Assessing the current status of underground mine ventilation system in ThanhCong-CaoThang area, HonGai coal company, QuangNinh region, Vietnam

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Abstract. In underground mine ventilation, there are many causes affecting the efficiency of mine ventilation, even affecting mine safety. In order to have an effective mine ventilation system, the research and evaluation of mine ventilation, in order to get timely solutions to improve the efficiency of mine ventilation, is essential and must be done. regularly.

Thanh Cong - Cao Thang coal mine area of Hon Gai Coal Company, Quang Ninh region, Vietnam is a mine exploited underground. The nature of this mine is the consolidation (connecting) of Thanh Cong areas and CaoThang areas in the period of 2016. After consolidation into Thanh Cong - Cao Thang mine, many factors in the mine ventilation system of The mine site is altered and affects the efficiency of mine ventilation. This article has analyzed and evaluated the current status of Thanh Cong - Cao Thang Area Ventilation System to help research and select appropriate solutions to promptly improve the efficiency of mine ventilation and ensure security, ensure a safe environment and reduce the cost of mine ventilation.

Keywords: Mine ventilation, Working mode of air fan, Main air fan, Thanh Cong-Cao Thang area.

1. Characteristics of current mining and ventilation

Thanh Cong - Cao Thang area is digging from -240 or higher, exploiting from -220 or higher. In general, the mining situation in 2017 with the mine capacity for the fourth quarter is about 405835 tons/quarter, the mine must mobilize 9 long mirror and 11 mirrors. In fact, this construction area consists of 2: Thanh Cong area and Cao Thang area which are merged into one. Cao Thang area is currently exploiting at -160, while Thanh Cong area is exploiting at -220 or more, these two areas are connected by a kiln connecting level -160 from Thanh Cong main well to road through the level -160 Cao Thang area [Ventilation room, 2017].

Currently, the mine area is being ventilated by 03 main fan stations: Thanh Cong area with fan station at the door of +25 (fan of code FBDCZ-8-N0 -24 / 2x315kW) and Cao Thang with 2 stations fans include: fan station at the door tunnel level +20 and fan station at the door tunnel level +29 (with the same fan type FBDCZ-4-N0 - 13 / 2x22kW). Wind network diagram is shown as in Figure 1 and Figure 2 ventilation diagram [Tran Xuan Ha, Nguyen Cao Khai, 2017]. In general, Thanh Cong - Cao Thang area shows that the ventilation work is relatively convenient, the fan stations are still working at low capacity as 2 fan stations in Cao Thang area working at the small wing mounting angle. Most (-2.5) while the fan in Thanh Cong area has just worked at the corner of the wing 35^0, also ensure safe ventilation and meet the demand for production for the mine.

