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EXPLORATION ON STEADFASTNESS OF MULTIFARIOUS COAL MINE VENTILATION SETUPS

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ABSTRACT

Ventilation networks is the main part of coal mine ventilation system, it takes the responsibility to transfer fresh air to the underground laneways to keep the whole safety of coal mine. In this paper, we discuss about the reliability of the ventilation networks by using Boolean calculation and Shannon formula, and expatiate the application process with a real case, the result shows the highly efficiency and maneuverability. Eight different collapse scenarios were proposed to study their effect on the air quantity distribution among the branches in the ventilation circuit. From these scenarios, it is found that providing a sufficient air quantity in the working places could be achieved through modification of the network topology and adjusting the values of the regulators pressure. It is also indicated that the distance between the collapse and working places has a great effect on the amount of air delivered to it. A reduction in the power consumption could be done by re-arrange the installed regulators and decreasing the number of nodes and branches inside the network. A relationship representing the effect of changing the network topology on the total network power consumption was deduced through regression analysis. It is found that the total network power is quadratic dependent on the number of regulators and number of branches while it is directly dependent on the regulator power.

INTRODUCTION

With the development of mining industry, the rationality and economy of mine ventilation system attracted the attention of the people.Airflow in mine ventilation network is in a certain state of equilibrium according to the air flow balance law. But, with the development of mine production and the interference of external factors, the network equilibrium flow will change, the airflow stability will be affected. Mine ventilation system facing the following problems in reliability:

(1) The concept of reliability of branch and network;

(2) Reliability calculation of branch and network;

(3) How to take advantage of the reliability parameters to design systems with higher reliability;

(4) The production mine how to make advantage of reliability theory to develop a rational management, use and maintenance measures to ensure the system works properly.

Usually, the reliability of branch of mine ventilation network is not only refers to the degree of stability of air or anti interference ability, It is closely related to the following factors: (1) The transient disturbance of airflow movement caused by the airflow stability, the possibility of reverse air caused by the diagonal branch of ventilation network, the unstable operation of the ventilating fan, underground lifting transportation equipment; (2) Work reliability of the the conditioning facility, the degree and scope of damage caused by the failure state; (3) The toxic, suffocating , explosive gas and dust concentration, once overrun will enable local network temporarily disabled; (4) Air leakage conditions, the quality of air and climate conditions.

Therefore, it exists essential difference between the reliability of mine ventilation network branches and components of general network (such as electric power network). Reliability in elements of general networks is their inherent characteristics, nothing to do with the other components and the associate nature of networks. While the reliability of the various branches of the mine ventilation network should not only reflect their own attribute, but also closely related to the attribute of the other branches and networks. This paper intends to calculate the reliability of each ventilation branch and use disjoint Boolean algebra to calculate the reliability of network under the conditions of branches resistance change, natural wind pressure change, fire wind pressure change and its random disturbance distribution density.

The hydraulic system plays an important role in supplying power and its transition to other working parts of a coal shearer machine. In this paper, the reliability of the hydraulic system of a drum shearer was analyzed. A case study was done in the Tabas Coal Mine in Iran for failure data collection. The results of the statistical analysis show that the time between failures (TBF) data of this system followed the 3-parameters Weibull distribution. There is about a 54% chance that the hydraulic system of the drum shearer will not fail for the first 50 h of operation. The developed model shows that the reliability of the hydraulic system reduces to a zero value after approximately 1 650 hours of operation. The failure rate of this system decreases when time increases. Therefore, corrective maintenance (run-to-failure) was selected as the best maintenance strategy for it.

The objective of this study is to propose a plan to improve a ventilation network of Missouri S&T Experimental Mine for use in the future with consideration to the source of losses through the network, design of network with multi fans and fire analysis. A first action is to quantify how the efficiency of a ventilation system can be increased with use of an additional main fan. The design of a multi fan future ventilation network can be demonstrated with the use of numerical modelling software. The layout of ductwork, door/stopping positions and fans with different characteristics has been examined. In all simulation scenarios, the interaction of operating main and booster fans with each other and the reversal ventilation network flow has been considered. The required flow rate at identified working faces has been determined. Efficiency, minimum energy losses and annual network power cost determines the best scenario. Designs have been proposed for the ventilation network future plan. The optimum flow rate across working faces is the key criterion selected.

