Research on the Construction Technology of Tunnel Internal Air Circulation Purification under High-Quality Air Quality

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Abstract. As the traffic volume increases, the air quality in the tunnel decreases. In order to ensure the health of the tunnel staff and the safety of tunnel operation, and to better play the role of the duty room in the tunnel, through the test and analysis of the tunnel ventilation and environment, it is proposed to take the air in the tunnel and circulate the purification and the roots blower to send and exhaust air. The design scheme combining methods effectively solves the design problems of small air volume and high air pressure of the air purification system in the tunnel, and has reference significance for the safe operation of similar long road tunnels.

Key words. Air quality optimization, tunnel ventilation, air purification.

1. Introduction
With the rapid development of my country's transportation construction, tunnel engineering is an important means to solve high-speed traffic. In traffic engineering projects, the proportion of tunnel length is constantly increasing, especially in the construction of railway projects. The length of single tunnels is constantly increasing, and extra-long tunnels are constantly being designed and constructed. Due to the limitation of construction level and construction technology, extra-long tunnels need more and longer auxiliary tunnels in the construction process to realize the purpose of short tunnels and rapid construction, and the length of single-head tunnelling is also getting longer and longer. In order to solve the ventilation problem of extra-long tunnel construction, press-in relay ventilation is usually adopted. Relay ventilators at all levels need to be arranged in the cave far away from the duty room outside the cave. Due to the long distance, manual control of the ventilators only consumes a lot of money. It is difficult to realize the scientific linkage of the ventilators outside the cave and inside the cave, which is easy to cause damage to the ventilators and waste of time [1]. Therefore, how to correctly select ventilation parameters such as air volume, wind resistance, and air pressure, and then reasonably configure fans and ducts must be studied in depth to ensure smooth construction of the project.
2. Key points of tunnel ventilation control

2.1. Dust concentration
When advancing tunnel construction operations, the relevant factors covered in it will all have a direct effect on its ventilation environment, and dust concentration is one of the most critical basic points. Research on tunnel construction is not difficult to find that the process of the process of project development will directly affect the geological conditions and environment in the tunnel. The construction process is often accompanied by a large amount of smoke and gas. Therefore, the dust concentration is tested and determined. In the process, the important indicator that needs to be relied on is the sulphur dioxide content, so the dust concentration is closely related to the sulphur dioxide content. Once it is found in the measurement process that its content exceeds 10% of the normal standard, the dust concentration needs to be quantitatively managed and controlled; conversely, if the sulphur dioxide content is within the empty range, the control of the dust concentration can be reduced accordingly.

2.2. Carbon monoxide concentration and nitrogen oxide concentration
Carbon monoxide is a type of gas commonly present in construction projects. Once its concentration exceeds the standard range, on the one hand, the smooth progress of the construction project will be affected, and the ventilation efficiency will continue to decline; on the other hand, after the construction workers inhale a large amount of this gas, Health will be seriously damaged, therefore, carbon monoxide has become a necessary factor to measure the ventilation effect of tunnel construction. Due to the different sizes of tunnel construction projects, the carbon monoxide content produced in the construction process is also very different, but from the perspective of its content and the degree of influence of the ventilation effect, in order to ensure the smooth progress of the construction project, it needs to be controlled. In a small area, at the same time, it is necessary to further accurately control the amount of production during the construction and excavation process, that is, it cannot exceed the standard range. After the construction project is advanced for a period of time, its concentration must be reduced [2]. The range of activities and concentration should not exceed one third of the excavation allowable content. In the tunnel construction process, environmental factors will be constantly changing, and there will be a certain degree of conformity index between the allowable content of its existence and the construction requirements. If the above factors can exist in coordination, and the carbon monoxide index in the tunnel is in the normal range, Then the carbon monoxide index in other areas can lower the control standard, which can not only improve the construction efficiency of the project, improve the ventilation quality of the tunnel, but also directly reduce the construction cost of the project and improve the economic strength of the project.

