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A REVIEW ON UNDERGROUND MINE VENTILATION SYSTEMS

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Abstract:

To support and improve miner's health, ventilation is a major aspect of underground mining. As a result, there is an increase in productivity and efficiency. To reduce the number of toxic gases in the air to a safe level. The ventilation system is a method of bringing fresh air into the mine. It is necessary to develop techniques for maintaining the quality of the ventilation. For ventilating in the working faces, the proper controlling devices were used for controlling air and sufficient ventilation survey techniques are to be developed to maintain the quality and quantity of air. This present paper shows a detailed view of the underground mine ventilation system, ventilation survey instruments and different parameters that contribute to provide ventilation effectively.

Keywords: Mine ventilation; underground mine; controlling devices; parameters

1. INTRODUCTION

Mining is a process of extracting the economically valuable minerals from the Earth. Personnel and machines require good quality air to breathe, to dilute both natural and introduced (e.g., diesel exhaust) gases, to dilute or carry away dust, and to provide cooling. In surface mines if any toxic gases were release then they will be mixed with the environment gases those won't affect workers in the mine. In underground mines there is no way for gases to go outside, the only way through ventilation.

In mine ventilation there will be mainly two types,

1) Natural ventilation
2) Artificial ventilation

In mines the air will enter from the surface through shaft or adit. The main purpose of underground mine ventilation is,

- To dilute and remove dangerous gases
- To remove dust
- To remove heat
- To supply oxygen for breathing

The primary sources that release gases will be

a. Vehicles
b. Human beings
c. Blasting and Drilling
d. Naturally generating gases.

2. OBJECTIVES

To review about various underground mine ventilation systems and ventilation monitoring instruments.

3. LITERATURE

Ventilation systems in mines can be classified as boundary or unidirectional, central or bi directional, combined, depending on the relative position of intake and return airways.

3.1. BOUNDARY VENTILATION SYSTEM

The boundary ventilation system, in which air flows unidirectional from the intake to the return via the working, is by far the most efficient, requiring the least amount of ventilation control devices and resulting in high volumetric ventilation efficiency (70-80 percent). In its most basic form, it is used in metal mines that work steep lodes, with the intake and return shafts positioned at the mine's strike limits. Lateral extent, a central input shaft with two return shafts or winzes at either end is desirable. Two exhaust fans are installed in the property.

On the top of the intake shaft, a single forcing fan is sometimes utilized. However, this needs an air lock on the hoisting shaft, which is not ideal. When the mine is large enough on the strike, it can be split into multiple lateral parts, each with its own fan. Separate exhaust fans are usually installed on each parallel lodes in mines with several parallel lodes, but there may be a shared intake. A single forced fan is a less attractive option.

3.1.1. ADVANTAGES

- The usage of ventilation control devices is limited by the boundary ventilation system.
- This lowers leakage and results in a high volumetric efficiency.
- In addition to conserving the capital spent in them as well as the cost of operation and maintenance.
- Separate fans can be used to air two distinct areas of the mine. As a result, the overall flow handled by a single fan is reduced, lowering the fan's head demand.
- Leakage is reduced to a lower head. The flow can be handled by narrower cross-sectioned airways.
- Each portion's ventilation may be regulated individually, and a section can be separated quickly in an emergency.
- Because there are more exits to the surface, there is more safety.
- The mine characteristic remains almost constant throughout the mine's life, resulting in the fan's operation being consistently efficient.
- The mine resistance, on the other hand, is constantly changing as the workings proceed.
- The property line in the central ventilation system, where the fan must navigate a larger range of mine characteristics.

3.1.2. DISADVANTAGES

- The reversal of air flow is more difficult.
- The cost of operation, management, and maintenance of separate fan systems rises.

3.2. CENTRAL OR BI DIRECTIONAL

Ventilation system that is either central or bidirectional is used. In-the-seam coal mines, where both the intake and return shafts are close by at the property's centre, the system is commonly used. In any district, intake and return air travels in opposite directions through parallel roadways, which are usually separated by stopping erected in the cross section between them. In order to join the main return, return air from a district must also pass the intake. Obviously, the central ventilation system permits a significant amount of leakage due to the number of stopping and air crossing points employed, resulting in a volumetric efficiency of just 40-50 percent.

3.2.1. ADVANTAGES

After a brief development period, the deposit may be exploited, allowing for a speedier start to production. Because long development headings aren't required, there's no need to worry about ventilation. Mineral loss in shaft pillars is reduced in central pits. The expense of digging deep pits nearer is reduced since some common amenities may be shared by the pits. On the other hand, boundary pits that are located far away from the sinking site need the construction of a road, the expansion of power lines, and other costs. Although both central shafts can be used for hoisting, boundary shafts are rarely employed since this would need the extension of surface transport to these pits. If they're on the rising side, they can also be used as stowing pits (with hydraulic stowing pipes attached).

