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Research Article

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Analysis and Application of Energy Saving and Consumption Reduction of Mine Wind Network Based on Ventsim

ZHU Xu-dong[1], LU Zhong-liang[1,2,3], WANG Hong-li[4]

[1]School of Safety Science and Engineering, Henan Polytechnic University, Henan Jiaozuo, 454000, China
[2]Key Laboratory of Gas Geology and Gas Control, Henan Jiaozuo, 454000, China
[3]The Collaborative Innovation Center of coal safety production of Henan Province, Henan Jiaozuo, 454000, China
[4]School of Mathematics & Information Science, Henan Polytechnic University, Henan Jiaozuo, 454000, China

Abstract In order to explore the important role of economy in the ventilation system optimization, using Ventsim software, combined with the measured data of mines, taking the Zhangcun Mine as an example, the 3D model of the mine was constructed. Based on the research on the status of mine ventilation, the dismantling west was analyzed. Returning the wind blower, changing the west return air well into the intake shaft and the west intake well, and closing the west return well two optimization schemes. The comparison of the simulation results shows that the west return wind blower is removed and the west return wind well By changing to the inlet wellbore, it will save more than 3 million ventilation energy consumption per year for the mine, thus achieving the purpose of energy saving and consumption reduction, and is more conducive to the sustainable development of the mine.

Keywords Ventsim, ventilation system optimization, economy, energy saving and consumption reduction

Introduction

Mine ventilation system is an important subsystem in the large mining system, which is attached to and restricts this large mining system [1]. The mine ventilation system consists of ventilation power and equipment, ventilation shaft network, airflow monitoring and control facilities. The quality of a mine ventilation system is generally evaluated in terms of technical, safety and economical [2-3]. At present, the research direction of mine ventilation optimization mainly focuses on the reasonable distribution of air volume, the improvement of fan efficiency, and the optimization of shaft section [4-6]. While considering technical and safety, most of them have neglected economic factors. Blindly opening up lanes, increasing ventilation adjustment facilities, and increasing motor power have become the most optimal adjustment schemes for mines. While effectively and accurately adjusting to improve mine ventilation systems, the goal of reducing ventilation costs and saving energy and reducing emissions has become the research direction of many scholars.

The Ventsim software, developed in 1993, was developed by Chasm Mining Consulting, Australia, and is one of the most popular ventilation simulation software in the world [7-9]. Ventilation Design, VENTGRAPH, VUMA, etc. developed by the United States, Poland, the United Kingdom, etc., as well as domestic MVSS, virtual mine ventilation system ventilation, CFIRE and other ventilation software also have a certain gap with the Ventsim software in terms of compatibility, interactivity, visualization, etc [10-16]. The Ventsim software uses the Hardy-Cross iteration method to solve the ventilation network. The solution of the ventilation network is based on the law of airflow balance (1), the law of wind pressure balance (2) and the law of resistance (3):

$$\sum_{j=1}^{n} Q_{ij} = 0 \qquad (1)$$

Where: Q_{ij} is the air volume of the branch j associated with the i-node; n is the number of branches associated with the point.

$$\sum_{j=1}^{n} h_{ij} = 0 \qquad (2)$$

Where: h_{ij} is the resistance of the jth branch belonging to the i loop; n is the number of branches in the loop.

$$h = R\,Q^2 \qquad (3)$$

where: R is the equivalent wind resistance of the wind network wind resistance; Q is the total air volume passed by the wind network.

Ventsim not only has a three-dimensional multi-window graphic interface, but also can input and output various ventilation parameters conveniently and quickly. In terms of compatibility, the domestic mainstream design software AutoCAD DXF file can be directly converted into Ventsim ventilation network model, which is more ventilated than other ventilation software. Cost and ventilation network economic optimization analysis, pollutant dynamic simulation, real-time monitoring, ventilation inspection files and other functions. This study uses Ventsim software to build a model of the ventilation system of the Zhangcun Mine to optimize the economy and provide reference for the optimization analysis of ventilation networks in more mines.

