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STUDY ON SIGNIFICANT TOOLS OF COAL MINE MAIN FAN SWITCHOVER AIMING WITH VENTILATION PERPETUAL

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ABSTRACT

The currently-used mine main fan switchover is to stop the working fan first and then to start standby fan, which makes underground ventilation interruption during switching, and it is liable to cause gas concentration exceeding limits in high gas mine and threaten mine production safety. Based on the thought of changing the fan on standby from cold standby to hot standby before switchover, a novel way of main fan switchover aiming at ventilation unceasing with the aid of ventilation network switchover is put forward. From the influence on ventilation system, ventilation interruption throughout switchover formerly can be improved to air flow rate fluctuation during ventilation network switchover only. Therefore ventilation stability during main fan switchover can be realized and potential safety hazard of gas concentration exceeding limits is eliminated effectively. According to the relationship between the boundary condition for the safety running of main fan and the stability of ventilation system air flow rate studied in this paper, based on four louver air-door cooperative regulation, a control strategy for ventilation network switchover to realize ventilation unceasing during main fan switching was given. Then an automatic control system has been developed with PLC. Practical operation indicates that the way of main fan switchover presented in this paper can deal with the deficiencies of the way currently-used, and it is important and significant for the safety of mine production.

INTRODUCTION

Ventilation is the control of air movement, its amount, and direction. Although it contributes nothing directly to the production phase of an operation, the lack of proper ventilation often will cause lower worker efficiency and decreased productivity, increased accident rates, and absenteeism. Air is necessary not only for breathing but also to disperse chemical and physical contaminants (gases, dusts, heat, and humidity). In the U.S., as well as in the rest of the world, mine ventilation practice is heavily regulated, especially in coal and gassy (noncoal) mines, and other statutes relate to air quantities required to dilute diesel emissions, blasting fumes, radiation, dusts, battery emissions, and many other contaminants. To ensure adequate ventilation of a mine, provision is made for suitable paths (airways or aircourses) for the air to flow down the mine to the working places and suitable routes out of the mine when it has become unsuitable for further use. The primary ventilation system thus consists of an intake or intakes (or downcasts) through which the fresh air passes, the mine workings, and an exhaust or exhausts (or upcasts) where the air passes after having ventilated the working places of the mine.

A well designed and properly implemented ventilation system will provide beneficial physiological and psychological side effects that enhance employee safety, comfort, health, and morale. In planning a ventilation system, the quantity of air it will be necessary to circulate to meet all health and

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safety standards must be decided at the outset. Once the quantity required has been fixed, the correct size of shafts, number of airways, and fans can be determined. As fresh air enters the system through the intake airshaft(s) or other connections to the surface, it flows along intake airways to the working areas where the majority of pollutants are added to the air. These include dust and a combination of many other potential hazards, such as toxic or flammable gases, heat, humidity, and radiation. The contaminated air passes back through the system along return airways. In most cases, the concentration of contaminants is not allowed to exceed mandatory threshold limits imposed by law. The return (or contaminated, exhausted) air eventually passes back to the surface via return airshaft(s), or through inclined or level drifts.

Country	Date	Coal Mine	Fatalities
China	14 February 2005	Sunjiawan, Haizhou shaft, Fuxin	214
USA	2 June 2006	Sago, West Virginia	12
Poland	21 November 2006	KWK Halemba, Ruda Śląska	19
Kazakhstan	20 September 2006	Lenina, Karaganda	43
Russia	19 March 2007	Ulyanovskaya, Kemerovo	108
Ukraine	19 November 2007	Zasyadko, Donetzk	80
Poland	18 September 2009	KWK Wujek (Śląsk), Ruda Śląska	20
USA	5 April 2010	Upper Big Branch, West Virginia	29
Russia	8 May 2010	Raspadskaya, Kemerovo Oblast	66
Turkey	17 May 2010	Karadon, Zonguldak	30
New Zealand	19 November 2010	Pike River Mine	29
Turkey	13 May 2014	Soma, Turkey	301
Ukraine	4 March 2015	Zasyadko, Donetzk	33
China	30 October 2016	Jinshangou, Chongqing	33

Major underground coal mine explosion incidents after 2000

Mine main fan switchover system (MMFSS) consists of two main fans, which are equipped with a horizontal air door and a vertical air door, respectively. The purpose of operating MMFSS is to ensure small fluctuation of the underground airflow quantity and to guarantee safe operations of both fans simultaneously by controlling the four air doors during switchover from working to standby fan. MMFSS has time-varying dynamics under different operating conditions, strong coupling, high non-linearity's and uncertainty in character, applying conventional control methods cannot lead to satisfactory performances. In this study, an adaptive intelligent decoupling proportional–integral–derivative (PID) control method is proposed, where the unmodelled dynamics are estimated and compensated by neural networks, the coupling effect is eliminated by the designed decoupling compensator, and a switching mechanism among multiple models is employed to deal with the effect of time-varying dynamics. By inspiring from the generalised minimum variance control law concept, the parameters of the developed controller are determined.