3.2.2. DISADVANTAGES

- The central mine ventilation method slows substantial leakage due to stopping and air crossing.
- With this system the loss of volumetric efficiency is 40% to 50%

  i) **Ascensional Ventilation**

  In this ventilation system fresh air is taken down to the bottom faces of a working district and is allowed to reach up the dip along the faces collecting heat from the freshly exposed rock at the face, this can lead to the development NVP that aids the fan pressure.

(ii) **Descensional Ventilation**

It implicit, taking the air to bottom faces from the rise side of a district to the bottom levels along with the working places and return are at the lower end of the working place. It has been asserted to reduce the quality of heat added to the air in workings, apart from making the workings less dusty.

(iii) **Antitropal Ventilation**

When air and mineral flow in different directions then the ventilation is known as antitropal ventilation.

(iv) **Homotropal Ventilation**

When the direction of air and mineral flow is same then it is known as homotropal ventilation

4. VENTILATION ENTAILS A VARIETY OF TASKS

Planning: Calculating the quantity of air required in the mine and how that volume will be transported to each region of the U/G workings, both now and in the future, for example, if the mine expands, produces more, or introduces new equipment, particularly mechanised, mobile equipment. Implementation includes planning and building intake and upcast airways, as well as choosing, installing, and maintaining equipment to provide the needed air volumes.

Temperature, dust levels, airflow, and pressure are measured on a regular basis in all working areas of the mine; Ventilation equipment and installations are inspected; Reports and suggestions on ventilation requirements are made. Mine air travels through vent columns (also known as vent ducts), which are pipelines with a relatively high diameter, or through excavations, which include tunnels and stopes, in U/G mines. Any of these might be an airway. Airflow happens only when a force or pressure is applied to it. A difference in pressure at the airways ends causes airflow in a mine or any other airway. Similar to an electrical circuit, friction along the sides of an airway or from obstacles in it, as well as the inertia (dead weight) of the air, create resistance to air movement. Similarly, to electrical conductors, the less resistance, the greater the cross-sectional area of an airway. An input airway, sometimes referred to as the downcast shaft, and an upcast or return airway, where polluted air is expelled to the surface, are both present in U/G mines.

Natural ventilation is created in small-scale U/G mines when there is a significant difference in natural pressure between two exits to the surface to produce an airflow through the mine. It's unreliable since the pressure differential might be tiny, and it could change from night to day or season to season, resulting in severe flow reversals. Building a fire in the exhaust part of the airway can help with airflow. Electric fans are utilised in most situations, especially in large, deep mines. A pressure differential is generated in mechanical ventilation by running one or more fans in an airway. As air flows down the airway against resistance, each fan creates a particular amount of pressure, which eventually decreases. The majority of miners follow one of two main strategies. Axial-flow fans have a set of blades inside a circular housing, similar to a household fan, with air flowing directly through the centre, propelled by the blades rotation at an angle or pitch.

The air stream changes direction as it travels through the centrifugal fan, which has an impeller that is supplied tangentially from the side. Force fans push air into an airway ahead of them, whereas exhaust fans physically suck air out of an airway, allowing new air to enter at the intake end. Mine fans are not self-contained like domestic fans in houses, workplaces, and other buildings. Domestic fans do little more than circulate air at a high velocity in order to keep people cool. Mine fans are attached to an airway through a duct (pipe) or a tunnel wall. Enormous U/G mines feature a main ventilation system that uses large fans, either axial-flow or centrifugal, to pull air out of a return route, allowing new air to flow in via another aperture.

Although radial booster fans may also be placed U/G to counteract pressure loss, primary ventilation systems are typically exhaust systems with main exhaust fans situated on the surface. Mines frequently feature several intakes and return airways running in tandem.

The secondary ventilation system distributes air to various sections of the mine as needed, helped by barriers and regulators that prevent air from escaping into places where restricted or zero quantities are necessary.

Erecting hessian screens and spraying them with concrete to form a seal, is a simple and inexpensive technique to make vent walls. Temporary barriers are sometimes necessary. Inflatable bags, which are easy to travel and can be set up in minutes to close an airway, can be utilised. Where access to a level is still necessary, doors are erected to block it off. This might be a tiny door in a vent wall allowing man access or a huge steel door that opens to enable rolling stock and vehicles access. Workers must be taught how to keep doors shut. A counterbalance is commonly used to close doors automatically. Pressure loss is reduced in lengthy airways, particularly ventilation columns (ducts), by connecting fans in series. Long tunnels are being built with overlapping force and exhaust columns for ventilation. By connecting two or more fans in parallel, volume may be enhanced.