A good mine ventilation design should maintain adequate airflow through mine working areas all the time even in case of emergency. It does not only conform to the safety and health standards and federal regulations, as defined by the Mine Safety and Health (MSHA), but also lower the cost of air supply (U.S. Code of Federal Regulations 2014).Providing continuous fresh air to the mine dilutes and removes noxious gas and dust. It also adjusts the climate in the underground mine workings, and consequently

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establishing a good working environment (Sui et al. 2011). Mining accidents may have a variety of causes, including leakage of poisonous gases (such as hydrogen sulfide) or explosive natural gases, especially firedamp or methane, or gas outburst or gas explosion, dust explosions, collapsing of minestopes, mining-induced seismicity, flooding, or common mechanical errors from improperly used or malfunctioning mining equipment (safety lamps or electrical equipment). The improper use of explosives underground can also cause methane and coal-dust explosions.

Thousands of miners die from mining accidents each year, especially in the processes of coal and hard rock mining. Deaths nowadays not only occur in underdeveloped countries and their rural parts, but also in developing states. On April 5, 2010: Upper Big Branch Mine disaster, West Virginia, United States. An explosion occurred in Massey Energy's Upper Big Branch coal. Twenty-nine out of thirty-one miners at the site were killed. November 19, 2010: Pike River Mine disaster in New Zealand. The coal mine exploded. Twenty-nine men underground died immediately, or shortly afterwards, from the blast or from the toxic atmosphere. May 13, 2014: Soma mine disaster took place in Soma, Turkey. The accident, called the worst mining accident ever in Turkey, and it is the worst mining accident in the 21st century so far. 301 people died and at least 80 workers were injured (Mining-Technology 2014; Retzer 2014; Schleifer 2014).

ANALYSIS TECHNIQUES

Research defining how system pressure, air power, and quantity are affected by multi fans network; describing how system efficiency and network power cost are affected by the location, placement, and size of the booster and surface fans; and identifying the relationships between booster fans and main surface fans in ventilation systems that are consistent with U.S. mining conventions is presented in this study. Besides research is going to clarify how percentage of noxious gases, psychrometric information of the mine, heat in unforeseen fire event is consistent with the knowledge about natural ventilation pressure, time, location of event and the procedures for controlling the fire intensity; and identifying the percentage of toxic gases has been controlled according to the U.S. mining conventions is presented in this study. Research explaining how ventilation network pressure and velocity through ducting are affected by losses which are caused by different bends and modulators such as elbow and louvers; and analyzing the shape, size; bend angle of these parts to optimize the air quality at the mine inlet shaft has been undertaken.

Method of solving mine ventilation networks

There are basically two sets of solving fluid networks:

- "Analytical" methods, which involves the formulation of the governing laws into sets of equation that can be solved analytically in order to obtain a solution, and
- "Numerical" methods, which become very popular with the availability of personal computers, which were then used to solve the equations through iterative procedures (Eng, 2009).

Analytical Methods: The "equivalent resistances" of a ventilation network is the most elementary method of solving and balancing a ventilation system. If two or more airways are connected in series or in parallel

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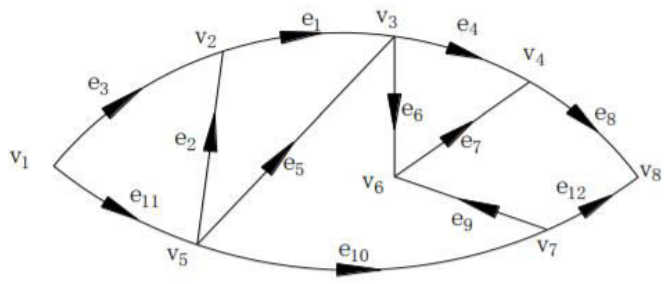
then each of those sets of airway resistances may be combined into a single "equivalent" resistance. The concept of equivalent resistances is particularly useful when combining two or more airways that run parallel to each other. Through this technique, thousands of such branches that may exist in a mine can be reduced to hundreds, thus simplifying the network schematic, reducing the amount of data needed to be processed and consequently, minimizing the time of solving and balancing a ventilation system (McPherson, 1993).

