

Study on the Simplification of Mine Ventilation Network Including Simple Diagonal Branches

Fengliang Wu, Honggang Wang

School of Energy Engineering, Xi'an University of Science and Technology, Xi'an 710054, Shaanxi, China

Abstract: It is easy to simplify a ventilation network with only series-wound or shunt-wound branches, but to a ventilation network with diagonal branches, it is still a difficulty. In a ventilation network, provided the uniform distribution of pressure drop along a branch, the pressure of an arbitrary point in a branch can be determined based on the calculation of pressure of each node. Thus by connecting the points with the same pressure in a ventilation network, the isobar of ventilation network can be formed. For a ventilation network including only simple diagonal branches, adopting the conception of isobar, the simple diagonal branches can be firstly simplified and then the changed ventilation network will contain only series-wound or shunt-wound branches. Afterwards the series-wound or shunt-wound branches in the left ventilation network can be combined step by step. The completed ventilation network is only a pathway that can be expanded step by step. The method looks like the management of a folder to its files in a computer, which has many virtues such as good legibility and clear hierarchy.

Keywords: series-wound; shunt-wound; diagonal branch; isobar; simplification of ventilation network

0. Introduction

The ventilation network graph is the base of ventilation network analysis and calculation. With the advance of production, the topology structure of ventilation network will change gradually. In an old mine, the ventilation system will become more complicated, which in one hand increases the difficulty of drawing a ventilation network and in other hand decreases the readability of an exact ventilation network, and thus the valuable analysis of the ventilation network graph becomes impossible.

The present researches have realized the auto generation of a ventilation network graph in computer^[1-3], but failed to simplify it. The series-wound airways can be simply combined to one airways, where the air resistance of the combined airway equals the sum of air resistances of the original uncombined airways, namely

$$R_{new} = \sum_{i=1}^n R_i; \text{ the shunt-wound airways can also be}$$

simply combined to one airway, where the air resistance of the combined one satisfies the following equations:

$$\frac{1}{R_{new}} = \sum_{i=1}^n \frac{1}{R_i}. \text{ The airflow direction of a diagonal}$$

branch is unsteady^[4], more importantly the existence of diagonal branches limits the simplification depth of a ventilation network. Presently the researches about diagonal branches pay more attention to the auto recognition of diagonal branches^[5-7] and the influence of diagonal branches on the stability and reliability of the ventilation system^[8-10], whereas the researches about the simplification of diagonal branches are not enough. Based on the calculation of nodes' pressure, the concepts

of isobar lines and points are adopted to simplify the simple diagonal network, which can realize the management mode of a ventilation network to its branches just as a folder to their files.

1. The concepts of isobar lines and points

In one coal mine ventilation, if the pressures of air nodes are set zero, the pressure of each node equals the ventilation pressure drop to air nodes. The pressure of each node is calculated along the airflow direction beginning at the air nodes, and the pressure of each new node equals the sum of that of the last one and the ventilation pressure drop of the present airway. In this way when every node is accessed the calculation of nodes' pressure of a ventilation system is completed.

It can be concluded from the energy conservation equation of ventilation's control equations that the pressures of one node stemming from different air routes are absolutely equal when ignoring the influence of thermodynamics. After obtaining the pressure of each node of a ventilation system, the pressure of arbitrary points in arbitrary airways can be calculated according to their relative positions to the start or end nodes of the airway. The pressure relations between two points (A and B) in two arbitrary airways have only three types: $A > B$, $A < B$ and $A = B$. If there is an airway between A and B, the air flow will have a direction from A to B when the pressure of A exceeds that of B, and the direction will reverse when the pressure of B exceeds that of A. Particularly when the pressure of A equals that of B the airflow cannot be formed between A and B., under this condition A and B are named isobar points reciprocally. As far as an arbitrary point is concerned, its' isobar points may exist or not, and the number of its' isobar points may be one or many. By connecting the points

with same pressure in a ventilation network, uncountable isobar lines that can never converge with each other will come to being. If some airways lay along the isobar lines, airflows in these airways can never be expected. In other words the air leak can never be expected along the isobar lines. When air resistance of each airway keeps unchanged, the isobar points and lines will not change with the variation of ventilation power.