5. VENTILATION CONTROL DEVICES

There are several ways to get a mines air supply to the operating area. Signs indicate the location of air in a mine. To control the ventilation, devices can be used in the underground mine ventilation. Some Among the control devices are the following ones:

5.1. STOPPINGS

To halt the airflow between intake and return when they are no longer needed for a ventilation. This will prevent the airflow from being short-circuited. These may be made from brick, stone, or concrete. Concrete blocks, or fireproofed timber blocks, can be used to build a structure. They should be securely anchored in the roof, floor and wall. especially if the strata are weak or unstable. Inflammability of coal mining

Fig. 1: Ventilation stopping

5.2. AIR CROSSINGS

Air crossings must be used where intake and return airways must cross over each other in order to prevent leakage between them. Air crossing erected upon the site of an existing crossing, has a decent level of rock-free terrain movement.

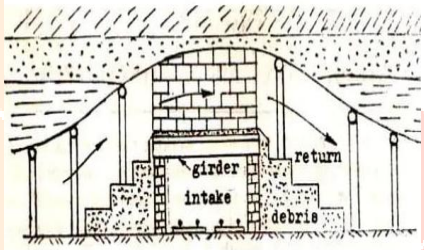

Fig. 2: Air Crossings

5.3. REGULATORS

This is a device that creates a shock loss to limit airflow via a respiratory tract. stoppings. The air amount may be changed by adjusting the pressure differential. The aperture's size can be altered. There are a number of regulators in the return airway to minimize the traffic interference. Locating the source of the problem at the intersection with other splits of a road. Leakage of air will be kept to a minimum.

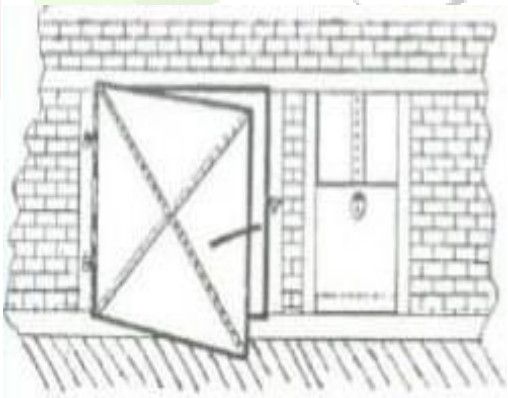

Fig.3: Regulators

5.4. BRATTICE CLOTH

It consists of a canvas sheet or sheets of canvas hanging on a strut to separate the aperture into intake and return airways. To prevent a short circuit of air from occurring, props and boards were used. Ventilation air is forced to return to the intake.

Fig.4: Brattice Cloth

6. INSTRUMENTS

The instruments that were used in the underground mining to know the parameters are,

6.1. BAROMETER

A barometer is a device that is used to detect atmospheric pressure. The use of a barometer is beneficial in the operation of a mine because it displays changes in air pressure as they occur. A detailed examination of these pressure variations in relation to the gaseous state of the mine workings allows for more intelligent ventilation design and management, and may frequently predict a dangerous gaseous condition in the mine due to a fast drop in the barometer. Regular barometer readings are important in mining operations because they indicate the expansive effect caused by a sudden drop in barometer or decrease in atmospheric pressure. As a result, air and gases confined in a large abandoned area are forced out into the live workings, significantly increasing the explosive condition of the mine air.

6.2. MINE WATER GAUGE

A water gauge is a partly filled glass U-tube that is open at both ends and graded in inches. In Mine Ventilation, a water gauge is used to calculate the amount of power in the air. As a result, it should be mounted on the fan drift to account for the full resistance of the shaft and mine, which the ventilation fan must overcome. When the water gauge is in this position, the reading reflects the pressure created by the fan, which is either above or below atmospheric pressure, depending on whether the fan is blowing air into or expelling air from the mine. The change in the level of the water column of one inch is 5.2 lbs. per square foot.

6.3. THERMOMETER

A device for measuring temperature that is used to assess the relative humidity of mine air and to measure temperatures in sealed areas. Regular temperature readings within and outside the mine are critical for determining if the air has a higher or lesser capability for transporting moisture or absorbing moisture from the mine. In a dry and dusty mine, hygrometer readings are most useful.