2. Construction and current situation analysis of mine model

2.1. Construction of mine model

Using the floor plan of the mining project of the Yucun Mine and the measured data of the downhole layout measurement points, draw the center line of each roadway in the plan of the mining project through the 3D multi-segment line in AutoCAD, upload the DXF file of the center line of the mine roadway to the Ventsim software and convert it into an entity. The three-dimensional roadway adjusts the wind path according to the measured data, and arranges the fan, airtight, air duct and other facilities to form a three-dimensional model of ventilation in the mine of Yancun Mine, as shown in Figure 1. In order to facilitate the intuitive understanding, a map of the mine ventilation network is also drawn, as shown in Figure 2.

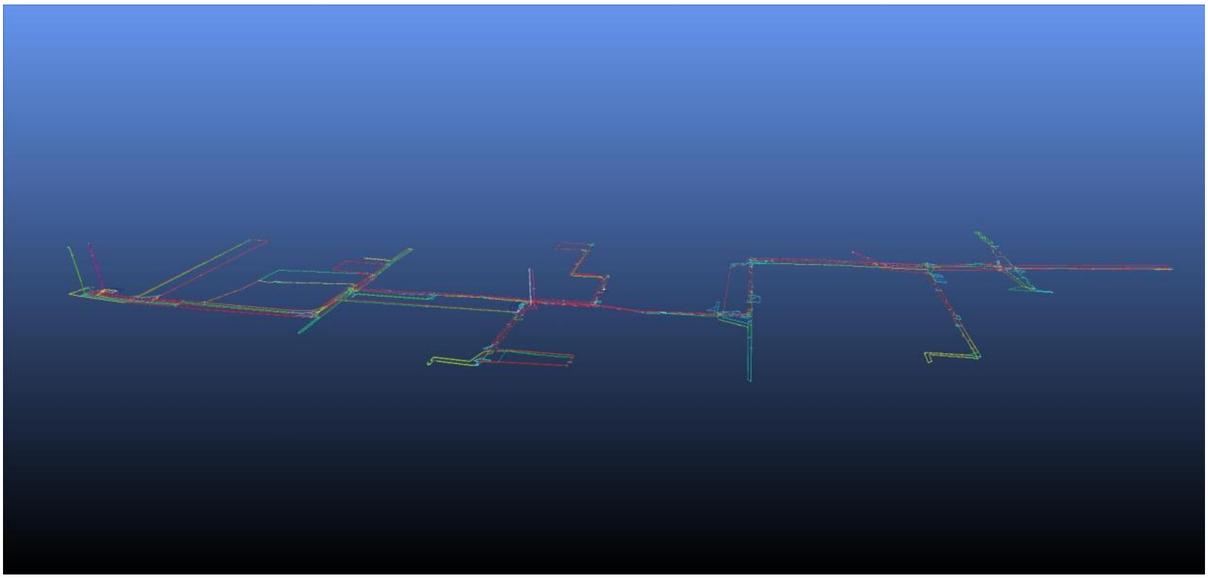

Figure 1: 3D model of mine ventilation in Zhangcun Mine

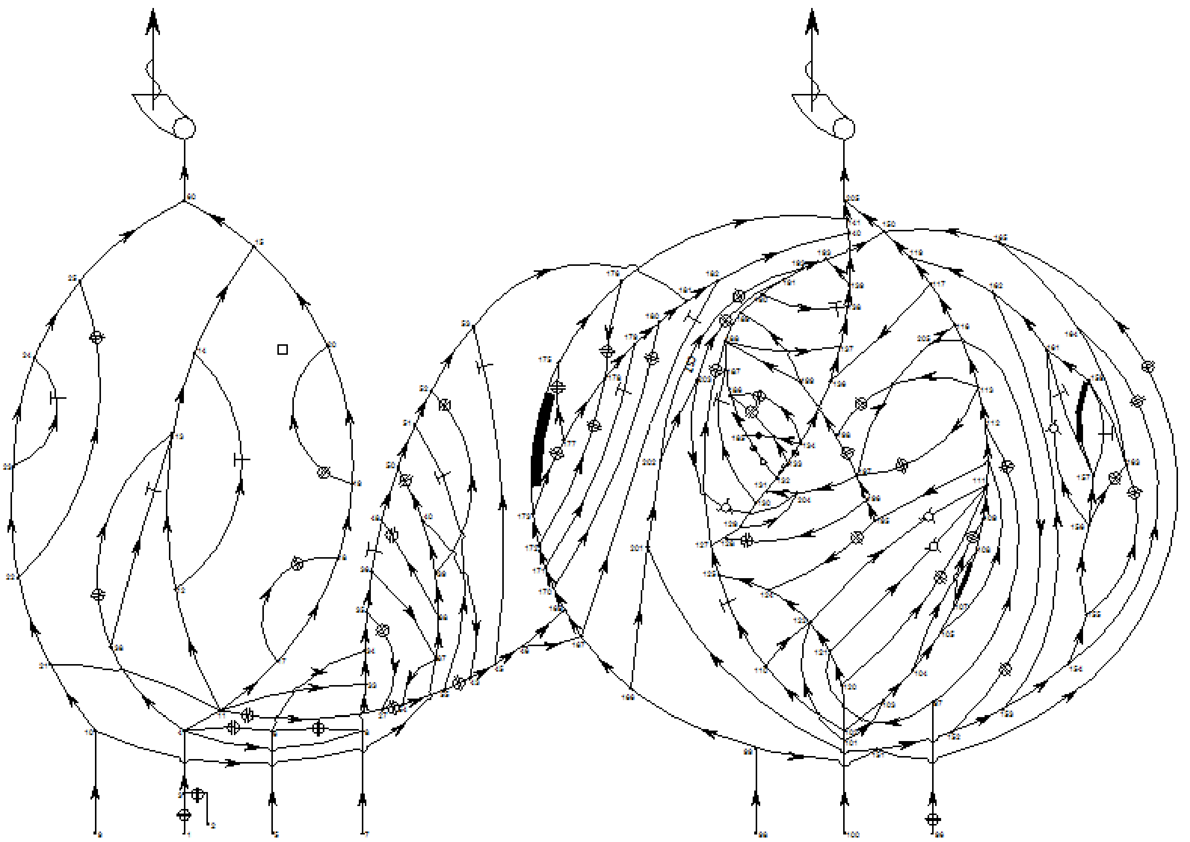

Figure 2: Mine ventilation network diagram

2.2. Analysis of mine ventilation status

The mining mode of the mine in the Yucun coal mine is the mixed well development of the inclined shaft-vertical well. The 3# coal seam is now mined. The mining method is the comprehensive mining method of inclined longwall retreat low-level top coal caving. The mine ventilation mode is mixed ventilation and ventilation. The method is draw-out. There are six inlet wind wells: main inclined shaft, auxiliary inclined shaft, pedestrian inclined shaft, west inlet wind shaft (inclined well), new inlet wind shaft (vertical well), scorpion wind shaft auxiliary shaft; two return air wells: West return air well (inclined well), new return air well (vertical well). After the underground survey point measurement and calculation, the total mine inlet air: 22487m3/min; the mine total return air: 22589m3/min; the mine calculated resistance value: West return air inclined shaft: 1884.01Pa, new return air shaft: 2775.89Pa; mine Equal hole: 3.3m2, with the excavation operation, the mine is currently preparing to set up the Xiituo District wind shaft at the junction of the 480 horizontal roadway and the 25 mining area air inlet extension. The specific position is shown in Figure 3.

