like, (producing contaminant gases &dust during drilling, blasting, transportation, etc.,) in which reduces the miner's efficiency &production (or) productivity of Mine.

So, to conquer these difficulties ample amount of "**Ventilation (or)Ventilation System**" should be provided to the miner's, who works in mines, normally the term '**Ventilation'** describes, "It means by which fresh air is introduced and circulated throughout the building, while contaminated (or) stale air is removed (or) diluted".

In the view of mine ventilation, it is an important aspect of underground mining in which it is required to clear all harmful gases, as in coal mines removes fumes from blasting and occasional exhaust from diesel equipment and also at the same time it provides fresh air to the miner's which improves their efficiency.
so, the careful study of mine ventilation is needed and it is vital to create a safe and healthy environment.

1.1. Objective

Here there are some objectives that we are going to give a brief explanation regarding the underground mine ventilation in which we are taking ventilation as our main objective or motive and the following objectives that we are going to addresses are:

- To study different ventilation systems used in mines.
- To study about ventilation parameters.
- Detailed view of the ventilation survey.

1.2. Project Background

The background of this project has been carried out (or) analyzed from the underground mine i.e., Kakatiya Khani -8 or 8A incline, Bhupalpally. The proposed project of an underground mine with a method of mining/technology (i.e. Bord and Pillar mining method). In which we have analyzed from the below-mentioned seams in mine they are,

- 1 seam average thickness of 2.5 mts to 3.30 mts.
- 2 seam average thickness of 2.5 mts to 3.30 mts.
- 3 seam average thickness of 3 mts to 3.60mts.

2. DIFFERENT TYPES OF VENTILATION SYSTEMS

Depending on the type of mine and disposition of local geology, the ventilation system is chosen, the basic ventilation systems are:

- U-tube system.
- Through-flow arrangement system.

2.1.1. U-tube system:

In u-tube system air flows towards and through the working area then returns along the adjacent airways, often separated from intakes by long pillars of stoppings. The airflow between the intake and returns is facilitated by access doors fitted in the stoppings.

2.1.2. Through-flow system:

In the through-flow system, the intakes and returns are usually separated geographically from adjacent airways, which are either all intakes or returns, hence reducing the number of leakages paths. There are fewer stoppings and air crossing but additional regulation like regulators (or) booster fans to control the airflow.

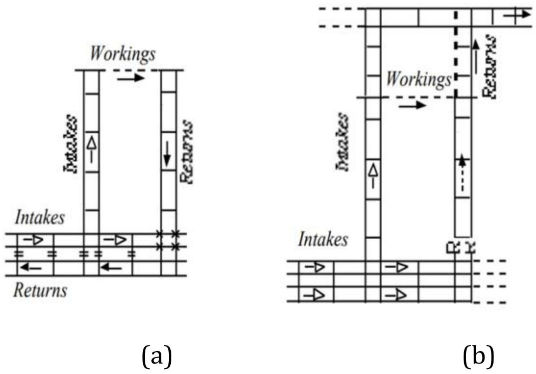

Fig.1. Basic ventilation systems (a) U-tube and (b) through- flow.

2.2. OTHER VENTILATION SYSTEMS

Different types of ventilation are as follows:

(i) Ascensional Ventilation

In this system fresh air is taken down to the bottom-most faces of a working district and is allowed to travel up the dip along the faces picking up heat from the freshly exposed rock at the face, this can be adopted as lit leads to the development NVP that aids the fan pressure.

(ii) Descensional Ventilation

It implies, taking the air to bottom-most faces from the rise side of a district to the lower levels along with the working places and return is at the bottom end of the working place. It has been claimed to reduce the amount of heat added to the air in workings, besides making the workings less dusty.

(iii) Antitropal Ventilation

When air and mineral flow is in opposite directions the ventilation is said to be an antitropal system of ventilation.

(iv) Homotropal Ventilation

In a homotropal system the air and mineral flow in the same direction.in this system, the velocity of air relative to coal is less compare to an antitropal ventilation system.

