Ventilation of Underground Workings and Improvement of Comfort Levels

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Abstract: Ventilation of underground mines is required to dilute and remove hazardous gases, control heat and provide oxygen for workers and machinery. Kahatagaha- Kolongaha mines, Dodamgaslanda was selected for the present study as it was restarted recently and therefore very little research has been done on air quantity and quality of the mine. The objectives of this research are to make a proposal to rectify the existing ventilation system and to upgrade the existing airflow system with modifications to the present system. A detailed ventilation survey was carried out by measuring the variations of airflow, pressure drop and humidity differences along four levels of the mine (i.e. 565ft, 805ft, and 965ft and 1132ft levels) and compared with the corresponding standard values which describe the permissible conditions to be met for working underground. The distributions of airflows, pressures and humidity in each level could be detailed on graphs and the areas where the additional air supplies were identified. It was proposed to install a dehumidifier to reduce the humidity level inside the mine. Suggestions were made to improve the present ventilation system by locating two booster fans in level 565 ft and 805 ft, which will enhance mine air quality increasing health and safety aspects of underground environment.

Keywords: Air quality, Ventilation survey, Humidity, Dehumidifier

1. Introduction

Ventilation is sometimes described as the lifeblood of a mine, the intake airways being arteries that carry oxygen to the working areas and the returns veins that conduct pollutants away to be expelled to the outside atmosphere. An underground mine environment is a closed space where considerable amount of hazardous and toxic gases are produced contaminating mine air which affects health and safety of miners and it may also leads to production losses.

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Heat is also generated due to various underground activities and remedial actions are required to reduce heat and temperature. (McPherson, 1993)

Ventilation data obtained from Kahatagaha-Kolongaha (KK mine) underground graphite mine, which was restarted few years back were utilized in this study. In this mine graphite mineralisation is restricted to loads and veins type and also located in structurally controlled antiforms and synforms. Therefore a detailed ventilation survey was required to be carried out to identify the drawbacks in the present system as the mine had been closed down for several years.

In KK mines, the ventilation system is operated by a main exhaust fan which is located in the upcast shaft (Kolongaha). Fresh air enters into the mine through the main shaft (Kahatagaha Mahawathaya). Air flows to the sublevels through winzes from respective cross-cuts or drives and there is no direct air flow to the sublevels. In addition, blowing fans are fixed in cross-cuts and drives according to the necessity of the working areas in each level. Ducts, doors and air-crossings have been introduced in some areas for control purposes and to prevent the short circuiting.

The objectives of this research are to make a proposal to rectify the existing ventilation system and to upgrade the existing airflow system with modifications to the present system.

2. Methodology

A ventilation survey was carried out in four main working levels at the mine (565ft, 805ft, 965ft and 1132ft levels). Air quantity, Air pressure and humidity were the main considerations during this procedure. All the measurements were taken in pre defined stations along crosscuts of above mentioned levels.

2.1 Air quantity survey

Ventilation survey stations were established in 40m intervals from the main shaft in each level i.e. level 565 stations A, B... and the cross sectional area of each station was measured using the offset method. The air velocity was measured by fixed point method with digital anemometer (AIRFLOW LCA 6000 VT). In every location several readings were replicated to obtain an average value with the standard deviation (SD).

2.2 Pressure survey

Locations were identified and air pressures near the shaft at each level were recorded using the barometer (type AD). The air pressure at each station was also measured. Pressure developed at fans was measured separately at the discharge side.

2.3 Humidity measurements

Whirling hygrometer (GALLEN KAMP GRIFFIN, type: BS 2848), which consists of a dry bulb thermometer and a wet bulb thermometer was used. Humidity chart provided with the instrument was used to determine the relative humidity.

The values obtained on above at each station were recorded in a spread sheet and graphs were plotted between the characteristics Vs the station. These graphs were interpreted by comparing with the standard values to determine whether the air quality and quantity inside the mine was in the comfort level for workers.

2.4 Calculation

i. The cross sectional area (A) corresponding to each station was determined by dividing the area to trapeziums.

ii. Average of the flow velocities by fixed point or moving traverse method was taken as the velocity (U corresponding to each station.

iii. Air quantity (Q) respective to each station was calculated.

$$Q = U \times A \quad \text{... (1)}$$

3. Results

Average air velocity value with SD was selected using five readings at a station. Calculated air flow rate distribution can be plotted as in figure 1. As station I of level 1132 ft was close to a booster fan high air flow rate has been indicated. In station H of level 805 ft was dead end and the air flow rate was 0ms-1 there.