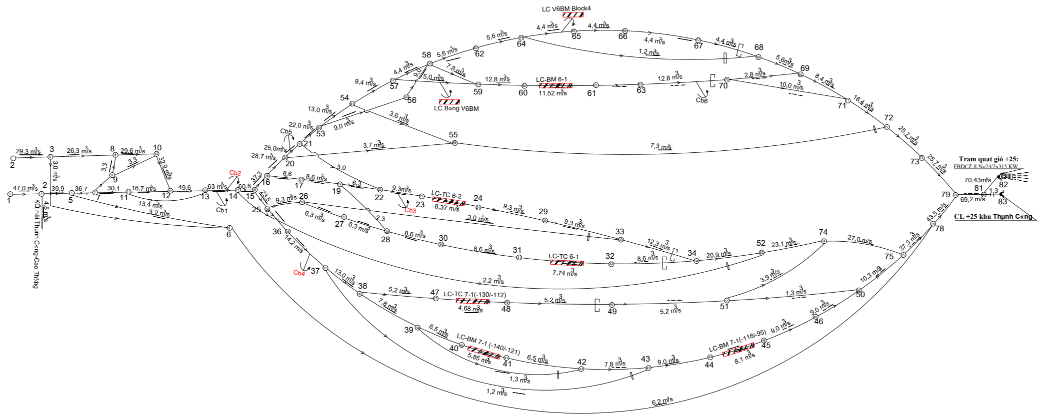

Figure 1. Ventilation diagram of Thanh Cong area mine

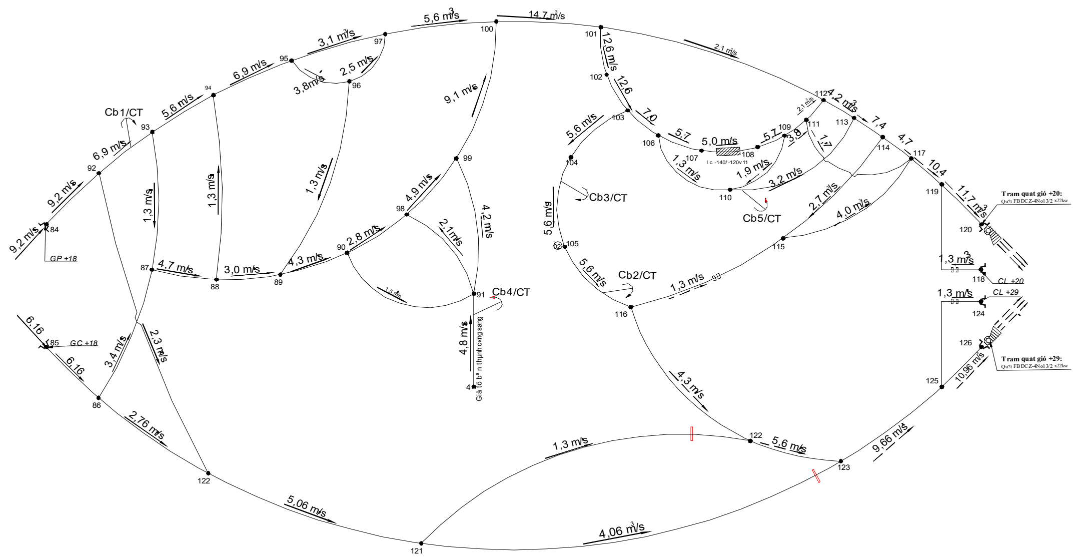

Figure 2. Ventilation diagram of Cao Thang area mine

2. Ventilation calculation for area mine (Thanh Cong - Cao Thang)

2.1. Calculate general air flow for the mine

To calculate ventilation for Thanh Cong-Cao Thang area, we apply the formula [Tran Xuan Ha et al, 2014]:

$$Q_m = 1,1(K_{sl}.\Sigma Q_{lc} + \Sigma Q_{cb} + \Sigma Q_{ht} + \sum Q_{rg});\ m^3/s \qquad (1)$$

Inside:

1.1 - The coefficient refers to the uneven distribution of wind in wind currents.

K_{sl}- Coefficients to account for the increase in output of the longwall (select kt = 1.1).

ΣQ_{rg} - Total leakage wind flow in mine, m^3/s.

ΣQ_{lc} - Total amount of wind flow required for the furnace oven, m^3/s.

ΣQ_{cb} - Total amount of wind flow needed for the digester mirror, m^3/s.
ΣQ_{ht} - Total amount of wind flow required for station, m^3/s.

Calculating the wind flow for long mirror

With the results of calculating the wind flow for long mirror according to 4 factors: According to the largest number of employees; According to output (methane production); According to dust factor; According to the largest amount of explosives, we choose the air flow for the long mirror according to the biggest factor. Results of total wind flow calculation for 9 long mirror: $\Sigma Q_{lc} = 41,0\ m^3/s$.

Calculating the wind flow for the prepareding mirror

With the results of calculating the air flow, the kiln mirrors prepared according to 4 factors; According to the amount of explosives; According to the escape of methane gas escaping in the oven prepared mirror; According to the largest number of people working and according to the dust factor, we choose the air flow for the oven mirror to prepare according to the biggest factor. Results of calculation of total air flow for 11 prepared furnace mirrors: $\Sigma Q_{cb} = 18,3\ m^3/s$.

Wind flow calculation for pump tunnels and power stations

Based on the capacity and the number of stations we calculate the total wind flow for the stations: $\Sigma Q_{cb} = 7,15\ m^3/s$.

