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General principles of managing the ventilation network of mining headings

The most important condition for safe operation of the mining installation is fully operational ventilation network of mining headings, ensuring the right atmosphere to breathe, effective exchange of air in the headings, and discharge of dangerous gases (CO, CO2, CH4, etc..) Ventilation engineer and subordinate services must ensure, using all available technical and organizational measures, reliability and safety of ventilation network. High qualifications of supervisors, their experience, in-depth knowledge of the phenomena and ventilation processes, as well as the correct evaluation are the key factors in the proper organization of the ventilation department.

By the term of ventilation phenomena and processes in mining installations is meant a number of issues related to the flow of air through the mine ventilation network. For the ventilation services of the mining installation, especially crucial are those issues that determine the capacity of the ventilation network, as well as changes in the air distribution in emergency situations. The ventilation processes in the mining installations often include whole areas or levels of the mine, and are the result of continuous changes of the network structure, such as drilling new headings and the liquidation of exploited ones. On that premise, maintaining constant control of a ventilation system requires a systematic measurement of the air flow, both qualitatively and quantitatively. The current update of the ventilation network documentation and analysis of the results is the main duty of the ventilation services.

The proper management of the network is associated with the criteria for the selection of ventilation parameters. They result from the legislation and norms in force in the mining installations, and a number of standards, guidelines and regulations of the District Mining Offices and State Mining Authority.

A mine ventilation network is a very complex system of sidings (cross-cut, rising and inclined headings) and nodes of a fixed, at a given time, distribution of air. Any change in the network structure, even within a single heading, usually leads to changes in the air distribution in large parts of the network.
In case of changes resulting from the operational progress, the control of such a network is a relatively simple task and consists in measuring the current air flow and comparing the results with the required values. The problem comes when there is a need for a more radical intervention in the structure of the network, for example, the opening of a new heading, changing the ventilation method of the entire region, building a new general fan or incorporating into the network a new ventilation shaft.

Each time before introducing the changes in the ventilation system, it should be considered how these changes will affect the air distribution, not only in the neighboring sidings, but throughout the ventilation area, or does it affect the network balance and the quality of ventilation.

The current practice of carrying out modifications or network regulations is intuitive and is the result of considerations based on the knowledge of mining aerology, and experience of ventilation services, acquired during many years of practice. This intuitive statements regarding the ventilation condition, while dealing with the complex ventilation networks, implies a risk of making a mistake or engaging teams to arduous adjustments of networks, and in the case of an emergency, threatens the safety of people working underground.

The development of computer technology, among others, personal computers and modern programs, gave the optimal solution to the problem of calculations and analysis of the ventilation data, due to the ability to carry out any number of simulations of expected changes in the ventilation structure.

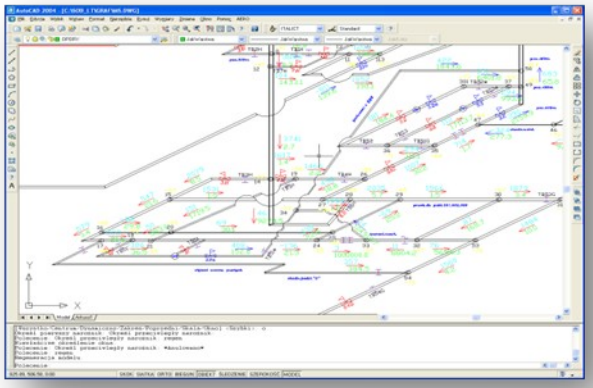
One of such solutions is to equip the mine ventilation services with the personal computer and the AERO 2014 software, which allows carrying out calculations of the current network conditions, modeling the changes, and preparing the documentation of the network parameters. The calculations are performed on-site and can be constantly updated and analyzed. In addition, the system uses the latest tool for vector graphics, which is a package of AutoCAD or BricsCAD for the graphical representation of the ventilation network.

AERO 2014 compares/balances the air distribution in underground mines. In order to effectively exploit the air distribution, a mathematical model must be created, which is based on the spatial scheme of the mine, and consists of the ventilation nodes and sidings.
The next step is to develop the so-called mine depressive photo, involving the measurement of pressure, damp and dry temperature in every node, and the air flow rate in each siding.
Knowing the geometric values of headings, altitude benchmarks and characteristics of the general fans, AERO calculates the isentropic potentials and air expenses using the Hardy Cross method in accordance with the Kirchoff's laws. Next, the model is sent to the user, and is the basis for further operation in the ventilation departments of the mine.

Functionality

Managing a ventilation network - calculating and balancing the air distribution

- Adjusting the ventilation network is based on resistance changes in any number of sidings and calculating a whole. In each siding one can take into account the value of natural depression, turn on the characteristics of a ventilator, and declare the measured values of the air flow in order to calculate the regulators (resistance or depression).
- For comparative purposes, the results of previous calculations are stored.
- There were used functions for quick retrieval of sidings, nodes or their filtering for the compilation and printing purposes (emission of data to EXCEL).

