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Evaluation and Optimization Suggestion of Mine Ventilation System in High Altitude Cold Zone

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Abstract: *Higher requirements are put forward for the reliability of ventilation system when mining coal resources in high-altitude cold area mines. Taking Yuka No.1 mine as the research object, combined with the current situation of mine ventilation, based on the analysis of mine ventilation capacity, ventilation resistance and ventilation needs, the mine ventilation system is evaluated and optimization suggestions are given. At the present stage, the ventilation of the mine is relatively easy, and the main problems faced by the ventilation are small ventilation section in part of the roadway, complex ventilation network in 1178 comprehensive mining face, and low automation degree of the underground ventilation facilities and the main ventilator on the ground; combining with the evaluation results, we put forward a targeted approach to reduce the resistance and simplify the ventilation network, and at the same time, we introduce intelligent control system on the ground ventilator. Through the evaluation of mine ventilation system and the implementation of optimization measures, the reliability of mine ventilation in Yuka No.1 shaft can be further improved to meet the ventilation needs of mines in high-altitude cold areas.*

Keywords: *high-altitude cold area; mine ventilation system; ventilation resistance; main ventilation fan*

1. Introduction

Reasonably determine the ventilation capacity of the mine and fully explore the maximum potential of the mine ventilation system in order to ensure the safe production of coal mining enterprises and obtain the maximum economic benefits [1~2]. With the innovation and rapid development of coal mining technology, the mine gradually develops to the high-yield and high-efficiency intensive mode, and the frequent succession makes the ventilation network topology and ventilation system parameters change quickly, which affects the safety and stability of the mine ventilation system [3~4]. High-altitude areas are rich in mineral resources, with the reduction of resource extraction in low altitude areas, the extraction and utilization of mineral resources in high-altitude and high-cold areas is an inevitable choice to alleviate the shortage of mineral resources in China [5~6]. Due to the characteristics of high altitude areas, such as thin air, low partial pressure of oxygen, large temperature difference between day and night, will not only lead to the lack of oxygen for the operators, resulting in a decline in labor efficiency and increased labor intensity, but also changes in the performance and use of mining machinery and equipment efficiency [7~10]. Therefore, it is of great practical significance to carry out the research on the evaluation and optimization of mine ventilation system under high altitude and high cold environment conditions.

2. Overview of the mine

There are four inlet shafts and two return shafts in Yuka No.1 Shaft. The inlet shafts are 1# main inclined shaft, 1# deputy inclined shaft, 2# main inclined shaft, 2# deputy inclined shaft, and the return air shafts are the east air shaft and the central air shaft. Yuka No.1 shaft is a high gas mine, the relative gas outflow of the mine is 1.769m3/t when the mine reaches production above +2750m level, and the absolute gas outflow of the mine is 14.897m3/min, which is low in gas content. The ventilation system of the mine is a mixed ventilation method with mechanical extraction ventilation. The No.1 main and deputy inclined shafts feed the air, and the east wind shaft returns the air; the No.2 main and deputy inclined shafts feed the air, and the central wind shaft returns the air. The ventilation equipments are located near the entrance of the East Wind Shaft and the Central Wind Shaft respectively, and are

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connected with the basic air ducts on the ground and the air refuge at the entrance of the shafts to form the return air system of the mine. Two FBCDZ-8-№22/2×185 explosion-proof counter-rotating axial flow ventilators have been installed in the east air shaft, one of which is working and the other one is in standby or for maintenance. Fan impeller diameter 2.2m, counter-rotating impeller. Equipped with YBF2315L1-10 type, 75KW, 380V explosion-proof motor, single power 185kW. the total air displacement of the east air shaft is 6389.16 m3/min, and the ventilation resistance is 1400 Pa. the central air shaft is equipped with two sets of FBCDZ-10-№24/160 explosion-proof axial-flow ventilators, one of which is working, one of which is in standby or under repair, and the diameter of fan impellers is 2.4m, with counter-rotating impellers. The impeller diameter of the fan is 2.4m, and the impeller is counter-rotating. The total exhaust air volume of the central air shaft is 5548.50 m3/min, ventilation resistance is 800 Pa, and the power of the single machine is 160kW.