Calculating leakage wind flow in the mine

Based on the number of wind gates and walls in the mine area, we calculate the total leakage of wind flow in the mine: $\Sigma Q_{rg} = 13,1 m^3/s$

Calculate the total wind flow for the mine

The results of calculation of wind flow for the mine are as follows: [Tran Xuan Ha, Nguyen Cao Khai, 2017]

$Q_m = 1,1(1,1 \times 41,0 + 19,3 + 7,15 + 13,1) = 93,13\ m^3/s$

2.2. Calculate the distribution of wind

Thanh Cong - Cao Thang is ventilated by 03 fan stations located at the door of the furnace: Level +25 is fan type FBDCZ-8-No24/2x315kW; The level +20 and +29 is the fan type FBDCZ-6-No13/2x22kW. So we have to calculate the wind flow for 03 fan stations to take charge, to determine the working mode of 03 main fans above. On the basis of wind consumers, the wind-wind network system, we distribute the corresponding wind to the wind branches undertaken by 3 fans. Results of wind flow calculation for branches for fans are as follows: [Tran Xuan Ha, Nguyen Cao Khai, 2017]

- Fan 1 (+25: FBDCZ-8-No24/2x315kW): $Q_{m1} = 70,43\ m^3/s$;
- Fan 2 (+29: FBDCZ-6-No13/2x22kW): $Q_{m2} = 10,96\ m^3/s$;
- Fan 3 (+20: FBDCZ-6-No13/2x22kW): $Q_{m3} = 11,74\ m^3/s$;

The results of wind distribution calculation are shown in figures 1 and 2.

2.3. Calculation of mine lowering

As shown in Figure 1, the mine site has 4 main winds. To determine the lower pressure of the mine, we calculate the low pressure of the wind currents and apply the formula [Tran Xuan Ha et al, 2014]:

$$h_m = \sum h_{ms} + \sum h_{cb}, mmH_2O \quad (2)$$

In which:

$\sum h_{ms}$: The total hypotension is caused by the frictional resistance of the segments that follow each other in a wind flow, calculated from the beginning to the end point. This pressure lowering is calculated according to the formula [Tran Xuan Ha et al, 2014]:

$$h_{ms} = \alpha_i \frac{L_i.P_i}{S_i^3}.Q_i^2 \ ;\ mm\ H_2O \quad (3)$$

In which:

α_i : The aerodynamic resistance coefficient in the ith tunnel on the air flow, kGS^2/m^4;

L_i, P_i, S_i : Length, circumference, cross section of tunnel i;

Q_i: The amount of wind going through the ith tunnel, m^3/s.

$\sum h_{Cb}$: The total hypotension due to local resistance calculated by a wind flow, in fact is often taken from (10 - 25%) H_{ms}.

The results of lowering the flow of the following lines [Nguyen Cao Khai et al, 2017]:

Lowering the flow caused by the fan FBDCZ-8-No24 at +25 is responsible for:

h_1 = 223,01 mmH_2O (through 2 serial tunnel furnace: LCBM7-1 level -140 / 1-121 and LCBM7-1 level -118 / -95);

h_2 = 97,19 mmH_2O (LCTC6-2);

h_3 = 197,29 mmH_2O (LCBM6-1 và LC bằng V6 BM);

h_4 = 213,77 mmH_2O (LCTC6-1);

h_5 = 220,25 mmH_2O (LCTC7-1);

h_6 = 215,94 mmH_2O (LC V6 BM Blook4).

Lowering the flow caused by the fan FBDCZ-6-No13 at +29 is responsible for:

h_7 = 90,86 mmH_2O.

Lowering the flow caused by the fan FBDCZ-6-No13 at +20 is responsible for:

h_8 = 110,43 mmH_2O (through long mirror: LC V11 CT -140/-120).

Balance of low pressure mine:

Here, only the +25 fan station section must be equal to the low voltage, because there are up to 6 main stream. There are 2 fan stations at +29 and +20 with only one main stream. In order to balance the pressure lowering of the mine, we apply a balanced method of using wind windows to adjust. The lower pressure of the mine is chosen as h_1 = 223.01 mmH_2O.

