AutoCAD Based Mine Ventilation Analysis

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ABSTRACT

MineVent is a mine ventilation analysis system which runs inside AutoCAD and uses the Penn State and other ventilation simulators. Working from AutoCAD as-mined and projected mine maps, the user picks the node locations and connects them with branches that correspond to the airway paths. Where survey data is not available, the system uses formulas to compute resistances. The system prompts the user for necessary parameters but the branch lengths are automatically computed. Powerful editing features reduce the time to modify existing schematics and try alternative ventilation options. The system also includes a survey data reduction module which outputs pressure drops and quantities values to feed the branch resistance calculator. Output includes color coded schematics with pressures and quantities shown. If the fan curve data have been digitized, the fan operating points are shown on the curves. Tabular output is also available.

KEYWORDS

Mine, Ventilation, AutoCAD, Simulation, Schematic, and Survey.

BACKGROUND

The ventilation network analysis software developed with the support of the US Bureau of Mines is well accepted in the mining industry. Some of these programs have been used for more than twenty years but often in the mainframe computers environment. These programs incorporate the well known Hardy-Cross method for network analysis. Since the software was developed prior to the widespread availability of interactive graphics, the systems are batch file oriented and has no graphical output capability. The user prepares the ventilation system input parameters in a prescribed tabular format, runs the simulator and receives a printed output report. This process involves the manual transcription of data from maps and ventilation survey notes into a table and very little is available in the way of data checking or editing functions. The output reports are very complete, but do not highlight the most significant information. Considerable manual effort is required to transcribe the data to a more useful graphical format.

The availability of AutoCAD on low cost graphics workstations and personal computers has allowed software developers to utilize its capability within their programs. A graphical user interface is an expected feature of any up to date software package. Charts and graphs have replaced or supplemented printed reports for most applications.

THE AUTOCAD APPROACH

Since the nodes in a ventilation network correspond to physical locations within a mine, these points are easily identified on a map. Rather than manually scaling airway dimensions from a map, the user can define the airways in AutoCAD by digitizing the known node locations off a map drawing. Since ventilation analysis typically involves the study of proposed ventilation plans, the mine map should include future projections as well as previously mined areas. If mine planning is performed on the computer, the anticipated mining progress will appear on the computerized maps and the user can easily select the expected ventilation node locations for any date in the future.

The user then connects the nodes with branches. Each branch can follow the actual airway path through the mine which allows the system to compute the true branch length. This capability makes the design and evaluation of alternative ventilation plans a quick and easy process. If the mine is already using the Pennsylvania State program, the existing data files can be converted to a DXF format and merged with the graphical node information.

USER INTERFACE

The enhanced version of the Pennsylvania State University ventilation analysis system runs within AutoCAD and has pull down menus and dialog boxes to simplify entry of branch parameters such as cross section area of the airways and resistance factors. Figure 1 contains the pull down menu format for developing the ventilation network.

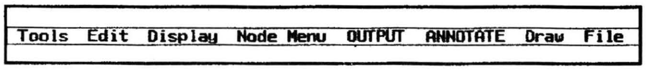

Figure 1. MineVent pull down menu

Locating Nodes

Selecting the option Node Menu, from Figure 1 pulls down a menu of options to enter, delete and modify the node information as shown in Figure 2. The ventilation nodes, hereafter referred to as nodes, are entered directly from an AutoCAD drawing on the screen. After a node location is selected, the program will prompt for a node number. The user can enter a node number or let the program assign the number. The node number will appear on the screen next to the node. Since the node numbers are stored in the computer, the program keeps track of unused node numbers and prevents the entry of duplicate node numbers.

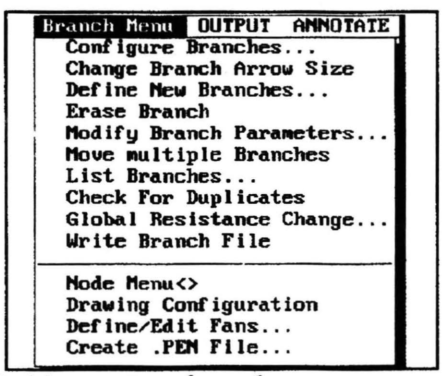

Figure 2. Menu options for nodes.