The altitude of Yuka No.1 shaft mine is about 3200m, with thin oxygen, large temperature difference, windy and cold, air oxygen content of 73%, which is a typical inland plateau desert climate, creating the climate environment of high-altitude cold area. In high altitude, because the density of the air, oxygen content and other parameters are reduced with the increase in altitude, the ventilation of high-altitude mines compared with the plains has increased many special requirements. Therefore, it is necessary to evaluate the ventilation system of Yuka 1 Mine and put forward optimization suggestions and measures, in order to make it possible to further improve the reliability of the mine ventilation system.

3. Analysis of the current situation of mine ventilation

3.1. Calculation of the actual air demand in the mine

3.1.1. Calculation of the existing main fan exhaust air volume of the mine

The main fan capacity of the east air shaft of Yuka 1 Mine is 6389.16 m3/min, and the main fan capacity of the central air shaft is 5548.50 m3/min. The total air capacity of the main fan of the mine is 11937.66 m3/min. At present, the main fans of the central air shaft and the east air shaft have been operating at full capacity, and the standby air capacity has not been taken into consideration.

3.1.2. Effective air volume of the mine

The total air intake of 1# main inclined shaft and deputy inclined shaft of Yuka 1 Mine is 4972.98 m3/min, the total air intake of 2# main inclined shaft, deputy inclined shaft and the first phase of the horizontal return alley of the Coal 7 Underground Exploitation Project is 6504.72 m3/min, and the total air intake of the mine is 11937.66 m3/min.

The actual total air volume of the 14 underground mining faces is 6,891.18 m3/min. The total effective air volume of the mine is 10,629.10 m3/min, and the effective air volume rate of the mine is 89%. The total air demand is 8237 m3/min, and the ratio of air supply and demand in the mine is 1.29.

3.1.3. Approval of late mine air demand

The total air intake of the mine is calculated according to the actual air demand and air leakage of each air-using place, and the actual total air demand is 22925 m3/min. The air distribution of each air-using place of the mine is shown in Table 1.

Table 1: Distribution of air volume at each air point in the mine.

sequences	location where the wind is used	Number (pcs)	Unit air volume (m3/min)	Total air consumption (m3/min)
1	General-purpose working face in the first mining area	1	3600	3600
2	Heavy-duty working face in the second mining area	1	1980	1980
3	Alternate working face in the first mining area	1	1800	1800
4	Alternate working face in the second mining area	1	990	990
5	Coal tunnel synthesized working face	12	600	7200
6	rock tunnel gunning face	2	420	840
7	Mining area substation	2	200	400
8	Distribution point 2920	1	140	140
9	Winch house in the fourth mining area	1	177	177
10	Winch house in the fifth mining area	1	140	140
11	Charging chamber	1	100	100
12	Underground Explosive Materials Distribution Chambers (UEMDCs)	1	100	100
13	other than		782	782
14	Total		22925	

The ventilation system of the east shaft requires 13781 m3/min, and the ventilation system of the central shaft requires 9144 m3/min. The future design of the mine will have 2 coal faces, 2 preparation faces, 12 coal faces, 2 rock tunnel gunning faces, 2 mining substations, 2 winch houses, 1 charging chamber, 1 underground blasting material distribution chamber, and a total of 22925 m3/min. At the time of the mine's construction, the total air demand was 22,925 m3/min. At present, the total air intake of the mine is 11,477.7 m3/min, and the main fans of the central air shaft and the east air shaft have been operating at full capacity, with a shortfall of 11,447.3 m3/min; of which, the total intake of the ventilation system of the east air shaft is 5,322.42 m3/min, with a shortfall of 8,458.58 m3/min; the total intake of the central air shaft is 6,155.28 m3/min, with a shortfall of 8,458.58 m3/min; and the total intake of the central air shaft is 6,155.28 m3/min. 6155.28 m3/min and 2988.72 m3/min in arrears, the existing ventilation technology conditions cannot meet the ventilation requirements of the mine in the later stage, in order to ensure safety, it is recommended to expand and renovate the central air shaft and the east air shaft.