2.4. Calculation determines the working mode of the main fans

Determine the wind flow of fans to create

- Calculation of fan wind flow to be created, we apply the formula [Tran Xuan Ha et al, 2014]:

$$Q_q = K_r Q_m, m^3/s. \quad (4)$$

In which:

K_r - Leakage coefficient at fan station, semi-fixed fan station get K_r = 1.15

Q_m - Airflow required for the whole mine, m^3/s

The results of calculating the airflow for fans are as follows:

- Fan 1 (+25: FBDCZ-8-No24/2x315kW): Q_{q1} = 81,0 m^3/s;
- Fan 2 (+29: FBDCZ-6-No13/2x22kW): Q_{q2} = 12,6 m^3/s;
- Fan 3 (+20: FBDCZ-6-No13/2x22kW): Q_{q3} = 13,58 m^3/s;

Determine lowering the fans to create

Lowering the pressure of the fan is calculated according to the formula [Tran Xuan Ha et al, 2014]:

$$H_q = (k_1.R_m + R_{tbq}).Q_q^2 \text{ , } mmH_2O \quad (5)$$

In wich:

k_1- the coefficient refers to the leakage at the fan station, $k_1 = 1/k_r^2$, k_1 = 0.76

R_m - mine resistance, kμ; For mine site, we have the resistance of kiln branches corresponding to 3 fan stations as follows: R_{m1} = 0.04496 kμ; R_{m2} = 0.75592 kμ and R_{m3} = 0.80118 kμ.

R_{bq}- internal fan fan resistance ($Rtbq = a. \pi/D^4$), kμ. For the main fans of the mine site, we have the resistance of the kiln branches corresponding to 3 fan stations as follows: R_{tbq1} = 0.0047; $R_{tbq2} = R_{tbq3}$ = 0.055;

Instead we have the Lowering the pressure of the fans to create:

- Fan 1: +25 (FBDCZ-8-No24/2x315kW): h_{q1} = 255 mmH_2O;
- Fan 2: +29 (FBDCZ-6-No13/2x22kW): h_{q2} = 100 mmH_2O;
- Fan 3: +20 (FBDCZ-6-No13/2x22kW): h_{q3} = 121 mmH_2O.

Determines the working mode of the main fans

The calculation and determination of the working mode of the main fans are as follows: [Nguyen Cao Khai et al, 2017], [Nguyen Cao Khai et al, 2015]

+ Determining equations and building characteristic lines of mines:

The equation of the mine characteristic curve of the branches to 3 fan stations is as follows:

- Fan 1 (FBDCZ-8-No24/2x315kW): $h_1 = 0{,}03887.Q^2$;
- Fan 2 (FBDCZ-6-No13/2x22kW): $h_2 = 0{,}6295.Q^2$;

- Fan 3 (FBDCZ-6-No13/2x22kW): $h_{q3} = 0{,}6639.Q^2$.
+ Working mode of main fans

The results determine the working mode of the main fans as follows:
- Fan 1 (+25: FBDCZ-8-No24/2x315kW), as shown in Figure 3

With fan working parameters: Fan flow generated: Q_{ct1} = 88 m^3/s; Fan-induced pressure drop: h_{ct1} = 305 mmH_2O; Wing mounting angle of impeller: $\theta = 35^0$ and Fan performance: $\eta = 0.73$.
- Fan 2 (+29: FBDCZ-6-No13/2x22kW), as shown in Figure 4.

With fan working parameters: Fan flow generated: Q_{ct2} = 15,3 m^3/s; Fan-induced pressure drop: h_{ct2} = 147,4 mmH_2O; Wing mounting angle of impeller: $\theta = -5^0$ and Fan performance: $\eta = 0.72$.
- Fan 3 (+20: FBDCZ-6-No13/2x22kW), as shown in Figure 5.

With fan working parameters: Fan flow generated: Q_{ct2} = 15,4 m^3/s; Fan-induced pressure drop: h_{ct2} = 149 mmH_2O; Wing mounting angle of impeller: $\theta = -5^0$ and Fan performance: $\eta = 0{,}73$.