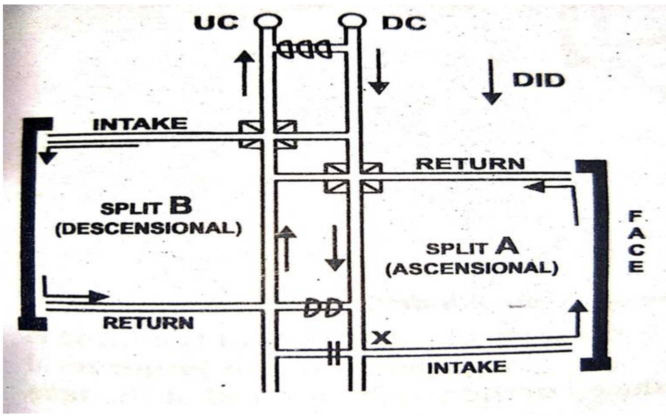

Fig.2. Ascensional Ventilation& Descensional Ventilation.

2.3. VENTILATION SYSTEM IN BORD AND PILLAR MINING METHOD

They are two methods of ventilating a bord and pillar development panel:

(a) Bi-directional or W system in which intake air passes through one or more central airways with return airways on both sides, and

(b) Uni-directional or U-tube system with intakes and returns on opposite sides of the panel. In both cases, the conveyor is shown to occupy the central roadway with a brattice curtain to regulate the airflow through it.

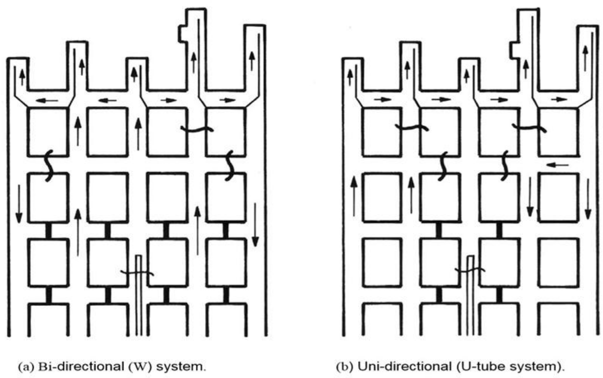

Fig.3. (a) Bi-directional system, (b) Uni-directional system.

- The bi-directional system is commonly adopted in the seam of coal mines where both intake and return shaft are both located at the center of the property.
- In a uni-directional system, the air flows from intake to the return through the workings and commonly adopted where the intake and return shafts are located at strike boundaries of the mine.

2.4. VENTILATION CONTROL DEVICES

- The air in a mine is coursed to the working place by the use of brick, stoppings, doors and brattice cloth, air crossings, air pipes, and regulators.
- The various devices used for distribution and control of air in a mine are shown on the mine plan by signs. Some of the control devices are:

2.4.1. Stoppings:

- A stopping block of a mine opening to prevent the flow of air between intake and returns, when these are no longer required for access or ventilation, to prevent short-circuiting of the airflow.
- Stoppings can be constructed from masonry, concrete blocks, or fireproofed timber blocks. Stoppings should be well keyed into the roof, floor and sides, particularly if the strata are weak or in coal mines liable to spontaneous combustion.

Fig.4(a). Stoppings.

2.4.2. Air Crossings:

- Where intake and return airways are required to cross over each other than leakage between the two must be controlled by the use of an air crossing.
- Normally air crossing constructed at the place where it has reasonable long life and ground free from rock movement.

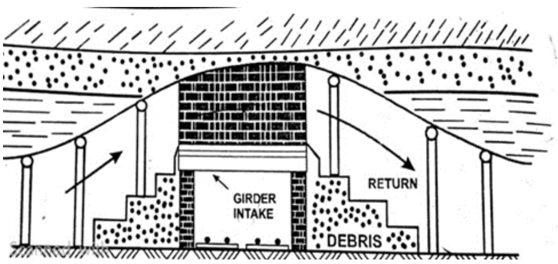

Fig.4(b). Air Crossing.

2.4.3. Regulators:

- Air regulator is a device for creating a shock loss to restrict the passage of air through an airway, these are usually rectangular adjustable openings left in stoppings. The air quantity can be adjusted by varying the size of the opening.
- Regulators are located in the return airway to minimize interference with traffic. Locating the regulator near the junction with the other splits of air will minimize leakage of air.