2.3. Volume concentration of nitrogen oxides
When advancing the tunnel construction project, the concentration of nitrogen oxides is also an important indicator that affects the ventilation efficiency. Therefore, it is also necessary to control the concentration in the construction process and ensure that its concentration is below the engineering application standard. Fundamentally improve the construction safety index, which puts forward higher control requirements for the effective air content in the tunnel. The air in the tunnel is relatively thin, and the realization of the ventilation goal also depends on air. Therefore, during the tunnel construction process, the air content index needs to be raised to the effective range, and the relative content of oxygen and carbon dioxide should also be two to zero. Five forms coexist. During the tunnel construction process, only the oxygen content meets the engineering application standard, the construction personnel can maintain normal breathing in the tunnel [3]. Therefore, it is particularly important to accurately control the volume concentration of nitrogen oxides in the tunnel engineering. Fully meet the ventilation requirements in the construction process, and at the same time, it can also provide an important guarantee for the personal safety of the construction personnel.
3. Research on remote central control technology of ventilator

3.1. Purpose of ventilation and air purification

3.1.1. Centralized management and control. Due to the long length of the inclined shaft of the horizontal tunnel, the manual management efficiency is low, and the multi-stage relay fan is not synchronized, which causes the relay fan in the cave to be easily damaged. The remote central control technology of the ventilators is used to realize the system management of all ventilators in the duty room, centralized control of start and stop, to ensure the safe use of multi-stage relay ventilators, and save energy and reduce consumption.

3.1.2. Remote control. It is connected with the ventilator through optical fibre and components, and the ventilator remote central control technology is used to directly control the start and stop of all ventilator and wind speed adjustment at the entrance of the hole, realize remote control and improve work efficiency.

3.1.3. Intelligent automatic control. Ventilation is an effective measure to reduce toxic and harmful gases. The remote central control system of the ventilator is compatible with the H2S gas monitoring system. The remote central control system of the ventilator automatically intelligently senses the H2S gas concentration. Once the H2S gas concentration in the cave exceeds the critical value, the ventilator the remote central control system automatically activates the switch or acceleration switch to increase the ventilation volume in the tunnel, effectively reduce the H2S gas concentration in the tunnel to a safe value, and ensure the safety of tunnel construction [4].

3.2. Principle of the ventilation scheme system

Through actual investigation, this paper found that the air quality 10 meters north of the west line of the North Exit Duty Room meets the requirements, and the air quality 10 meters south of the east line of the South Exit Duty Room meets the requirements. Adopting the approach of taking the wind from the nearest main tunnel, the north exit duty room takes wind from the west line and extends 10m northward in the direction of reverse traffic, and the south exit duty room takes wind from the east line and extends 10m southward in the direction of reverse traffic, each with a 200mm diameter ventilation duct. Take the wind and lead to the duty room at the north exit and south exit. One end of the ventilation duct is installed in the main tunnel of the tunnel to take air, and the other end is connected to a customized combined purification air conditioning system located in the cross passage of the duty room [5]. The combined purifying air-conditioning system completes air purification and oxygen production, and sends fresh oxygen-enriched air into the renovated cabinet in the duty room. The indoor cabinet can complete oxygen concentration and temperature detection and alarm. For the main air pollutant CO, CO detection and alarm can be realized in the duty room, and according to the CO concentration, the linkage with the outdoor purification filter unit can be realized.

The plan mainly includes outdoor purification and filtration system, outdoor oxygen-enriched system, indoor circulation system and exhaust system. The outdoor purification and filtration system includes filter device, mixed flow device and air supply device; outdoor oxygen-enriched system includes filter device and oxygen generator; indoor the circulatory system includes a detection device and a display device. Figure 1 shows the schematic diagram of the scheme.
Figure 1. Schematic diagram of tunnel ventilation scheme

3.3. System hardware and software
The hardware control part includes: PLC programmable controller, intermediate relay, optical fibre transceiver and air switch. The hardware in the cave is protected by an explosion-proof box to make it a fan control box as a whole to isolate the external environment. The hardware composition and connection are shown in the figure. 2 shown. The software part includes: the code written for the fan control in the PLC, and the B/S control interface.