3.2. Mine ventilation system resistance

3.2.1. Ventilation resistance at the current stage of the mine

The ventilation system of Yuka No.1 shaft is in the period of easy ventilation, and the ventilation system is running reasonably. According to the "Lenten Basic Statement of Mine Ventilation and Gas Situation" of Yuka No.1 Mine, the negative pressure of the main fan of the east air shaft is 1400 Pa, and the negative pressure of the main fan of the central air shaft is 800 Pa.

3.2.2. Ventilation resistance during the difficult period of mine ventilation

The main ventilation route of the coal face is the longest when the mine carries out the mining of five mining areas in the late stage, which is the difficult period of mine ventilation, and the ventilation power of the five mining areas mainly comes from the main fan of the East Wind Shaft. According to the ventilation resistance of the existing ventilation system, it is assumed that the resistance of the ventilation system in the later stage of mining in the fifth mining area is mainly due to the resistance of the roadway of the track downhill extension of the 1# sub-shaft at the +2400m level, the downhill extension of the return air of the 1# sub-shaft at the +2400m level, the transporting chute of the working face, and the return-air chute of the working face, which is predicted to be 2,600 Pa in the period of difficult ventilation of the mine.

4. Evaluation of the ventilation system and optimization recommendations

4.1. Existing problems

The ventilation resistance of Yuka No.1 well meets the requirements, the ventilation system is in the period of easy ventilation, and the operation of the ventilation system is basically reasonable. However, from the field investigation and measurement results, the system also has the following problems:

(1) No.1 main inclined shaft air inlet alley, No.1 deputy inclined shaft air inlet alley: for the mine's eastern mining area public air inlet alley, section is small, respectively, 9.3 m3 and 8.6 m3, the maximum air volume of the two alleys is about 4,464 m3/min and 4,128 m3/min, of which the No.1 main inclined shaft air inlet alley, the No.1 deputy inclined shaft air inlet alley at present the wind speed of 3.41m/s, 5.95m/s, respectively, the mine later with the mine, the mine will have to be more efficient with the increase in the number of air inlet alley, and the air velocity is about 3.41m/s, 5.95m/s, respectively. / s, with the later development of the mine, the air consumption will increase greatly, the wind speed in this section will exceed the limit, and the ventilation resistance is large.

(2) The total return air lane of the central air shaft of the mine is the total return air lane of the central production area of the mine, with a roadway section of 9.4m3, and the maximum return air volume of the roadway is 8,460m3/min according to the maximum wind speed of 15m/s as agreed in the Coal Mine Safety Regulations, in which the current wind speed of the total return air lane of the central air shaft of the mine is 9.68m/s, and the wind speed will be over the limit and ventilation resistance will be large in the later stage of the mine with the exploration of the mine, and the air consumption will be greatly increased. The wind speed in this section will exceed the limit and the ventilation resistance will be large.

(3) The total return air lane of the east wind shaft of the mine is the total return air lane of the eastern production area of the mine, with a section of 12m3, and the maximum return air volume of the lane is 10,800m3/min according to the maximum wind speed of 15m/s stipulated in the Coal Mine Safety Regulations, in which the current wind speed of the total return air lane of the east wind shaft of

the mine is 8.55m/s. In the later stage of the mine, as the mine is being developed, the air consumption will be increased significantly, and the wind speed of this section will exceed the limit, and the ventilation resistance will be large. The wind speed in this section will exceed the limit, and the ventilation resistance is large.