2. The simplification of diagonal ventilation network

For a simple diagonal branch, its' start node has an isobar point in the airway which flow towards its' end node. Due to the airlessness between isobar points, two isobar points with different position in a ventilation network can be regarded as one point, thus can simplify the simple diagonal sub-network. Finally the whole ventilation network can be simplified to several simple air routes from different intake shafts to different return shafts. More interestingly this simplification is reversible.

Taking figure1 as an example, in the simple diagonal ventilation network the start node 3 of diagonal branch 5 has a isobar point 3) in the branch 4 which starts from 2 and end in 5, and then the two isobar points can be united as shown in figure2.

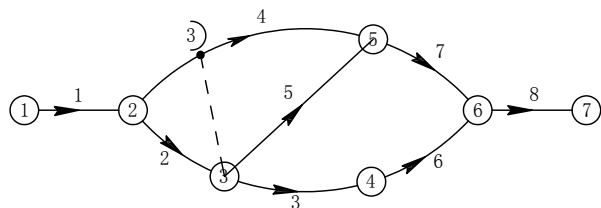


Figure1. A simple diagonal network where node 3 and node 3) are isobar points

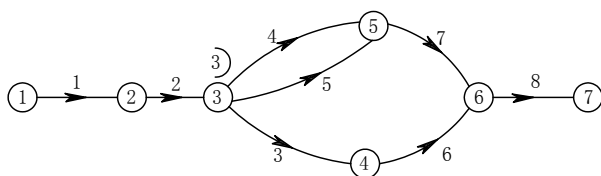


Figure2 The diagonal network after uniting node 3 and its isobar point 3)

In figure2, the air resistance of airway 2 equals that of shunt-wound branches of airway 2 and the sub branch 2-3) of airway 4. After the simplification the diagonal branch disappeared. Next step is the simplification of other shunt-wound branches in figure2, the results are shown in figure3 and figure4.

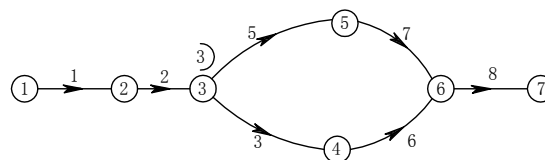


Figure3. Airway 5 is the union of shunt-wound airways 4 and 5

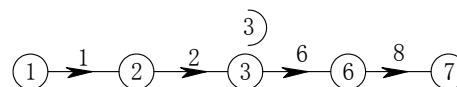


Figure4. Airway 6 is the shunt-wound simplification of serial-wound airways (5, 7) and (3, 6)

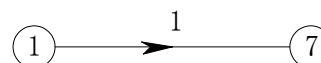


Figure5. Airway 1 is the union of serial-wound airways (1,2,6,8)

Figure5 is the final simplified result of figure1, which is just an air route from intake shaft and return shaft. By using the stack structure to record each step of simplification, the simplification chain from figure1 to figure4 is reversible, where figure5 can become figure4 by clicking airway 1 and then figure4 can become figure3 by clicking airway 6, etc. Finally figure1 can be restored. This kind of representation of airways likes the management of a folder to its files.

The simplification technology of a ventilation network based on the isobar points can be employed to analyze the ventilation network structure interactively, and then realized the dynamical zooming of a ventilation network graph. Putting a pile of files into one folder will result in the confusion of vision and make the management and using of these files inconvenient. With the same reason, putting a pile of airways on one graph will also result in the confusion of vision. The simplification technology presented in this paper directs plenty of airways into different "folders", and by clicking these different "folders" can be opened and present distribution of there airways.

3. Conclusions and Prospect

In the field of simplification of ventilation network, the simplification of diagonal network is an importance and difficulty. In this paper, based on the calculation of nodes' pressure, the pressure of an arbitrary point in a ventilation network is firstly worked out, and then the concepts of isobar points and lines are put forward. By combining the start node of a diagonal airway and its isobar point, the simple diagonal ventilation network can be simplified to a shunt-wound network, which can be united again and again. Finally the ventilation network will become an air route. This kind of simplification is reversible, which doesn't really delete other branches but

encloses them into different “folders” according to some logical layers. This method realizes the classified management of each airway in a ventilation network, which provides a new technology mean to the area analysis of ventilation network.

It must be pointed out that the research in this paper is effective only to a simple diagonal ventilation network. Its application to a complex diagonal ventilation network needs continued research.

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