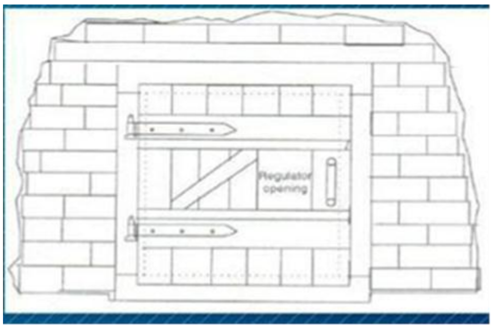

Fig.4(c). Regulator.

2.4.3. Brattice Cloth:

- A partition erected in the opening to divide it into the intake and return airways is termed as line brattice, the partition is simply a sheet or sheets of canvas hung from props and planks to prevent the short circuit of air from intake to return, so causing the ventilation air to reach the faces.

Fig.4(d). Brattice Cloth.

3. VENTILATION PARAMETERS

Generally, there are most important parameters that are required to design the ventilation system, which helps in to maintaining the distribution of airflow in the proper direction and also to improve the efficiency of miner's and helps in increasing the productivity of mine and the following parameters are:

3.1. Natural Ventilation Pressure (NVP):

- Airflow through the mine opening causes by natural means due to difference in air densities in an upcast and downcast shaft, aids to natural ventilation.
- Natural ventilation pressure in a mine is the difference of pressure of air columns in downcast and upcast shafts.

i.e., $NVP = P_1 - P_2$

$= D.\ \rho_d\ g - D.\ \rho g$ pascal

$= D.g\ (\rho_d - \rho_u)$ pascal.

3.2. Motive Column:

- The pressure due to natural ventilation may be expressed in meters of air column (or) motive column, which is the height of an imaginary column of one square meter in the section that produces a pressure equal to the difference of pressures between the bottoms of downcast and upcast shafts. It is an effective force causing flow.

The motive column in meters $h = \dfrac{NVP}{\rho d\ g}$

3.3. Laws of Mine Air Friction:

- The relation between various factors was enunciated by J.J Atkinson in 1854. The frictional resistance of the air depends on the Dimensions on the roadway (area, length, and perimeter), the velocity of air, nature of roadway along with air passes. An account is taken of these factors under the following four laws:
- Law 1: The pressure required to overcome friction is directly proportional to the area of rubbing surface i.e.,

$P \propto S,$

= perimeter of airway × its length.

- Law2: The pressure required to overcome the friction is directly proportional to the square of the velocity of air

$P \propto V^2$

- Law3: The pressure required to overcome the friction is inversely proportional to the area of cross-section of the airway.

$$P \propto \frac{1}{A}$$

- Law4: The pressure required to overcome the friction varies with the degree of roughness of the rubbing surface, or the coefficient of friction of the airways,

$P \propto K$

Atkinson's equation:

The above laws are combined in this as follows:

Pressure overcoming friction $P = \dfrac{KSV^2}{A}$

Where K value ranges from 0.004 to 0.015.

- Form the Atkinson's equation we have $P = \dfrac{KSV^2}{A}$
- In terms of quantity of air, we have $P = \dfrac{KSQ^2}{A^3}$,

3.4. Resistance System of Roadways

3.4.1. Roadways in Series:

- A series ventilation circuit is one in which the air is first used in one workplace, then directed to another workplace, and then potentially reused in many other workplaces. It has also been variously described as "cascade" ventilation or "daisy-chaining".
- where flow occurs in two or more roadways in series, a quantity of air flowing through every roadway is the same (Q), and the pressure spent P is the sum of pressure in individual roadways.

- Using the Atkinson equation i.e., $P=RQ^2$

$RQ^2= R_1\ Q^2+R_2\ Q^2+R_3\ Q^2+$----------$R_nQ^2$ or

$R = R_1+ R_2+ R_3+$----------$+R_n$

3.4.2. Roadways in Parallel:

- The other major system of ventilation circuit design is parallel circuits, also known as "one pass" or "single pass" ventilation. In parallel designs, the air is used in one workplace and then directed to the return.

- Where airflow occurs in two or more roadways in parallel, pressure difference P is the same across every split, while the air quantities get distributed amongst them depending on their resistances. Thus, the total quantity of air is the sum of the individual quantities of air passing through the splits.