Numerical Methods: The method that is most widely used in computer programs for ventilation network analysis was originally developed for water distribution systems by professor Hardy Cross at the University of Illinois in 1936. This was modified and further developed for mine ventilation systems by D. R. Scott and F. B. Hinsley at the University of Nottingham in 1951 (McPherson, 1993)

Rationality of mine airflow G_3	Rationality of ventilation style G_1	Rationality of ventilation style I_1	0.0618
	Rationality of ventilation network G_2	Rationality of network distribution I_2	0.1956
		Rationality of roadway resistance force I_3	0.0399
		Rationality of series, parallel, and diagonal structure ventilation I_4	0.0670
		Rationality of air pressure and return deployment I_5	0.1160
		Normative of ventilation structure I_6	0.0618
	Reliability of mine airflow G_3	Qualified degree of air velocity on roadway I_7	0.0260
		Qualified degree of used air quantity I_8	0.0405
		Qualified degree of effective rate I_9	0.0061
		Qualified degree of used aeration quality I_{10}	0.0157
		Suitability degree of thermal environment I_{11}	0.0100
	Reliability of ventilation power systems G_4	Rationality of ventilation style I_{12}	0.0190
		Integration of safety facility in machine room I_{13}	0.0117
		Qualified degree of ventilator performance I_{14}	0.1166
		Qualified degree of air reversing facility I_{15}	0.0382
		The reliability of partial ventilation system I_{16}	0.0770
	Normative management of mine ventilation	Integrity of figure for ventilation system I_{17}	0.0116
		Integrity of safety institution for ventilation I_{18}	0.0181
		Qualified degree of ventilation monitoring I_{19}	0.0292
		Qualified degree of regulation-abiding worker I_{20}	0.0053
		Qualified degree of special worker I_{21}	0.0037
		Qualified degree of safety facility for fire fighting I_{22}	0.0292

METHODOLOGY

The mine ventilation network as shown in Fig. 3, Please calculate the reliability between point v1 and point v8. Each branch reliability are given as follows: P(e)=(0,85, 0.90, 0.90, 0.75, 0.60, 0.76, 0.83, 0.94, 0.80, 0.76, 0.64, 0.52).



The mine ventilation network

Step 1. Listing all the path set, Write it as S, S =8, That is to say the network G has a total of 8 path sets;

Step 2. Boolean algebra calculation, we can use the comparison procedure and running program given by literature (10)and(11) ;

Step 3. Taking the branch reliability into step 2, we can get the following results: P(S)=0.9033. It is important to know that the scope of what the network is working properly of the network G, The standard network corresponding to the G can generally be selected, that is according to the same reliability for all branches empowerment. This kind of network reliability upper and lower bounds can be calculated from the following equation

$$\left.\begin{aligned} P(S_p) &\le P_{\max} = P(S_1) + P(S_2) + \ldots + P(S_p) \\ P(S_p) &\ge p_{\min} = 1 - \left[P(\overline{S_1}) + P(\overline{S_2}) + \ldots + P(\overline{S_p})\right] \end{aligned}\right\}$$

CONCLUSION

The reliability of mine ventilation network is a problem in the theory of mine ventilation, a lot of questions about the reliability analysis require for further study. This paper calculate the reliability of each ventilation branch by the reliability mathematics under the conditions of

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branches resistance change, air pressure change, and its random disturbance, It also calculate the reliability of the network through the disjoint Boolean algebra algorithm, in this paper, the reliability theory of mine ventilation applied in the practical mine is studied, providing a new method for the numerical analysis of the rationality and the reliability in mine ventilation network design. It will be helpful to the design, management and technological transformation of mine ventilation network.

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