(4) At the present stage, the air route of 1178 general mining face is as follows: No.1 sub-shaft inlet alley - 1178 transportation chute - 1178 general mining face - 1178 return air chute - No.1 well +2750 horizontal return air uphill - 3070 east return air alley - general return air of east wind shaft. -3070 East Return Alley - East Wind Shaft General Return, the whole air system ventilation tunnel network is more complex, need to be further optimized.

(5) Ventilation facilities and equipment construction: the existing dampers in No.1 well of Yuka are self-processed mechanical structures, and the automatic monitoring and data uploading functions of opening and closing of the dampers can be realized by installing additional in-situ dampers monitoring sensors. Along with the enhancement of the degree of intelligence of Yuka, the existing dampers of the mines lack the function of in-situ automatic control, and it is not possible to realize the automatic opening and closing of the dampers; at the same time, there is a lack of video monitoring and remote centralized control functions. At the same time, there is a lack of video monitoring and remote centralized control functions, which makes it impossible to realize remote monitoring, centralized control and unattended functions of the dampers. The existing regulating windshield of Yuka No. 1 Shaft is a mechanically-structured plug-plate regulating windshield, which realizes the adjustment of the airflow between different production areas of the mine by adjusting the area of the plate, and it is impossible to adjust the opening area of the windshield automatically to realize the functions of in-situ automatic control and remote control.

(6) Main ventilator construction: The results of on-site research show that the existing main ventilator of Yuka Well has the function of monitoring wind speed, wind pressure, temperature and current parameter information, but it does not yet have the functions of one-key start, one-key anti-wind, fault analysis and diagnosis, and frequency remote centralized control, and it is unable to realize the on-line optimal adjustment of air supply of the main ventilator; at the same time, along with the extension of the mine to the deep part of the mine, the capacity of the air supply of the existing mines exists. At the same time, along with the extension of the mine to the deeper part, the existing air supply capacity of the mine is in a tight situation.

4.2. Optimization Recommendations

4.2.1. Resistance reduction measures

Part of the local resistance of the roadway is large, mainly because of the change of roadway section area, right-angle turns, and many obstacles increase the local wind resistance [11]. There are some unnecessary accumulations in the individual ventilation roadway, it is recommended to remove them; local sections due to roadway deformation, affecting the effective ventilation section, resulting in a large local ventilation resistance, it is recommended to strengthen the maintenance of the roadway, to ensure the smooth flow of the wind, which will receive a significant effect of resistance reduction.

4.2.2. Ventilation network optimization

Underground ventilation network is more complex, can reduce the number of branch nodes, reduce the number of angular connection branches, so as to optimize the mine ventilation network, try to maintain the stability of the wind flow in the ventilation system, to avoid the emergence of insufficient air supply, tandem wind, circulating wind and other failures.

4.2.3. Measures to enhance the reliability of the main ventilation operation

The current ventilation method of Yuka No. 1 Mine is a hybrid of central parallel and zonal diagonal, and the ventilation method is mechanical extraction ventilation, and the mine has four existing inlet air shafts and two return air shafts. The inlet shafts are 1# main inclined shaft, 1# secondary inclined shaft, 2# main inclined shaft, 2# secondary inclined shaft, and the return shafts are the east wind shaft and the central wind shaft. The mine is ventilated by two main fans connected in parallel in zones, and this ventilation method is applicable when the air pressure of one main fan is enough but the air volume is not enough. The return air flow of the main fans in each partition, the central main fan and the return air flow of the main fans in each wing must be strictly separated. Multiple main fan parallel operation, to minimize the wind resistance of the common airway, where possible, the section of the common airway should be as large as possible, the length should be as short as possible, or make the mine into the airway as much as possible. Fan selection should not only ensure the required air volume of the mine, but also use less or not use the characteristic curve of the maximum angle of the main fan blade [12~14].