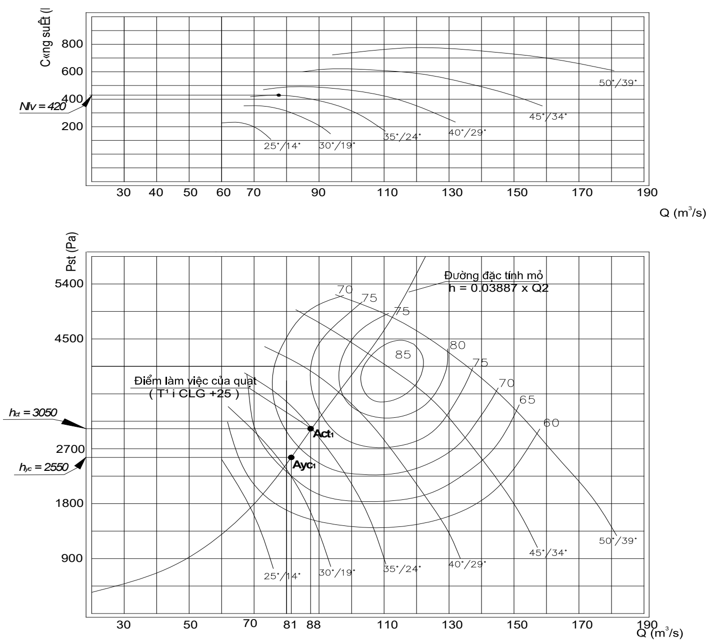

Figure 3. Graph of determining the working mode of the fan FBDCZ-8-No24 at the door of tunnel the level +25 Thanh Cong Area

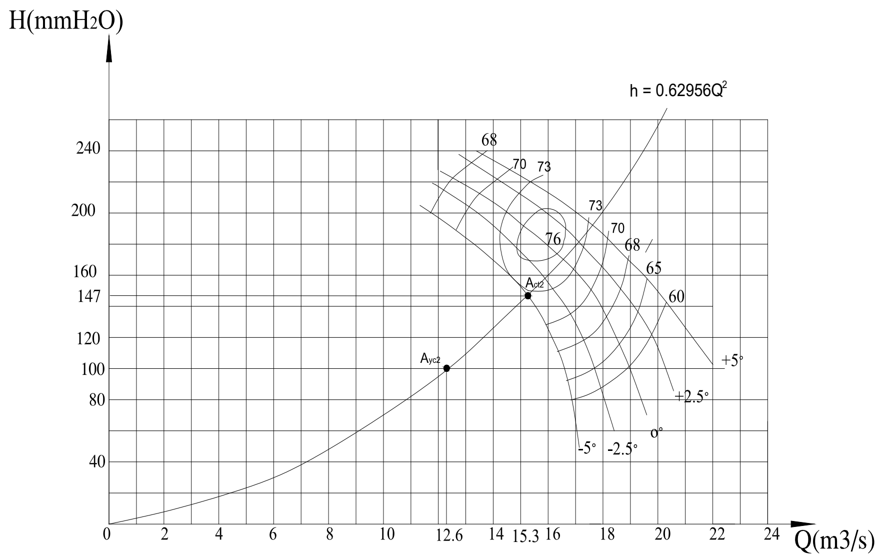

Figure 4. Graph of determining the working mode of the fan FBDCZ-6-No13 at the door of tunnel the level +29 Cao Thang Area

