Sensitivity analysis of ventilation networks Using Derivative Methods Approch

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Abstract:
Providing fresh and cool airflow in underground mines is one of the main concerns during mine planning. Ventilation network is affected by internal and external parameters such as: presence of undesirable objects in the air way, or destruction of support systems leading to pressure loss and distortion of air flow which then affects the mining operations performance. Since it is necessary to keep the network performances at an appropriate level in such conditions, derivative methods were used in this paper for sensitivity analysis and reliability evaluation. Accordingly, changes in the tunnels resistance were considered as the input, and flowrate changes for all branches were considered as the output for the Sensitivity analysis evaluation model. This paper describes a stepwise method for evaluating Sensitivity analysis of an underground coal mine network associated with major losses. Proposed model was validated by the data from Takht Mine ventilation network.

***Keywords*:** *Sensitivity analysis mine, drope presure, ventilation, network*

INTRODUCTION

Deep mining is possible nowadays owing to the advancement of technology. Underground mining is dependent on appropriate ventilation, therefore, it is often necessary to provide fresh air according to initial mining plan. The proposed mathematical models for analyzing the ventilation networks are logically related and can be used for mine planning. The development and growth of mine space imposes new conditions on the ventilation network; on the other hand, uncertainty in the new conditions requires a sensitivity analysis of the mathematical model. Sensitivity analysis has been widely used in feasibility studies, mine closures, and mine developments. The cost imposed by the insufficient air flow has been investigated by Wang using sensitivity analysis methods (Wang, 2014). Lee et al. presented a sensitivity analysis of the flow intensity in the ventilation network considering the speed of fan blades as an input parameter (Li, Kocsis, & Hardcastle, 2011).

In underground mining, the initial task of ventilation network is to provide fresh and cool airflow for human and extraction equipment. Thus a reduction in the quality or amount of input and output airflow of a mine ventilation network can increase the number of expected system failures during a specified time period. Airway resistance is one of the reasons for pressure losses in ventilation networks. Development and growth of a mine space during the extraction inflicts resistance on the ventilation network, which in this study has been characterized as the resistance of obstacles. The whole ventilation network is affected by resistance changes in each branch of the network. According to the sensitivity analysis of mine ventilation network, high sensitivity branches are important and can create stronger probability of failure. Therefore, it is necassary to identify sensitive branches in ventilation networks. In this research, , the sensitivity analysis of airflow in Takht Mine ventilation network was evaluated using derivative methods, according to the transport tunnel resistance variation (transport tunnels are responsible for the transportation of excavated ore and mine personnel).

METHODS

Engineering, physical, environmental, social and economic phenomena are modeled using mathematical approximations. A mathematical model contains parameters that are logically related to each other. Determination of the parameters with the greatest impact on the model results is necessary to develop the model. Sensitivity Analysis (SA) considers how the variation in the output of a numerical model can be interdependent to variations of its input factors. Therefore, type of approach, level of complexity, and purposes of SA vary quite significantly depending on the modeling area and the specific application aims. According to the type and application of the mathematical model, sensitivity analysis was divided into four groups by Pianosi et al (2016); Local and Global SA, Quantitative and Qualitative SA, One-At-a-Time (OAT), and All-At-a-Time (AAT), Purposes (settings) of SA. They distinguish different types of sensitivity analysis based on formulating and addressing those input factors causing the largest variation in the output . Different results may be produced by various sensitivity analyzes for a model.

Analyzing the changes in the input factors is the simplest type of sensitivity analysis. In this method, the output variations are determined by changing the input values during a constant time (other variables kept constant). The objective function is represented by Equation 1:

$$y=g(x)=g(x_1,x_2, \ldots,x_M) \qquad (1)$$

If y is a scalar output value, the most common method for analyzing output sensitivity to the i^{th} input variable is to use differential gradient (Equation 2).

$$S_i(x)=\frac{g(x_1,\ldots,x_i+\Delta x_i,\ldots,x_M)-g(x_1,\ldots,x_i,\ldots,x_M)}{\Delta_i} \qquad (2)$$

In this research, derivative methods have been used for sensitivity analysis.

