Designing an Underground Ventilation System and Fan Selection

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Abstract: Mixing of stale air with fresh air (short-circuiting of airflows) is a critical issue in any underground ventilation system. This study was done at Bogala mines owned by Bogala Graphite Lanka Ltd, where this type of mixing takes place in certain levels leading to a cyclic movement of stale air. The main objective of the research project is to design an underground ventilation system and to select fans to overcome these adverse effects and making ventilation more effective and efficient. As the mine is of complex nature, two particular levels at 205 and 240 fathoms were selected for the analysis, where the short circuiting of air is predominant. A detailed survey was carried out to measure the variations of airflow and frictional pressure drop along cross cuts, development drives and winzes in selected levels. The corresponding values of mine air resistance for airways were determined to generate a solution followed by suitable fan selection. Suggestions were made to improve the present ventilation system, which will enhance mine air quality increasing health and safety aspects of underground environment.

Keywords: Mine air quality, mine resistance, short - circuiting, stale air

1. Introduction

Graphite is one of the naturally occurring crystalline and amorphous forms of carbon and normally occurs in loads and veins structurally controlled and restricted to antiforms and synforms. To exploit this type of deposit, a complex mine structure is required.

One of the most important aspects of underground mining is ventilation. An underground mine environment is a closed structure where considerable amount of hazardous and toxic gases are produced contaminating mine air which affects health and safety of miners, may leads to production losses. Heat is also generated due to various underground activities and remedy is required to reduce heat and temperature.

Therefore, ventilation of underground mines is required to dilute and remove hazardous gases, control heat. and provide oxygen for workers and machinery.

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1.1 Problem analysis

Since the air intake to every level in Bogala mines is through the main shaft, for the 205FM level also, fresh air is taken from the very shaft. This fresh air travels along the cross-cut and meets stale air coming from 240FM workings at a junction and diverts to 'NA' vein with the aid of a blower fan (19.5kW) located at the 'NA' vein. After passing through the cross-cut, air comes to 'NA' vein development drive (DD) and flows to 240FM level via 220FM sub level. There are six working areas to be ventilated from this air flow. Then this stale air mixed with fresh air, coming from shaft due to a blower fan (43kW) at 'Na' side cross-cut.

The short-circuiting of airflow occurs at two junctions at 205FM level and 240FM level. Also both mixings occur near the air intake shaft along the crosscut. Our task was to rectify this mixing to take optimum usage of fresh air available, while considering air quality and fan pressures.

2. Methodology

A comprehensive ventilation survey was carried out at 205FM and 240FM levels to evaluate the present states of ventilation with humidity and dust concentration records.

2.1 Air quantity survey procedure

Ventilation survey stations were established and the cross sectional area of each station was measured using the offset method. Then air velocity was measured by moving traverse method with manual anemometer (type T16204) and fixed point method with digital anemometer (AIRFLOW LCA 6000 VT).

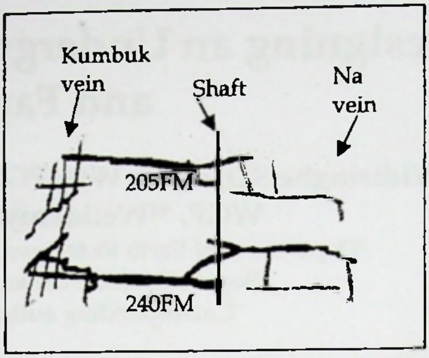

Figure 1 - The selected levels in Bogala mines

2.2 Pressure survey procedure

Locations were identified and air pressure near the shaft at each level was recorded using the barometer (type AD). Then pressure drops were measured along each airway by gauge and tube method with 'Dwyer' series 477 handheld digital manometer and 27m (90ft) long plastic tube of internal diameter 4mm. Pressure developed at fans was measured separately at the discharge side.

2.3 Humidity measurements

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

2.4 Dust sampling

For dust measurement, Casella Apex personal air sampling pump was used. Sampling was carried out for 30 mins with flow rate of 4 l/s. Later, dust concentrations were determined at laboratory with the use of electric oven, desiccators and digital balance.