Frequently the user must edit an existing ventilation network drawing. Specific nodes may be difficult to locate on a large complex ventilation network diagram. Since the computer knows the location of each node, it can highlight nodes at the users request. The system also keeps track of all unused node numbers and provides a list on request.

Defining Branches

Selecting the Branch Menu option in Figure 1 pulls down the menu of options to define, delete and edit the branches. As shown in Figure 3, the **Define Branches** option provides a dialog box for selecting the branch type, code and other characteristics.

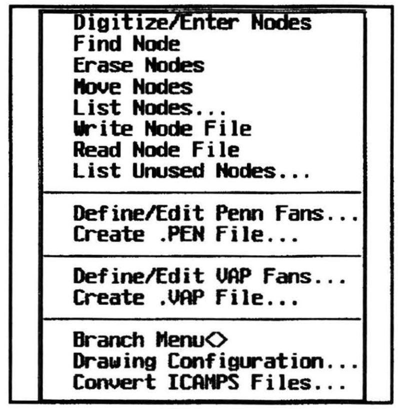

Figure 3. Branch Menu options.

To minimize the manual data entry process, before defining any branches the user selects the **Configure Branches** option. It provides dialog boxes for storing the commonly used resistance formulas and parameters for each branch code as shown in the Figure 4.

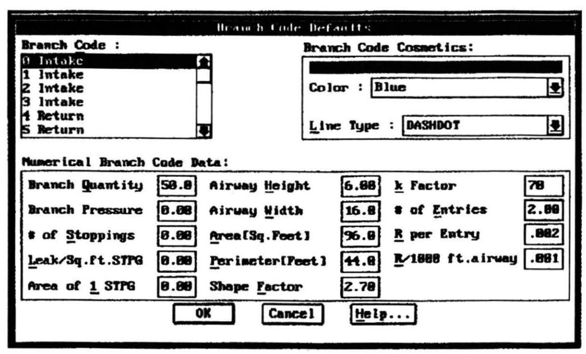

Figure 4. Branch code defaults.

After the branch type and code have been entered, the polyline representing the branch must be drawn. The rubber-banding feature allows the user to pick the center of the starting node and click the mouse to place vertices at turning points which represent the actual path the air follows through the mine to the ending node. If a multi-level mine has a single ventilation system, the mine layout for each level is displayed separately within a single drawing. The system will calculate the length of branches that span two or more levels or connect to the atmosphere.

The program also provides options to enter the branch name and select the line type and color. The resistance always defaults to a specified value, but normally the user will select the **Calculate Resistance** option which brings up the dialog box shown in Figure 5.

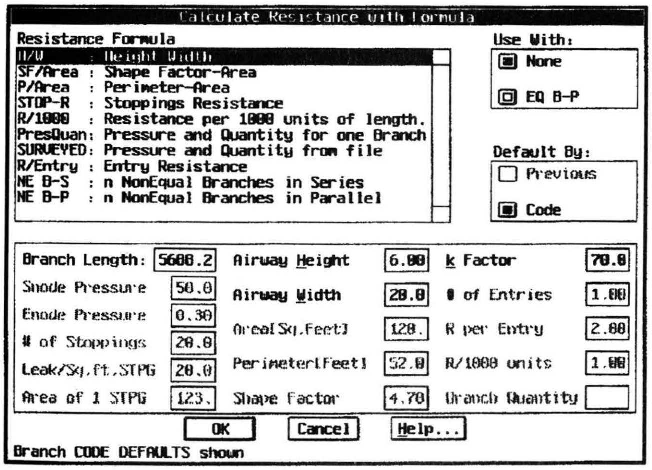

Figure 5. Resistance calculation dialog box.

This option computes the branch resistance from the airway characteristics or survey data. After the user selects one of the resistance formulae, the user specified default values for the necessary airway parameters, such as height, width and resistance factor, are highlighted.