Combined with field ventilation survey, a variety of ventilation software oriented towards ventilation network solutions has been widely used in the mining industry. With the aid of modern computers, the overall status of the ventilation system can be determined and visualised in three dimensions, as well as the optimisation of the existing ventilation system. Some computer programmes, typically known as mine ventilation network models (e.g., Ventsim), provide the function of heat and humidity analysis, together with fire and contaminants dispersion studies in the mine atmosphere. Efforts have also been put to improve the performance of these network models. It is noted that these ventilation programmes are written to solve the overall distribution of airflow or pressure in the entire mine ventilation system, and the actual working places and roadways are represented by nodes or branches in 3D views, as a result, a detailed airflow distribution on different cross sections of these locations cannot be obtained using the ventilation software.

The ventilation system of an underground mine provides fresh air to personnel and equipment, dilutes pollutants and hazardous gases, and maintains a

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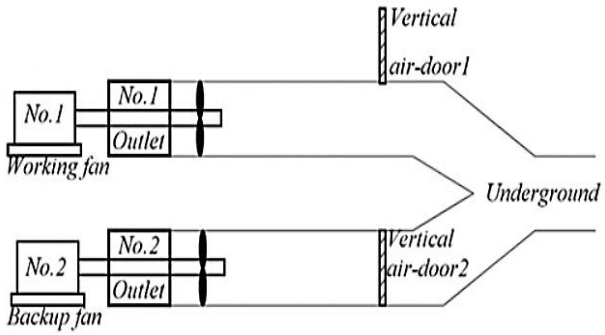
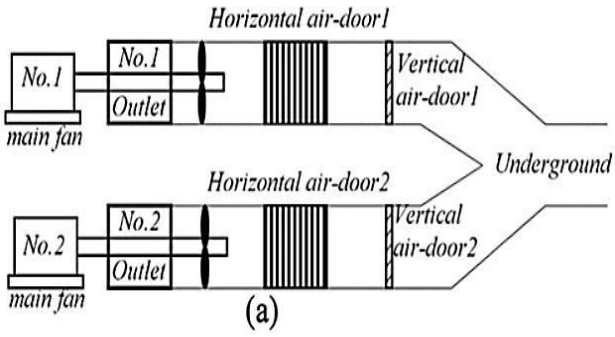
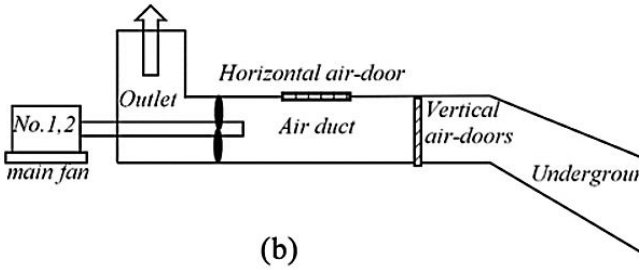
comfortable working environment. On one hand, this system is of greater importance for a coal mine primarily because of the methane emission issues. Most coal mines seams have high level of methane that continuously emit to the airway during the mining process. Ventilation system needs to provide enough fresh air to dilute the methane to the regulated limit for preventing methane explosion hazards. On the other hand, ventilation is used to adjust underground climate conditions, create a good production environment, ensure the normal operation of machinery and equipment to ensure the health and safety for operating personnel, and to achieve the goal of safe production. It is vital in mining industry.



The traditional fans switchover system





The automated fans switchover system: (a) plan view and (b) side view.

METHODOLOGY

Major Ventilation Systems

The objective of any ventilation system is twofold. First, the primary ventilation must course air through the main airways to the immediate working area outby the working faces, thus making fresh air available for face ventilation, and then return the contaminated air through return (exhaust) airways to the surface. Second, the face ventilation system must be designed to effectively utilize the available air in the immediate working area to sweep the working face, to capture and remove dust, and to dilute and carry away gas, if any, emitted during mining activities. Without a properly designed ventilation system, an efficient production cycle would not be possible. The system should provide the required air volumes and quality at reasonable pressure losses, perform with minimum interference and cost to production, and do so in the most cost-effective way possible.