Figure 2. Connection diagram of tunnel ventilation control system composition

3.4. System control flow
The signal is sent by the industrial computer and converted into the PLC through the optical fibre transceiver. The PLC outputs the corresponding output to the intermediate relay according to the written program, and the relay is connected to the power distribution box of the fan to realize the control of the fan. The remote central control system of the tunnel fan can manually use the
programmed B/S system on the industrial computer to remotely control the fan [6]. It can also be compatible with the H2S gas monitoring system, automatically and intelligently sense the H2S gas concentration, and automatically switch or accelerate according to the concentration. For specific data, see Table 1, Table 2.

**Table 1.** Comparison table of CH4 concentration and fan status

| CH4 concentration or tunnel state | Fan status  | Measures                                |
|----------------------------------|-------------|-----------------------------------------|
| Concentration below 0.3%         | Low speed   | Strengthen monitoring                    |
| Concentration 0.3%-0.5%          | Medium speed| Strengthen monitoring                    |
| Concentration 0.5%-1%            | high speed  | Strengthen ventilation, strengthen monitoring, check the cause |
| Concentration 1%-1.5%            | high speed  | Suspend over-limit section, strengthen ventilation and check |
| Tunnel blasting                  | high speed  | Enhanced ventilation during blasting    |

**Table 2.** Comparison table of H2S concentration and fan status

| H2S concentration or tunnel state | Fan status | Measures                                                                 |
|-----------------------------------|------------|--------------------------------------------------------------------------|
| Concentration below 10ppm         | Low speed  | Strengthen monitoring                                                    |
| Concentration 10-20ppm            | Medium speed| Strengthen monitoring                                                   |
| Concentration 20ppm               | high speed | Strengthen ventilation, strengthen monitoring, check the cause           |
| Concentration greater than 20ppm  | high speed | Work stoppage, evacuation, strengthen ventilation and monitoring         |

The fuzzy control block diagram of the H2S gas monitoring system integrated tunnel ventilation remote control system is shown in Figure 3. This system adopts the traditional control method, namely realizes the control of tunnel ventilation by dividing the control level. This system adopts tunnel ventilation fuzzy control. The H2S and gas concentration monitored by sensors in the H2S gas monitoring system are selected as the input of the fuzzy controller. After fuzzification, they are input into the fuzzy controller respectively, and the control results are obtained through fuzzy inference. Control the speed of the fan.

![Figure 3. Block diagram of fuzzy control](https://via.placeholder.com/150)
4. Conclusion
By using the remote central control system of the extra-long tunnel fan, the fan manager can remotely control the fan outside the tunnel, and realize the system management of the fan outside the tunnel, saving labour and time. At the same time, the system can be compatible with the H₂S gas monitoring system. Through the H₂S and gas content monitored by the H₂S gas monitoring system in real time, the fan speed can be automatically adjusted to achieve the effect of automatic control. In addition, because the control system adopts PLC as the controller, the reliability and anti-interference ability of the system are greatly improved. In terms of signal transmission, the system adopts leather cable as the signal transmission channel, which can be effective in long-distance transmission. Reduce the attenuation of light, and ensure the smooth flow of signal transmission channels in the harsh environment of the tunnel. Taking into account the presence of flammable gases such as H₂S and gas in the tunnel, the system hardware is protected by an explosion-proof box to isolate the contact with the outside world and ensure the safety of the system. Generally speaking, the remote central control system for the fan in the extra-long tunnel not only realizes the remote control and automatic control of the fan, but also takes corresponding measures to ensure the safe operation of the system according to the special conditions of the tunnel, which effectively reduces the probability of fan damage and improves work efficiency and ensure the safety of H₂S gas tunnel construction.

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