6.4. ANEMOMETER

Anemometers are commonly used in coal mining and consist of a metal ring with a revolving propeller of blades. The air stream striking the inclined blade rotates the bane, with a series of gears recording the number of rotations on the dial's face. The device is used to calculate the air current velocity in mine airways, which is given in feet. When taking a reading, choose a spot where the air is travelling straight and won't be diverted unequally to either side, then measure the area of the airway. Hold the anemometer at arm's length so that the blades move in a plane perpendicular to the air current, then use the anemometer's reset lever to reset all dial hands to zero, then release the brake lever near the handle. The anemometer is exposed to the air current for one minute, moving about to acquire an average reading for the airway's enter sectional area, following which the anemometer is removed. Brake lever is released and the anemometer is exposed to the air current the amount of air moving in cubic feet per minute is calculated by multiplying the anemometer measurement by the square footage of the airway.

7. CLASSIFICATION OF MECHANICAL VENTILATION

All powered machinery used to generate air flow through mine entrances or ducts are considered mechanical ventilation devices. Fans are the most important and most common of these but compressors and injectors also have application to ventilation.

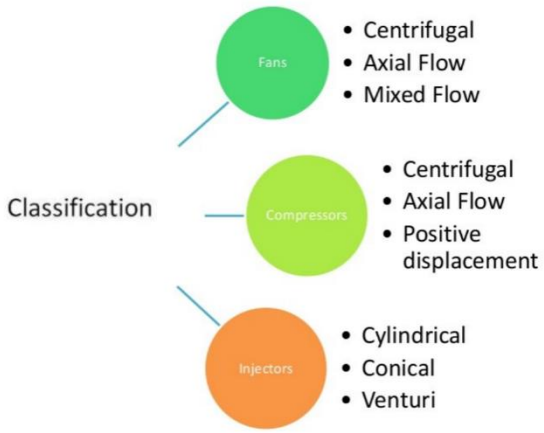

Fig.: Classification of mechanical ventilation

7.1. FANS

A fan is an air pump, a mechanism that generates air flow by creating a pressure differential in a duct or airway. The air pump or pressure source collects air at a certain input pressure and releases it at a higher pressure in a constant flow operation. The fan is an energy converter (from mechanical to fluid).

7.1.1. CENTRIFUGAL FAN

Centrifugal Fans: Air is sucked into a revolving impeller and released radially into an expanding scroll casing in centrifugal fans. It's further broken down into:

1) A plate of steel

2) There are many blades

Fig.5: Centrifugal fan

7.1.2. AXIAL AIR FLOW FAN

Axial Air Flow Fans are divided into two kinds, both of which employ an impeller in a cylindrical housing with a mounting disc or air foil shaped blades to provide axial air flow. Axial flow mining fans with a diameter of 209 inches and a power rating of 5000 horsepower are used.

Fig.6: Axial Air Flow fan

7.1.3. THE MIXED FLOW TYPE

The mixed flow type resembles a cross between centrifugal and axial flow types, with an axial flow fan flaring in the direction of air flow and blades on the impeller that resemble a cross between centrifugal and axial flow types. This kind is rarely used.

7.2. COMPRESSORS

Because they also function as air pumps in the ventilation system, compressors for ventilation can be thought of as high-pressure fans.

7.2.1. Centrifugal and Axial Flow Compressors:

Centrifugal and axial flow compressors look similar to fans of the same type. They operate at considerably greater pressures than fans and handle lesser quantities of air.

7.2.2. Positive Blowers:

Positive blowers feature two spinning impeller that mesh in such a way that a virtually constant amount of air is displaced (in all other mechanical ventilation devices, the volume of air discharge varies with the pressure).

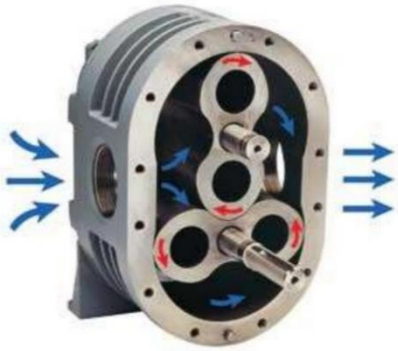

Fig.7: Positive Blowers

7.2.3. INJECTORS

Injectors use compressed air's kinetic energy to en-train ambient air, giving mostly kinetic energy to it. Injectors force a jet of compressed air into the open end of a short pipe segment or ventilation duct, en training the ambient air and establishing a flow. The injector's characteristics are determined by the geometry of the pipe or duct input.

8. CONCLUSION

Ventilation is one of the major aspects that needs to be focused in underground. The study was focused on reviewing various underground ventilation systems were studied along with the instruments used for monitoring ventilation and for performing ventilation survey. Also, various ventilation stopping were studied which were useful in minimizing the losses so as to improve the ventilation to an underground mine.

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