2.5 Calculations

1. The cross sectional area (A) corresponding to each station was determined by dividing the area to trapeziums.
2. Average of the flow velocities by fixed point or moving traverse method was taken as the velocity (U) corresponding to each station.
3. Air quantity (Q) respective to each station was calculated.

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

4. Resistance(R) of each branch and Atkinson friction factor (k) was calculated using Atkinson formula.

$$P = \frac{k \times L \times Per \times U^2}{A} \quad \text{... (2)}$$

$$R = \frac{k \times L \times Per}{A^3} \quad \text{... (3)}$$

3. Results

Equivalent resistance for selected levels was obtained as 0.599 $Nm^{-8}s^2$

Table 1 - Calculated friction factors for airways in Bogala mines

Airway type	*Friction factor (k) ($Nm^{-5}s^2$)*	*Resistance per meter ($Nm^{-9}s^2$)*
Cross-cut	0.312	0.022
DD - 205FM	0.143	0.006
DD - 240FM	0.143	0.072
Winzes	0.256	0.018
shaft	0.006	0.003

DD - Development drives

Note: These friction factors are complying with values in literature.

Mine resistance curve was plotted and characteristic curves were overlapped on it.

eg. The air requirement for 205FM level is 5.2 m^3/s.

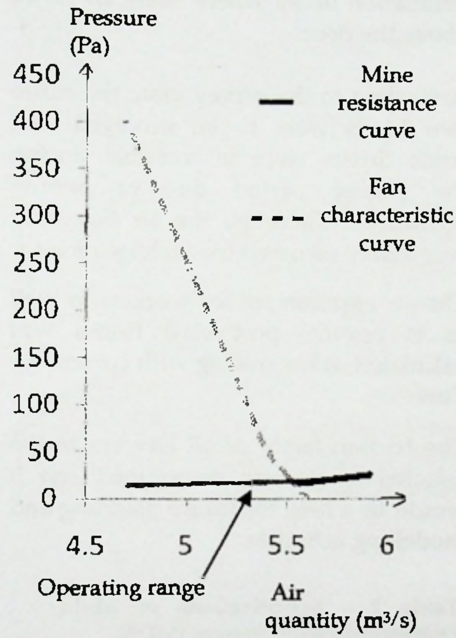

Figure 2- Fan characteristic and mine resistance curves

Table 2 - Measured fan pressures

Fan location	*Pressure (P_v)*
205FM- Na cross-cut	500Pa
240FM - K cross-cut	575Pa

4. Discussion

The primary concern was to study the present ventilation status of Bogala mines and to determine corrective actions that could be taken to optimize the ventilation system.

Various difficulties such as air leakages from drives and winzes were encountered. Sometimes, air tends to flow via cavities in the filled areas, rather than flowing through DDs. Air leakages were observed at certain ventilation doors where some air flows above the door.

According to the survey plan, the entire two levels were to be surveyed. But some drives were inaccessible during the survey period due to mining operations. Therefore the air flow was reasonably assumed for such locations.

The air requirement for workers as well as to remove post blast fumes was calculated, it is agreeing with current air flow.

The friction factor of all airways in the selected levels was determined and it would be a help for future planning and modelling activities.

Table 2 - Specifications of Mold Dehumidification System (MDS)

Model	Air flow (m^3/s)	Water removal (kg/hr)
MDS - 100	4.72	152.4
MDS - 150	7.08	228.4
MDS - 200	9.44	304.8

Removal of moisture from air could be achieved by installing a dehumidification system. 'Mold Dehumidification System' (MDS) manufactured by Bry air systems (Asia) employs a plastic resin to absorb moisture from air stream.

Not only proposing the modifications, but also a post-survey is required to ensure the success of this research.

5. Conclusion

According to the study, 'JM aerofoils' cased - 2 speed (2910/1440 rpm) fans are suitable to be used as blower fans to give required pressure.

205FM - Model 56JM/20/2-4/6/20
240FM - Model 63JM/25/2-4/9/24

Since these fans can operate at 2 speeds, they could be used at a high speed when a high air flow is required to remove post blast fumes.

Mold Dehumidification System - type 'MDS – 150' is suitable to be established at 205FM 'K' cross cut.

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