 Using the relation $P = RQ^2$ or $Q = \sqrt{\dfrac{P}{R}}$

$$\sqrt{\frac{P}{R}} = \sqrt{\frac{P}{R_1}} + \sqrt{\frac{P}{R_2}} + \dots\dots\dots + \sqrt{\frac{P}{R_n}}$$

or because of pressure across the splits in the same,

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

4. VENTILATION SURVEY

A ventilation survey is an organized procedure acquiring data that quantify the distribution of airflow, pressure, and air quality throughout the flow paths of the ventilation system. Better planning of ventilation can be done by analysis and evaluation of data obtained survey in different parts, for the ventilation system to efficient and economic. Generally, ventilation survey is carried out in three different ways i.e.,

4.1. Quantity surveying:

The quantity surveying mainly involves to analysis the distribution of airflow in the main roads, galleries, and at the working faces. It also determinates to locate the leakages between intake and returns and to know the efficiency of the fan during fan tests.

Quantity of air passing per minute is normally measured by given formula i.e.,

$$Q = A \times V$$

4.1.2. Pressure Surveying:

The purpose of the survey is to determine the frictional pressure drop(p), that corresponds to the airflow(Q), measured in each branch of a survey route. The basic principle of the pressure survey in a mine is Bernoulli's theorem.

4.1.3. Qualitative Survey:

The survey involves the determination of firedamp content at different leakage points in the mine and chemical analysis of the air samples. If the firedamp content in the general body of the return air of the ventilation district exceeds 0.75%, the ventilation is inadequate.

4.2. Flow Chart for Conducting Ventilation Survey

The following steps are carried out as part of the initial planning for the survey:

↓

Initial checking and calibration of instruments

↓

Selection of survey routes from mine plan

↓

Marking of survey stations on ventilation plan

↓

Time table for required days is need to be done

↓

Time of conducting survey during minimum labour force

↓

Pressure and quantity readings must be taken at the same time

↓

Field books must be maintained for easy to understand it.

↓

Calculations and checking must be done with accuracy

Fig.5. Flow chart for conducting a ventilation survey.

4.3. TYPES OF VENTILATION SURVEY

4.3.1. Hygrometric Survey

Hygrometric survey in mines is normally carried out to check and control the environmental conditions at various parts of the mine to maintain the mine atmosphere (wet-bulb temperature and air velocity) within statutorily permissible limits. It is generally carried out by whirling hygrometers, readings must be taken at all splits, points of leakages, haulages, compressors, etc.,

4.3.1.2. Instruments used to measure relative humidity

- **Whirling hygrometer:**

To determine the relative humidity of the air to the extent which it is saturated with moisture is known as a hygrometer. the hygrometer consists of two thermometers i.e., (wet bulb and dry bulb thermometers), and the wet- bulb is surrounded with muslin sack which immersed into the water.

Normally the hygrometer is whirled to force air about 200 rpm to a minute the readings of the dry and wet bulb are calculated. when the instrument is whirled through the air, water from the muslin sack evaporates this takes to the wet bulb.

Evaporation of moisture takes place from the wet bulb, thereby cooling it an bringing down its temperature. when the air is relatively dry it has low relativity humidity, when the air is nearly saturated the two readings have hardly a difference.

In Indian underground mines, the relative humidity of mine air in the temperature can normally range as follows:

R.H (%) = 100 – X (D.B.T-W.B. T)
X= 7, for D.B.T > 25
8, for D.B.T, 20-25
9, for D.B.T < 20

According to standards of ventilation in C.M.R 2017, the wet-bulb temperature should not exceed 33.5^0c whereas dry bulb temperature is about not less than 30.5^0c if it is, exceeded for every one degree there is to be increasing of air velocity about 1 m/sec.

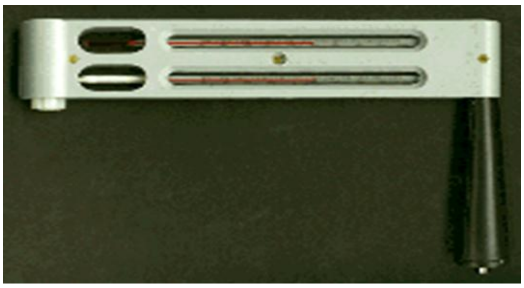

Fig. 5. Whirling Hygrometer.