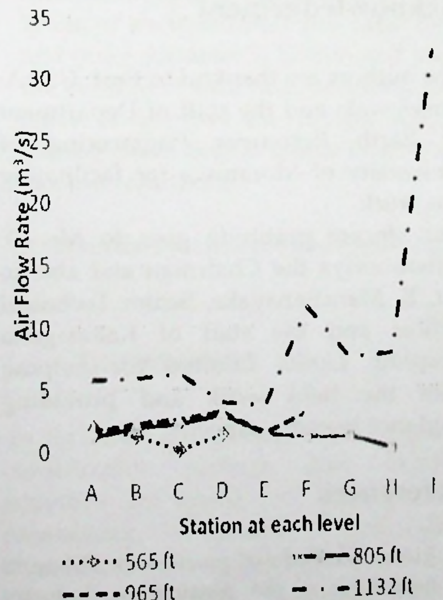

Figure 1. Air Flow Rates in each level

Using dry and wet bulb temperatures in every location humidity values were calculated. Stations with low air flow rates i.e. station D in level 565 ft and station G and H in level 805 ft , have humidity level more than 90%.

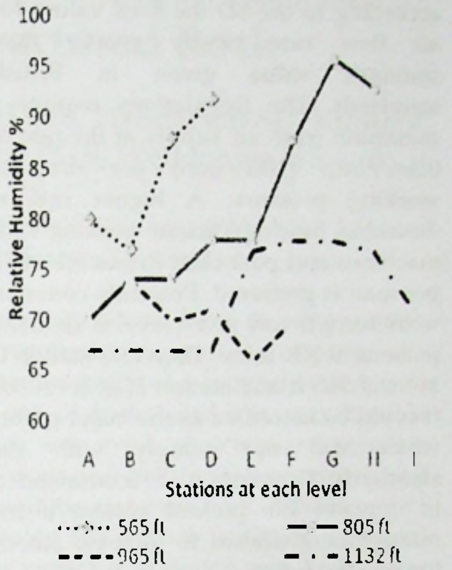

Figure 2. Humidity Level in each level

The barometer reading variation along a tunnel was not much considerable.

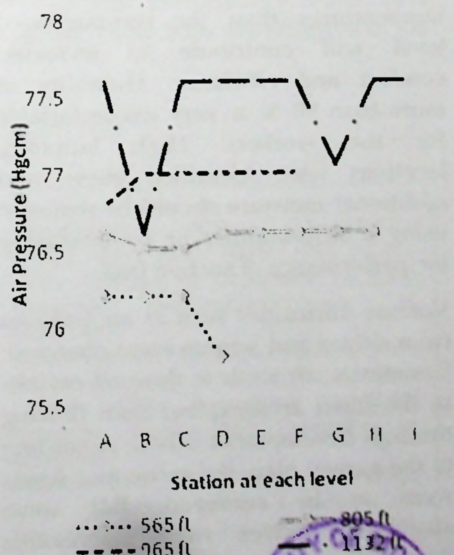

Figure 3. Air Pressure in each level

4. Discussion

From the ranges of air flow rates according to the SD the least values for air flow rate mostly greater than standard value given in British standards. The Regulations require a minimum fresh air supply at the rate of $0.3m^3/min$ ($10ft^3/min$) per man at working pressure. A higher rate is desirable. But for efficient working with machines and post blast fumes $0.1\ m^3/s$ per man is preferred. Presently common work force in any given level is about 10 persons at KK mine. Therefore station C at level 565 ft and station H at level 805 ft could be identified as the major points which did not comply with the standards. Therefore it is recommended to improve the present system if the management desires to increase labour force in the future.

According to the British standards the air supplied in to a mine should be as cool and dry as practicable. The wet-bulb temperature in any working area should not exceed 27 °C. Much lower temperatures than the recommended level will contribute to increased comfort and efficiency. Humidity of more than 90 % is very uncomfortable for the workers. High humidity locations were identified above and additional moisture should be removed using a dehumidifier or by increasing the performance of suction fans.

Various difficulties such as air leakages from drives and winzes were observed. Sometimes, air tends to flow via cavities in the filled areas, rather than flowing through development drives. According to the survey plan, the entire four levels were to be surveyed. But some abandoned drives were inaccessible during the survey period.

5. Conclusion

Location C in level 565 ft and location H in level 805 ft identified as low air flow rate stations during the survey, were mainly recommended for installing booster fans with relevant capacities to regulate the air flow inside the mine. High humidity in level 565 ft and 805 ft has to be condensed to maintain the mine atmosphere in a comfort level. Removal of moisture from air could be achieved by installing a dehumidification system. Therefore 'Mold Dehumidification System' (MDS) manufactured by "Dry Air Systems (Asia)" which employs a plastic resin to absorb moisture from air stream or Chinese 'Preair CFZ20/S' dehumidifier with the cycle of wind capacity 6,000 $m^3/$ hour is recommended to enhance the comfort levels in the mine.

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References

BS 6164:1990 Code of practice for Safety in tunnelling in the construction industry (pf 48- 55.

McPherson, M.J., (1993). Subsurface Ventilation and Environmental Engineering 3rd ed., Chapman and Hall, London.

http://www.msha.gov, (Visited, 15th April 2009)