If the branch is a fixed or limited quantity type or a dummy branch for injecting gas into the mine, the user must enter the quantity of air flow. Dummy branches always start at node 1 which is the atmospheric node. If natural ventilation pressure is significant, the user can also enter the pressure at the branches starting node. The standard default value for all these parameters is zero. Fan branch data must include the fan reference number for the Penn State simulator and fan specifications for the other simulators.

Fans Characteristics

The system maintains a file of available fans. Fan characteristics are entered by selecting the **Fan Menu** option which brings up the dialog box shown in Figure 6.

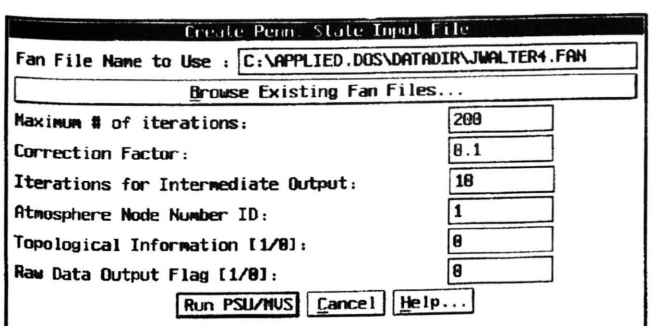

Figure 6. Fan input dialog box.

The dialog box allows the user to define a new fan or to erase or modify the parameters in an existing fan record. The dialog box has space for entering the fan type, speed and air density followed by the fan curve data, The curve data starts with the left most point. Three points on the curve are used for the Penn State system and five points for the VAP program. The same fan file may be used with any number of schematics.

Updating Schematics

Airflow through a mine continually changes as faces are advanced. Consequently the schematic must be updated to reflect new conditions. The modify branches option dialog box has a function for splitting branches to insert new nodes and for removing nodes and merging two or more existing branches. Branches can also be moved, stretched or shortened as a group to reflect advancing faces. The system automatically recalculates the branch resistances in proportion to the any changes in the branch lengths. The system also checks for unreasonable modifications such as splitting a branch into two limited or fixed quantity branches in series.

Output

After the ventilation schematic is complete, the information must be put in the proper format to run the simulator program. The user selects the simulator option. Figure 7 is the dialog box for creating the Penn Vent input file. The user must specify the stopping criteria, i.e., the maximum

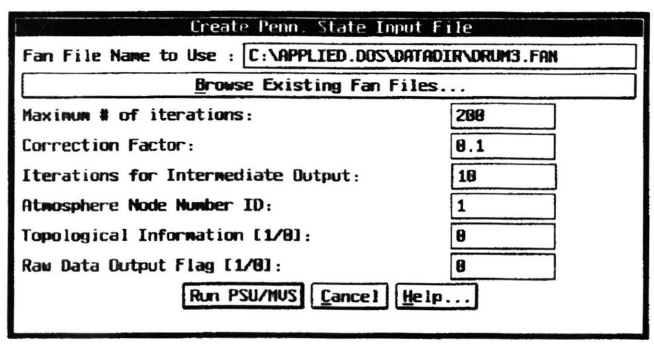

Figure 7. Simulator input dialog box.

number of iterations and correction factor. Clicking the **Run PSU/MRS** button creates the input file and starts the simulator. After the program runs, the user is asked for the destination of output. A summary of the results of the simulation always appears on the screen. The MineVent system checks for illogical results, that is, air flowing from low to high pressure in non-fixed quantity branches. Figure 8 is a list of the output options.

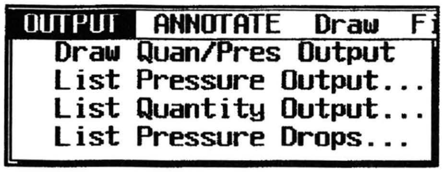

Figure 8. Output options menu.

Figure 9 is an example section from a color coded ventilation schematic diagram. The pressures and quantities are shown next to the corresponding nodes and branches. If gas was injected into the mine, the diagram can include both the quantity of air and gas flowing in each branch. The text can be resized and relocated to improve the appearance of the schematic and the program will use the new specifications in subsequent runs.