4.4. Air Quality Suvey

The quantity of air passing through any airway every second, Q is generally given by the expression

$$Q = U \times A \ (m^2/s)$$

Where, U = Velocity of air passing through that point(m/s)

A = Area of roadway (m^2)

4.4.1. Measurement of Cross-Sectional Area

The accuracy of the calculation of air quantity is equally influenced by the measurement of air velocity and measurement of the cross-sectional area of the roadway. Thus, it is most important to ensure that a standard method is used to carry out area measurements. Normally for better accuracy results, we use the Taping method of measurement.

Taping:

This is the easiest and the most commonly used for measuring cross-sectional areas in mines. Procedure in this method, a tape is stretched over the airway, and with the help of another tape, the perpendicular offsets to the periphery of the airway on either side of the stretched tape are taken regular intervals of 0.3-0.5 m. The measurements can be plotted with a scale and the area of the resulting diagram determined by a plan meter.

4.4.2. Measurement of Air Velocity by Traversing

Fixed point traverses /single point measurement:

Here, we can measure the air velocity by traversing in two different methods i.e., (moving traverses and fixed-point traverses). In this method, the anemometer is held at a fixed point on the cross-section of the airway, the reading multiplied by a method factor of 0.8 to get the average velocity value.

Usually, readings are taken at the center of the shaft. The method factor varies with a roughness of the side of the airway and the Reynolds number. The method factor is unity at one-seventh of the distance between opposite walls from any wall. An accuracy of 5% can be obtained with single-point measurement.

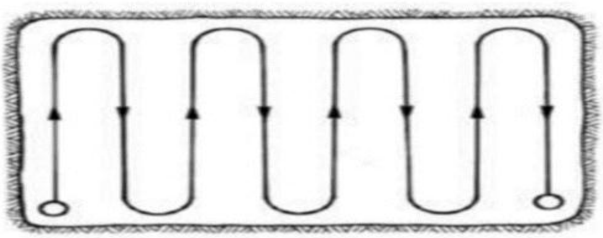

Fig.6. Waves to Move Traverse.

4.4.3. Instrument Used for Measuring Air Velocity

The vane anemometer is the classic device used to illustrate the mechanical effect of the air; it is simply termed as an anemometer. It is an instrument to determine the distance traveled by air in a given time and used where air velocities between 60m and 1000m^3/min.

The anemometer is a small windmill-like instrument consists of several radial blades or impellers at 40^0 to 50^0 to the direction of airflow and also used a gearing mechanism, a pointer, and a clutch system. A zero-reset lever is also mounted on the instrument. Anemometers are specially designed to measure the air velocity from lower range velocities to higher range velocities are about (10.16 to 50 m/sec or 2,000 to 10,000 fpm).

Fig.7. Vane Anemometers.

4.5. Pressure Survey

Airflow from a region of high pressure to lower pressure, in general, the maximum pressure is found at the top downcast shaft and the minimum pressure is found at top of the upcast shaft.

The pressure difference between them causes the flow of air and the traveling of air in mine airways often, km's in length. In those cases, there is to determine the gradual pressure fall from point to point.

4.5.1. Determination of Pressure Loss by Gauge & Tube Method:

The pressure losses are determined directly by differential pressure measurement i.e. Gauge and Tube Method. the procedure of gauge and tube method as follows:

- The pressure difference between the required two points connected by a hose is directly on a manometer.
- This method gives accurate results but is time-consuming as it involves laying and carrying the hose from point to point.
- This method is generally employed in typical coalmines where very high pressure is not observed

5.0. RESULT AND ANALYSIS

5. 1. FIELD OBSERVATIONS

5.1.1. Observations regarding Air Velocity

Table-1. Air velocity measurements.