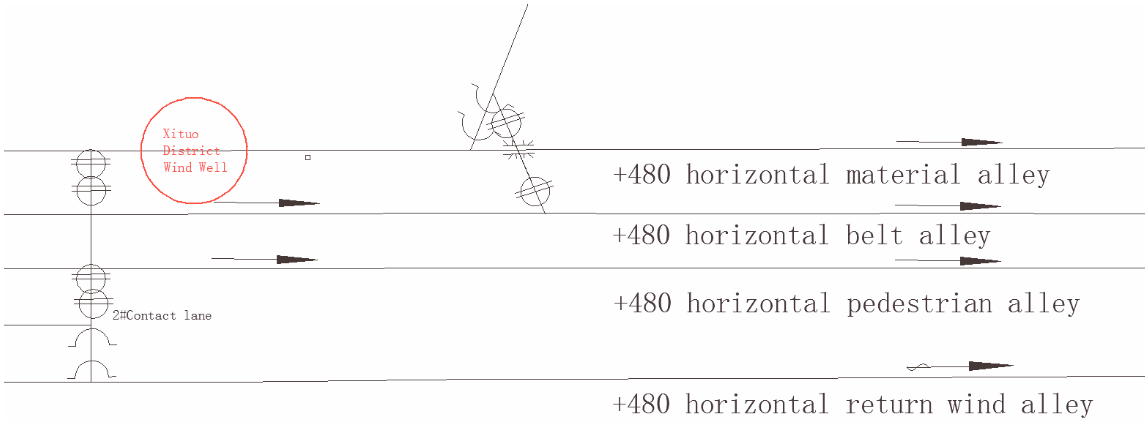

Figure 3: Xituo District wind well location map

3. Optimization analysis of energy saving and consumption reduction plan

3.1 Optimization plan

Combined with the intake shaft of Xituo District to be excavated in the mine, the Ventim software is used to set the intake air volume of the intake shaft in the Xituo District, and the air volume changes of the two return air wells and the mining areas after the intake of the west extension area are obtained. The situation is shown in Table 1. It is concluded that the intake air volume after the intake of the intake shaft in Xituo District is 2000-3000m3/min, and the impact on the current status of the entire mine ventilation system is minimal. Combined with the above analysis, two optimization schemes are initially proposed: (1) not considering the intake shaft of the Xituo District, and changing the west return wind well into the inlet wind shaft; (2) crossing the intake shaft of the Xituo District and closing the west return air well.

Table 1: Comparison of air volume changes in the wind shaft and the mining area in the Xituo District

	North wing belt lane (m^3/min)	**South wing belt lane (m^3/min)**	**13 mining area (m^3/min)**	**21 mining area (m^3/min)**	**22 mining area (m^3/min)**	**23 mining area (m^3/min)**	**25 mining area (m^3/min)**	**South belt lane (m^3/min)**
Before closing	1071	413	1707	2449	2701	2729	1416	946
After closing	522	202	850	2089	2433	2366	1286	859
Before and after influence	Greater impact	Less affected						
Reduce the percentage of %	51.26	51.09	50.21	14.70	9.92	13.30	9.18	9.20

3.2 Optimization plan analysis

3.2.1 Changing the West Return Wind Well into the intake shaft

Regardless of entering the intake shaft of Xituo District, dismantle the west return air blower and change the west return wind well into the intake shaft. The power of the west return air blower is reduced from 317kw to 0, and the power of the new return air blower is reduced by 1560.2kw. To 1471.2kw, the efficiency increased from 43.7% to 67.1%, and the total power decreased by 406kw. The fan parameters and characteristic curves can be obtained intuitively in the Ventsim software. The mine negative pressure new wind well decreased from 3482Pa to 2943Pa, which decreased by 539Pa. The air volume of the fan increased by 608m3/min, which was almost unchanged. After changing the west return air well into the air intake well, it will affect the air flow of the main roadway and each mining area, as shown in Table 2.

Table 2: Main roadway and air volume comparison table of each mining area

Level	**Region**	**Closing the front air volume (m^3/min)**	**Closed air volume (m^3/min)**	**Change (m^3/min)**	**Percent change (%)**
Second level	New into the wind well	10225	8618	-1607	-15.72
	21 mining area	2272	1881	-391	-17.21
	22 mining area	2603	2315	-288	-11.06
	23 mining area	2932	2551	-381	-12.99
	25 mining area	1622	1550	-122	-7.52
One level	West into the wind well	3886	2646	-1240	-31.91
	Deputy inclined well	2548	1670	-878	-34.46
	Main inclined well	1588	1050	-538	-33.88
	Pedestrian inclined well	1103	721	-382	-34.63
	South wing mining area	359	150	-209	-58.22
	North wing mining are	1065	480	-585	-54.93
	13 mining area	1950	843	-1107	-56.77

Through the analysis and calculation of Ventsim software, the west return wind well was changed into the inlet wind shaft, which mainly affected one level of the north and south wing and 13 mining area, of which the impact on the 13 mining area was the largest, but there was no underground production activity at one level, but the ventilation and drainage were the Lord. The total air intake in the mining area of the whole mine is reduced by 2,825 m3/min, which has little effect on the main wind mining area, and can even reduce the negative pressure for the 21 mining area with abundant air volume.