FINDINGS AND ARGUMENT

The coal region of Eastern Alborz located in the north of Iran is a significant deposit of coal. The area extends from the east of $54^{\circ}25'18$ to $55^{\circ}26'41$ longitude and the north of $36^{\circ}24'22$ to $37^{\circ}8'48$ latitude at 900 to 2200 meters above the sea level. There are several coal seams in this region few of which are currently being extracted in underground mines, such as Tazareh, Razi, and Takht as shown in Fig.6. In this research, Takht coal mine was selected as the case study. The annual production capacity of Takht mine is 50,000 tons.

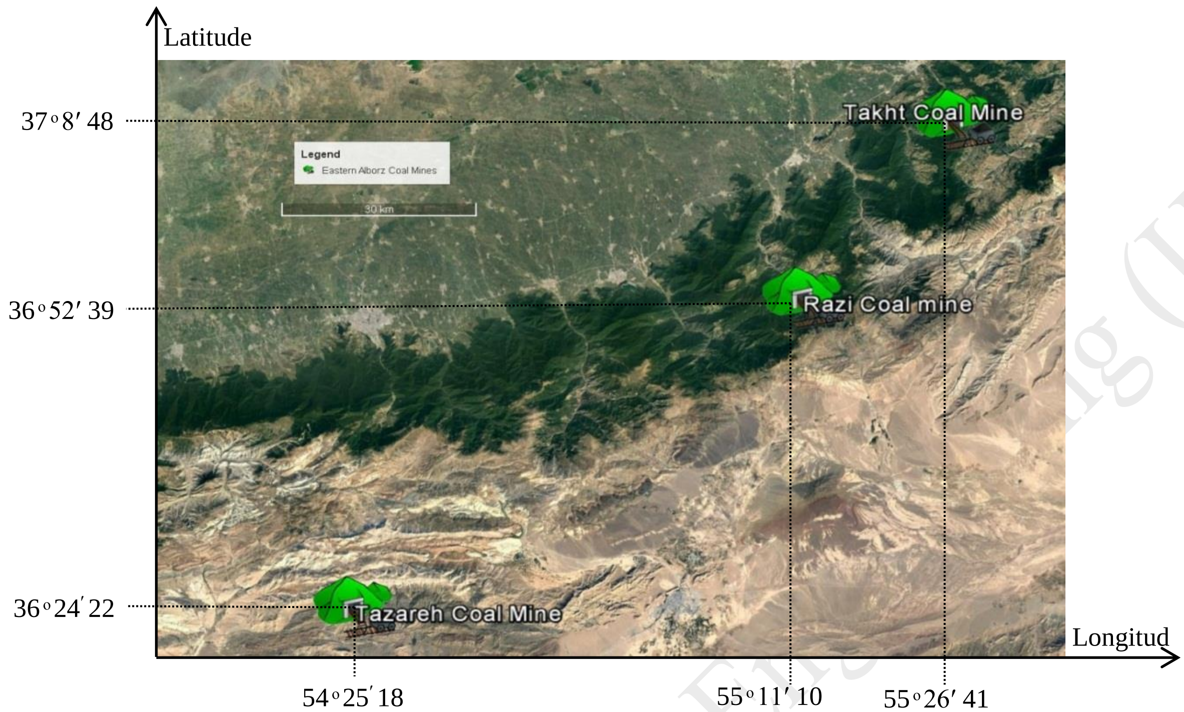

Fig.1. Aerial photo of the study area showing the location and coordinates of the eastern coal mines area

Fatal and financial disasters in mining industry have been happening for some reasons including underground coal mining operations. Providing fresh and cool airflow in underground mines can prevent these events during mine life. Sensitivity analysis of the mine ventilation network was identified, evaluated, and managed considering the relationship between air flowrate and network resistance. Sensitivity analysis has been commonly used in mining industry, but it was underestimated in mine ventilation by researchers. A Sensitivity analysis evaluation methodology was proposed to provide a general frame work for evaluation of the failure probability or sensitivity analysis of a mine ventilation network in any coal underground mine. In order to validate this model, it was implemented for Takht coal mine ventilation network.

CONCLUSIONS

Providing fresh and cool airflow in underground mines can prevent fatal and financial disasters during the mine life. In this study, sensitivity analysis of the mine ventilation network was identified, evaluated, and managed considering the relationship between air flowrate and network resistance. Accordingly, mine ventilation network was drawn as a graph, the volume flow rate and resistance were assigned as weights for the mine ventilation network graph.

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