1 SEAM					
SL NO.	LOCATION OF AMS	NATURE OF AIR	AREA M2	VELOCITY M/min	QUANTITY M3/min
01	MWD/10L	INTAKE	12.01	92	1104
02	MID/10L	INTAKE	13.50	88	1188
03	22LS/MID	INTAKE	10.50	89	934
04	11R/24L	LVC	10.5	66	693
05	10R/23L	LVC	14.31	85	1216
06	1R/17AL	RETURN	12.22	176	2150
07	1R/14AL	RETURN	13.19	169	2229
2 SEAM					
08	CCDT/1Seam	INTAKE	12.54	111	1391
09	MID/8A	INTAKE	13.31	157	2061
10	MWD/8A	INTAKE	11.34	236	2676
11	14R/23L	LVC	8.36	153	1071
12	14R/22L	LVC	9.02	160	474
13	20LS/SID	RETURN	9.66	195	1315
14	S1D/20L	RETURN	9.40	60	1681
3 SEAM					
15	MID/8INC	INTAKE	13.36	232	3099
16	MWD/8INC	INTAKE	12.49	198	2473
17	CHDT/2L	INTAKE	17.50	50	875
18	N1D/3L	LVC	13.35	72	961
19	N2D/4L	LVC	12.50	32	400
20	23LS/S1D	RETURN	13.50	160	2160
21	MWD/23L	RETURN	14.70	28	411

5.1.2. Observations regarding Hygrometric survey

Table-2. Hygrometer survey readings.

NAME OF SEAMS	LOCATION	WBT IN ^{0}C	DBT IN ^{0}C
1 SEAM	24LS/11R	29.5^0C	30. 0^0C
	22LS/12R	29.5^0C	30. 0^0C
	12D/21BLS	29.5^0C	30. 0^0C
2 SEAM	24LS/14D	29.5^0C	30. 0^0C
	15R/22L	29.5^0C	30. 0^0C
	16D/21AL	29.5^0C	30. 0^0C
3 SEAM	4LN/N2D	26.0^0C	27. 0^0C
	5LN/2D	27.0^0C	27. 5^0C
	6LN/N1D	27.5^0C	28. 0^0C

NOTE: WBT (Wet-bulb temperature), DBT (Dry-bulb temperature)

5.1.3. Observation of existing main mechanical ventilator

Table-3. Main mechanical ventilators readings.

Existing Main Mechanical Ventilators at K.T.K-8 or 8a Incline			
Sl.no.	Description	Fan no. 1	Fan no. 2
01	Make	MMM	Voltas
02	Capacity	300HP	300HP
03	Dated on	Sep-12	Jun-13

04	Intake air quantity in m^3/min	11,200	10,549
05	Status	Running	Stand by
06	Water gauge in mm	20	18
07	Resistance of the mine	0.66murge= 0.00647 Ns^2m	0.66murge= 0.00647 Ns^2m
08	Power in amps	31	28
09	Blade angle	22.5^0	12.5^0

5.2. ANALYSIS

5.2.1. HYGROMETRIC SURVEY

- Concerning the above observations i.e. (Table -2 hygrometric survey readings) from that, we have analyzed the difference between dry and wet bulb temperature for calculating the existence of relative humidity of air in the below-mentioned seams and locations of mine.

Table-4. Analysis of Hygrometric Survey.

ANALYSIS OF HYGROMETERIC SURVEY			
Name of the seams	Location	Difference between dry and wet bulb temperature	**Relative humidity**
1 seam	24LS/11R	0.5^0C	**96.5%**
	22LS/12R	0.5^0C	**96.5%**
	12D/21BLS	0.5^0C	**96.5%**
2 seam	24LS/14D	0.5^0C	**96.5%**
	15R/22L	0.5^0C	**96.5%**
	16D/21AL	0.5^0C	**96.5%**
3 seam	4LN/N2D	1^0C	**93%**
	5LN/2D	0.5^0C	**96.5%**
	6LN/N1D	0.5^0C	**96.5%**

5.2.2. AIR POWER

- concerning the above observation i.e. (Table-1 measurements of air velocity) from that, we have calculated the Airpower of mine by taking pressure as 20mm (196.136 pascals) and also quantity of air from the particular locations in mine. Hence the air power is calculated as.,

Table-5. Calculations of Airpower.