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4.2.4. Main ventilation fan equipped with intelligent monitoring system

The intelligent monitoring system of the main ventilator of Yuka No.1 coal mine takes Siemens S7-1500 series PLC as the control core, which can realize the centralized control of the electrical part of the fan, and through the sequential control program, it can realize one-key starting, one-key stopping, one-key switching, and one-key resetting, which can conveniently realize the control function of the main ventilator [15~16]. The specific construction structure of the online monitoring system of the main ventilator in Yuka No.1 coal mine mainly consists of the upper computer control system (upper computer, group 0-state monitoring software), PLC control system, field sensors, etc. At the same time, a remote monitoring station can be set up in the main control room of the main ventilator room through the local area network (LAN), etc., so as to realize the remote centralized monitoring and equipment control. The specific structure is shown in Figure 1.

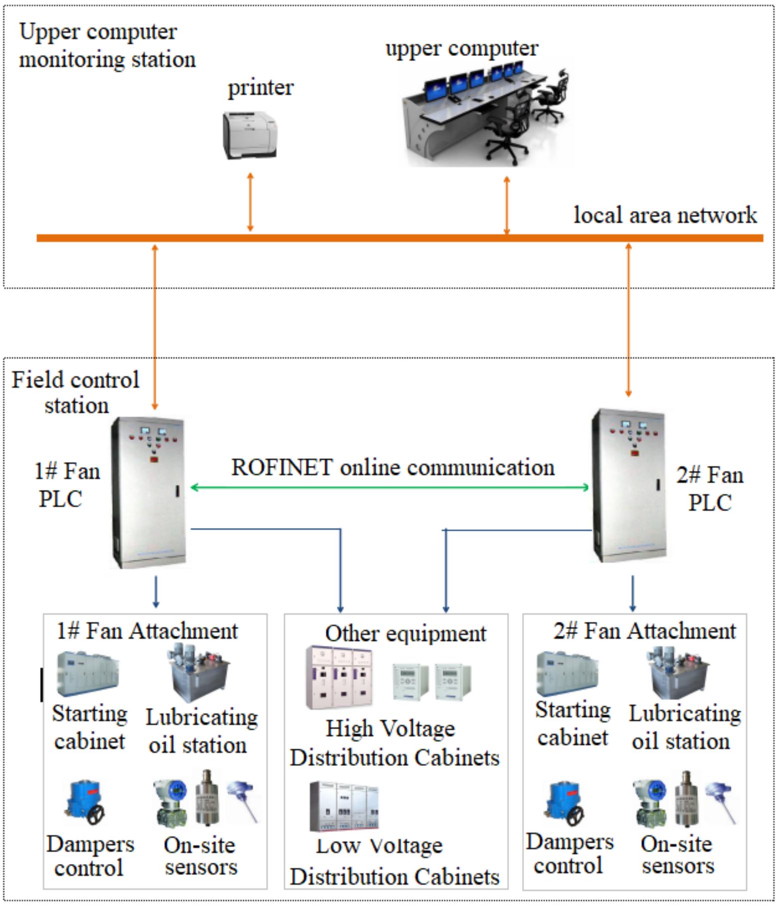

Figure 1:System Architecture Diagram.

5. Summary

At this stage, the ventilation resistance of Yuka No.1 well meets the requirements, and the ventilation system is in an easy period, and the operation of the ventilation system is basically reasonable, and there are mainly the following problems in the ventilation system: ① small section of the No.1 main inclined shaft inlet alley, the No.1 secondary inclined shaft inlet alley, the central air shaft general return alley, and the east air shaft general return alley, and the ventilation resistance of ventilation anemometers, etc., which is one of the constraints to the efficient operation of the ventilation system; ② the present 1178 comprehensive mining face unified ventilation tunnel network is more complex, need to be further optimized; ③ ventilation facilities and equipment automation level is low; ④ the main ventilator does not have the frequency remote centralized control function, in the deep mining face the problem of tight air supply capacity. In view of the current situation of mine ventilation system, we reduce the ventilation resistance, improve the operation efficiency of the main ventilator and the intelligent control level by reducing the ventilation resistance, optimizing the ventilation network and introducing the intelligent monitoring system on the main ventilator.

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