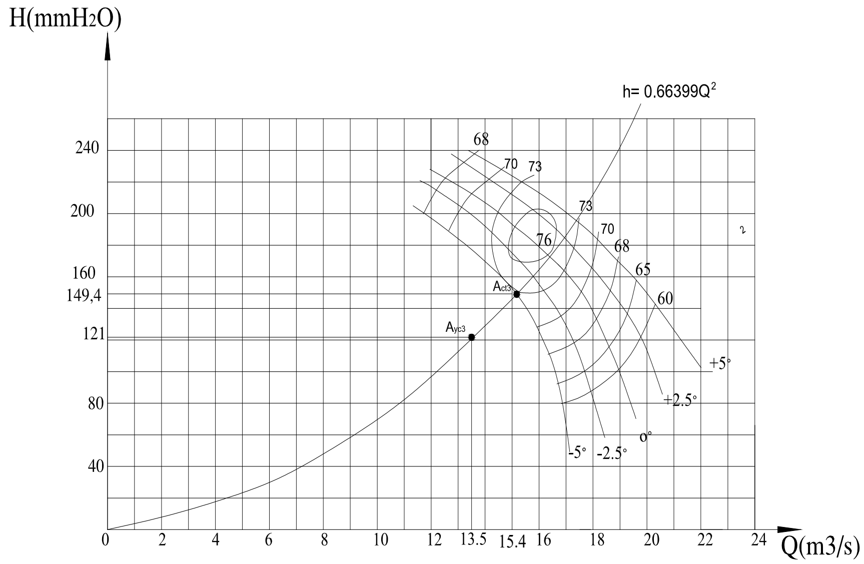

Figure 5. Graph of determining the working mode of the fan FBDCZ-6-No13 at the door of tunnel the level +20 Cao Thang Area

3. Results of assessment of the current status of the mine ventilation system

The results of the survey and assessment of the current ventilation system are as follows:

- General ventilation method for existing mine is the method of use suck ventilation. This is a reasonable ventilation method. The diagram of the wind network is generally quite complicated, with many cross branches.
- The quality of ventilation for longwall kilns is generally not very good about the amount of wind needed to be supplied, because in the 7 kilns operating of mine, there are 3 longwall ovens that still lack wind, although not big, on the other hand the content of toxic gases or harmful (CO_2 and CH_4) are all below the permitted limit.
- In terms of microclimate conditions, the quality of ventilation is guaranteed, however, the humidity is quite high. Therefore, in general, microclimate conditions in the mine are not comfortable.

- For the prepared oven mirrors, it is similar to that in the longwall oven, the quality of ventilation for the new kiln mirrors basically ensures the minimum amount of wind and the ability to dilute toxic gases, explosive gases, but about microclimate conditions are not really good because the humidity is still high.

- The quality of ventilation works is generally not good. At the fan station, there is still a lack of fan window to check the working mode of the fan (flow and low pressure). On the other hand, three main wind gates at the door level of +25, +29 and +20, where 3 main fan stations are located, do not guarantee airtight quality. Therefore, the amount of wind leakage through these three wind gates still exceeds the permitted standard. This makes the three main fan stations work bigger than required.

- All 03 main fan stations have working modes to ensure ventilation requirements. The amount of wind generated is higher than the calculation required for a certain amount of wind: The kiln door is +25 excess 7 m^3/s (about 8.64%), the kiln door is +29 residual 2.7 m^3/s (about 21.4%) and the kiln door is +20 surplus 1.9 m^3/s (about 14.1%).

4. Conclusion

The results of calculation of working regime of the main fans in Thanh Cong - Cao Thang area, Hon Gai Coal companie show that the current ventilation capacity of the fan stations is suitable and ensures to meet the current ventilation. Reserve capacity of the main fans remains, especially the fan station at +25 Thanh Cong area. However, 2 fan stations are at +29 and +20 levels in Cao Thang area although the reserve capacity is still available, but because these two fan stations are used as fan type FBDCZ-6-No13, the ventilation capacity is not large. storage capacity of maximum flow is only about 17m3 / s, although only working at the angle of wing -5 installation, but the wind flow only increases by about 3.5m3 / s. Cao Thang area currently has only 1 kiln longwall, so in the future when Cao Thang area will bring in a new furnace to operate, it is necessary to consider replacing the new fan station. It is considered that the reserve capacity of the +25 fan station in Thanh Cong area is still high, but due to the connection of the two new areas at -160, it is impossible to bring dirty wind from Cao Thang area to turn. Return and exit the +25 level door of Thanh Cong area.

The solution when operating an additional longwall in Cao Thang area to operate to increase the mining output of the area as planned, the company must calculate additionally replace a station fan at the door level +20 or replace Both 2 fan stations in Cao Thang area with a fan station with large ventilation capacity and equivalent capacity of FBDCZ-8-No24 [Babak GA, KP Bocharov, AT Volokhiev. 1982].

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