3.2.2 Crossing the intake shaft of Xituo District and closing the west return air well

Through the intake shaft of Xituo District and closing the west return air well, the parameters of the new wind turbine will change. The power of the new wind turbine is reduced from 1512kw to 1441kw, the power of the west return air blower is reduced from 317kw to 0, and the total power is reduced by 388kw. From 51.7% to 70.3%. After the closure of the West Wind Well, the air volume of the new fan increased from 16471m3/min to 16859m3/min, and the air volume remained basically unchanged. The negative pressure of the new wind well decreased from 3215Pa to 2717Pa, a decrease of 498Pa. Through the intake shaft of Xituo District and the closure of the west return air well, the air volume of each wind well and each mining area will have an impact, as shown in Table 3.

Table 3: Comparison of air volume and air volume in each mining area

Xituo District wind well (m^3/min)	**New into the wind well (m^3/min)**	**West into the wind well (m^3/min)**	**Impact on each mining area**				
			25 belt (m^3/min)	**23 belt(m^3/min)**	**21 belt (m^3/min)**	**22 belt (m^3/min)**	**13 mining area (m^3/min)**
0	16066	5057	1416	2729	2449	2701	1952
1042	16288	5071	1426	2835	2397	2655	1926
2071	16473	5098	1623	2933	2273	2602	1919
3098	16615	5124	1754	3059	2126	2556	1913
4011	16689	5147	1853	3178	1987	2515	1908
5000	16759	5170	1937	3303	1859	2479	1904
6037	16824	5191	2070	3343	1749	2449	1900
7039	16968	5207	2286	3520	1621	2436	1898

Through the analysis and calculation of Ventsim software, the wind inlet well in the Xituo District is closed, and the west return air well is closed, which mainly affects a horizontal well and mining area close to the west return air well. However, there is no underground production activity in this area to ventilate and drain. Mainly, the appropriate mining area to adjust the air volume measures, can meet the wind requirements of this area. The two levels of the main wind location have little impact.

2.3 Optimization scheme comparison

Through Ventsim software analysis, the total power of the scheme 1 decreased by 406kw, the negative pressure decreased by 539Pa; the total power of the scheme 2 decreased by 388kw, and the negative pressure decreased by 498Pa. From the point of view of the adjustment effect, the effects achieved by the two optimization schemes are basically similar. In the first scheme, the west return air shaft fan is removed, and the west return air shaft is changed into the inlet wind shaft. Only the relevant ventilation facilities need to be adjusted, and the annual electricity cost and The maintenance cost is about 3 million or more, and the second option is to use the intake shaft of the Xituo District to close the west return air well. The annual electricity and maintenance costs and the maintenance fee are basically the same, but the tunneling costs and auxiliary facilities required for driving the wellbore Costs, management fees, etc. will exceed 15 million, which is very unfavorable from the perspective of energy saving and consumption reduction for the wellbore that plays a major role only in 5-10 years.

4. Conclusion

- Through the analysis of Ventsim software, the West Return Wind Turbine is replaced by the West Return Wind Turbine, and the adjustment scheme will save energy of 3 million yuan per year for the mine. Wind wells, closed west return air wells, this adjustment scheme saves energy consumption the same as the former, but will also invest an additional 15 million yuan, and is very unfavorable for the later ventilation management.

- In the optimization of mine ventilation system, while considering the technical and safety, it should also be combined with economic considerations, not only to meet the mine ventilation requirements, but also to prevent "big horses", not only to achieve "systems" Simple, safe and reliable, but also to reduce ventilation costs, energy saving and emission reduction.
- Ventsim software can not only calculate the direct energy cost of wind turbine procurement cost, mining tunneling cost, ventilation cost, damper, damper, windwall construction cost, but also the ventilation safety cost caused by unreasonable distribution of ventilation system. Indirect costs such as inadequate ventilation are essential to help mine operations achieve cost savings, improve safety, and optimize production management efficiency.

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