This form of output has proven to very useful for finding errors in the ventilation schematic. Because the schematic is drawn to scale and can be superimposed on the mine map, discrepancies are easier to see. For example, users detected the problem of air flowing from low to high pressure only after the AutoCAD graphical output became available. Of course the output is now automatically checked for such errors.

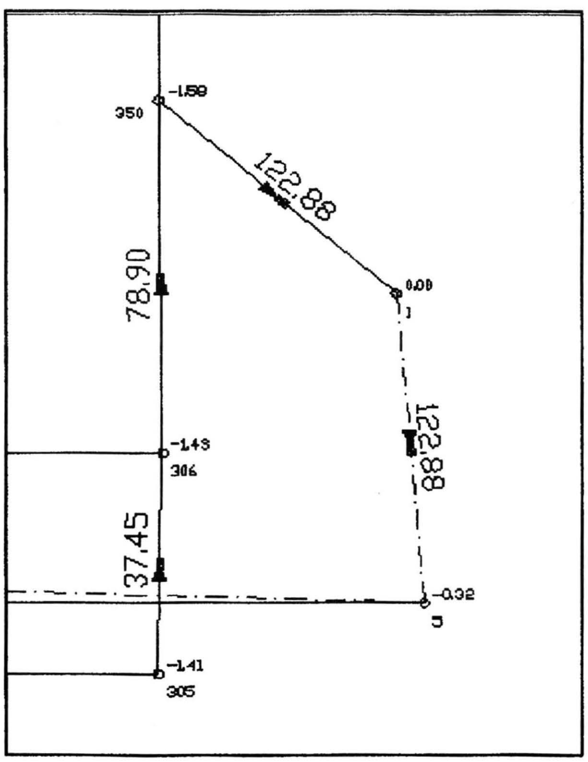

Figure 9. Sample of a schematic diagram.

The text can be resized and relocated to improve the appearance of the diagram. The program stores these changes and will use the new configuration in subsequent runs.

The user can also request a tabular list of the node pressures, branch quantities and branch pressure drops. The original tables created by the Penn Vent program are also available. This information is particularly useful for locating data errors.

The network diagram contains very complete information about every branch. The small mark at the end of each arrow (see Figure 9), is an attribute box which contains a complete list of branch data. The attribute box is created when the branch is entered and the zoom option allows the user to read the contents of individual attribute boxes as shown in Figure 10. The contents of the attribute boxes are also available in tabular form and can be sorted by branch type. The branch attributes are updated whenever the schematic is edited or the ventilation analysis program is run.

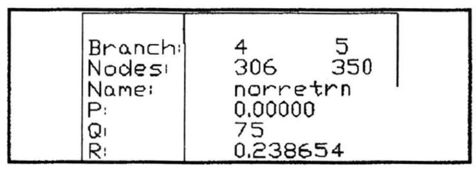

Figure 10. Typical attribute box.

Other Enhancements

MineVent now has a system for preparing survey data for input into the simulator. This program reads the survey information into Microsoft Access files and performs the calculations needed to yield branch flow quantities and pressure drops.

SUMMARY AND CONCLUSIONS

In recent years, interactive graphics capabilities have reduced the time and effort required to define and verify a ventilation network. Interfacing with AutoCAD yields an easy to interpret output format. Also, full AutoCAD capabilities allow the user to develop a presentation quality schematic with minimum effort. This approach can also be applied to other aspects of ventilation network analysis. For example, a graphical display of ventilation survey readings is an aid to editing such data. Today, a mining engineer can simulate current or future underground ventilation conditions in a matter of hours. and make revisions to assess alternative scenarios in minutes. And, he probably won't even use his pencil or calculator.

REFERENCES

Didyk,M., Ramani,R.V., Stefanko,R. and Luxbacher,G.W., 1977 "Advancement of Mine Ventilation Network Analysis from Art to Science" U.S. BOM Report No. H0133040. 84 pp.