Furthermore, the primary ventilation system may be well designed, but if the available air brought to the working area is not properly utilized for ventilating the faces where most workers are located, the total system has failed (Bossard, et al., 1982). Depending on the type of mine and disposition of local geology, ventilation layouts can be divided into two broad classifications; either a U-tube system or a through-flow arrangement (McPherson, 1993). Basic U-tube configuration where air flows towards and through the working area then returns along adjacent airways, often separated from intakes by long pillars and/or stoppings. Access doors in the stoppings facilitate traffic between intake and return airways. The variation of this

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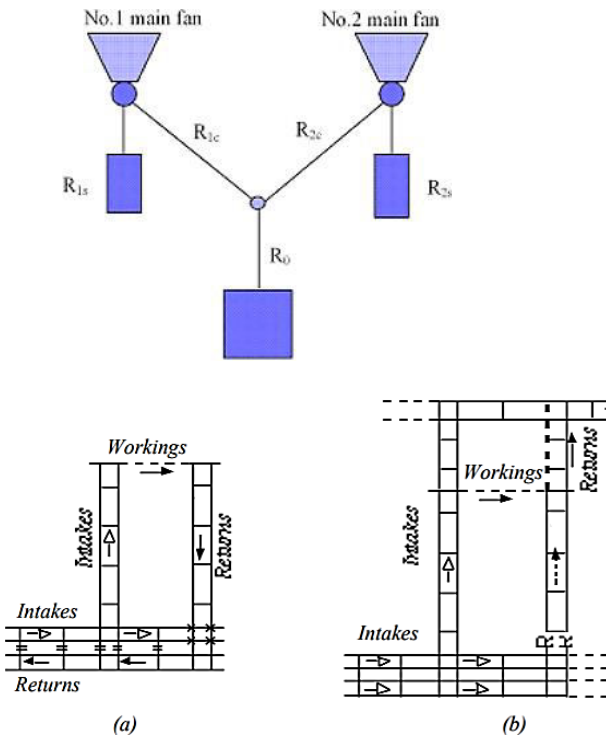
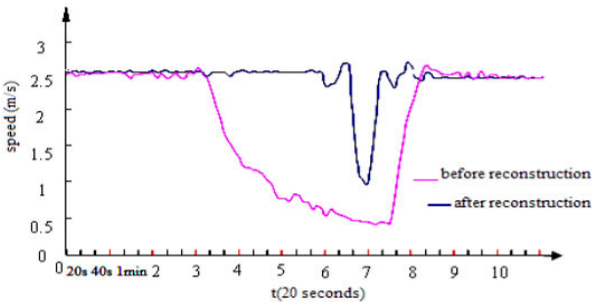
arrangement would be room-and-pillar and longwall type mining methods. The other arrangement, where intakes and returns usually are separated geographically from adjacent airways, which are either all intakes or returns. Although less stoppings and airways are needed because of the geographical separation, which often results in less air leakage, air current regulations and boosters may be required for airflow control in work areas (McPherson, 1993). Parallel flows between intake and return airshafts across the multilevel metal mines and the bleeder system in a long wall panel would be typical examples of this type layout.



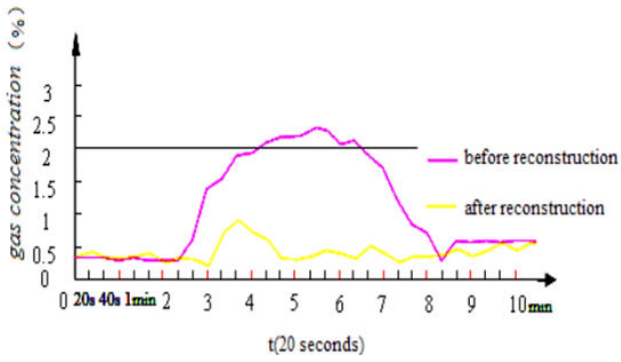
(a) U-tube and (b) through-flow

RESULTS

Based on the switchover way studied in this paper, an automatic control system made of PLC is developed. After reconstruction, gas concentration exceeding limits has not happened any more during main fan switchover, what is more, all the consequent main fan switchover operations has been completed successfully. Which are 10 minutes wind speed and gas fluctuation contrast measured in field fore-and-aft reconstruction respectively, length of the influence on underground ventilation has decreased to about 30 seconds and the lowest speed about ventilation fluctuation is kept above 40 percent of the normal rate. In consequence, the problem of gas concentration exceeding limits during main fan switchover has been eliminated successfully.



Wind speed contrast fore-and-aft reconstruction



Gas fluctuation contrast fore-and-aft reconstruction

CONCLUSION

With the technology of making main fan on standby enter into reliable hot standby and the strategy of air-door cooperative regulation for ventilation network switchover during mine main fan switchover, not only the successful rate of main fan switchover can be enhanced, but also ventilation interruption formerly has been improved to ventilation fluctuation effectively. The corresponding

automatic switchover control system has achieved the goal of gas concentration under limits during main fan switchover, so it has a great value for popularization and application for the sake of mine safety production.

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