CALCULATIONS OF AIR POWER=PQ (kW)					
Sl. no.	Name of seam	Locations	Pressure (pascal)	Quantity (m^3/sec)	**Air Power (KW)**
01.	2 Seam	MID/8A	196.136	34.35	**6.737**
02.		MWD/ 8A	196.136	44.60	**8.74**
03.	3 seam	MID/8INC	196.136	51.62	**10.12**
04.		MWD/8INC	196.136	41.21	**8.08**

5.2.3. VENTILATION DISTRIBUTION

- Distribution of ventilation in a mine can be determined or calculated based on the number of districts employed or works in mine. By analyzing the distribution of ventilation, we can know the average temperature, the quantity of airflow, and ventilation equivalent orifice in particular districts of mine. Hence the analysis is calculated and tabulated below.

Table-6. Analysis of Ventilation Distribution.

Sl. no.	Name of districts	Quantity at districts entrances	Quantity at LVC	Ventilation equivalent orifice	Temperature	
					Dry	Wet
01	21AL	6574	4675	71.11%	27.5^0C	28^0C
02	2AL	6574	3663	55.71%	27.5^0C	28^0C
03	20L	4722	2899	61.18%	27.5^0C	28^0C

5.2.4. EQUIVALENT ORIFICE OF MINE

- The equivalent orifice is the resistance of a mine and as it is the area of the orifice in a thin plate that offers the same resistance to airflow as the mine.

$$A = \frac{1.19}{\sqrt{R}} \quad (\text{R is in } Ns^2m^{-8})$$

by using this formula, we can calculate the equivalent orifice of mine by taking mine Resistance(R) as 0.66murge= 0.0647 Ns^2m. hence by substituting "R" value in the formula we get.,

$$\boxed{A = 14.79\ m^2.}$$

5.2.5. THEORETICAL DEPRESSION

Generally, the theoretical depression is nothing but it is the pressure difference that would be generated by a mechanical fan running under ideal conditions when connected to evasee chimney infinite height.

$$\boxed{\frac{U^2}{g} = \frac{U(U \pm V_1 \cot\theta)}{g}}$$

We have calculated the theoretical depression based on the speed of a fan, angle of the blade, water gauge pressure, and also on by considering the diameter of fan and width of periphery blade which we have taken this observation from the Table-3 i.e., (main mechanical ventilator). Hence, we have calculated and result as.,.

Theoretical depression= 217.364 mm.

5.2.6. MANOMETRIC EFFICIENCY

we can calculate the manometric efficiency by considering the value of theoretical depression why because it is the ratio between effective water gauge and theoretical water gauge. Hence by using formula i.e.,

$$(\eta) = \frac{\text{Actual depression delivered by fan}}{\text{Its theorteical depression}} \text{X } 100.$$

by considering actual depression as 20mm and taking theoretical depression as 217.364 then the result as.,

(η)= 9.20%.

6.0. CONCLUSIONS

From the field observations, calculations and results, the following are conclusions as.,

- The relative humidity is almost 96.5% at most of the places in mine, which results that the saturation of moisture in the air is less.
- The maximum and minimum wet bulb temperature readings are 29^{0}C and 25^{0}C. Hence, the wet-bulb temperature readings are maintained at particular places is less than 30^{0}C in accordance to the coal mines regulations specified by the DGMS.
- From the concerning to the field observations it is to conclude that the least air velocity is at 8 LS/ MID of 0.33 m/sec and maximum air velocity at S1R/23L of 4 m/sec.
- Similarly, from the field data, the least quantity of air is at 27LS/MID of 223 m^3/min or 3 m^3/sec and maximum air quantity at MID/8INC of 3099 m^3/min or 51 m^3/sec.
- It is also observed that locations at 21ALS/MID, 21LS/S1D, and 20 LS/S1D (working faces) of districts 21AL, 21AL, and 20 L respectively. The velocity of air flowing is 88 m/min, 41 m/min, and 92 m/min which is above the DGMS recommended level of velocity, and the velocity air has to be more than 30 m/min.
- From the calculations and analysis, it is required to send a minimum of 1320 m^3/min through LVC (Last ventilation connections) but practically the least quantity of air at LVC is of 20L district is 2899 m^3/min. Which is greater than the amount.
- The mine has four entrances, from the calculation is observed the maximum airpower is from MID/8INC of 8.74 KW and least airpower from MID/8A 6.737 KW.
- Hence, from the above conclusions, it is clear that the mine has very good working conditions according to DGMS recommended level and requires no additional changes in its working system of ventilation.

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