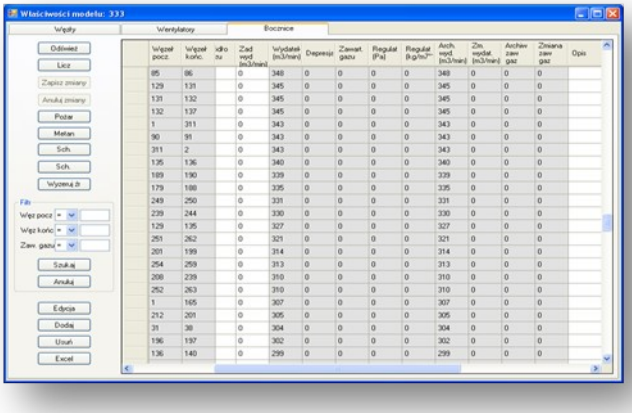


Support for spatial schemes and canonical mines in AutoCAD (BricsCAD)

- Thanks to the cooperation with the popular graphic editor AutoCAD, the system gives the comfort of analyzing all information directly on the spatial or canonical mine scheme. In the graphics mode, you can edit the data (changes in the resistance of any number of sidings), calculate the network and settle it in terms of dispersion of hazardous gases, including fire fumes. In the fire mode, the system determines the danger zone showing in red the smoky headings along with the WYDATKAMI and gas concentrations. Methane hazard zone is marked in yellow. The system also identifies the nodes of observation posts.
- The ability to generate the arrays of sidings and nodes in the fire mode allows you to quickly find a suitable place in the scheme as well as determination of the areas for formation of the security and observation posts.
- Since there is the possibility of adding any drawing layers, the schemas can be used for documentation purposes of 'The mine fire-fighting plan'.

Easy maintenance of the nodes records, and the characteristics of fans and sidings.

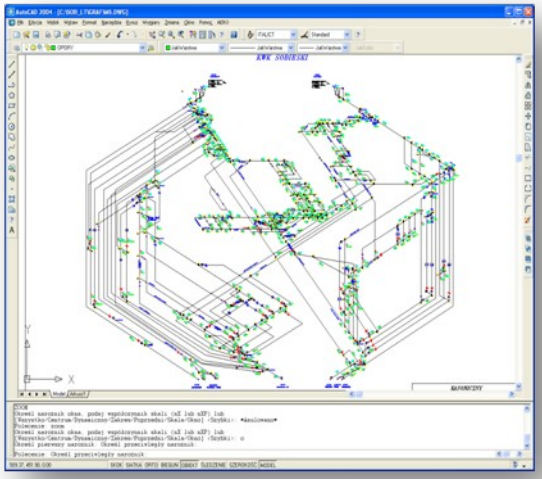
- The system uses a window interface that allows for entering and editing numerical data, amount of which has been limited to a minimum. The change in the structure of the mathematical



model can be realized only in a graphics mode - the 'Save/Remember' function updates and organizes the database automatically.

The mechanism of characteristics approximation of any number of fans, their drawing and determination of the mine equivalent orifice

- After introducing some coordinates of the fan characteristics, the system calculates the coefficients of the approximating curve, draws it, and if the fan is connected to the network, the system draws the characteristics of the mine along with the equivalent orifice.
- There are no limits on the amount of introduced characteristics, even if they are inactive in the network, and are only used for the simulation of ventilation projects.

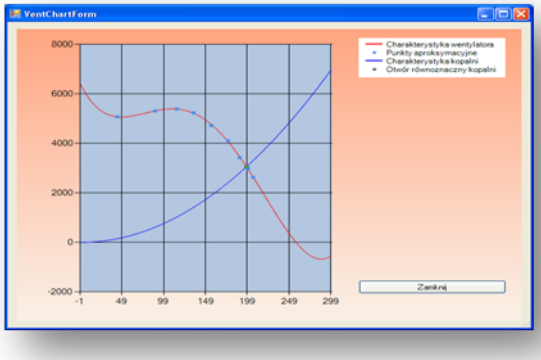


Easy-to-use user interface allowing for an easy match of the sidings with sensors of the dispatch system

- While editing a siding record, there is a function assigning a pool of automatic methanometry system sensors to the edited record. It is accomplished by choosing the sensors from the list of the used ones, and which is updated by the dispatch department.

Manual or automatic control by using the dispatch system

- At any time, the user can decide how to simulate the propagation of gases or fire fumes, taking into account the data entered manually or from the dispatching system.



The main advantages of the system

1) A siding resistance is the main parameter allowing for updating the network mathematical model (subsequently - depression with the natural depression)
2) Multi-functional and easy-to-use standard system of providing and editing data (filtering, sorting, dynamic creation of summaries and printouts)
3) A simple method of approximation of fans characteristics by introducing a number of points coordinates with an automatic calculation of the operation point and the mine equivalent orifice, along with their graphical charts.
4) A simple analysis of the ventilation network by an automatic generation of the canonical structure and the possibility of a free movement across it.
5) High speed data conversion (a model of a mine is recalculated at the time of approx. 1s.)
6) Interpretation of the calculation results is displayed directly on the graphical models - spatial and canonical.
7) A vast number of variants and easy method of duplication.
8) Most of the basic functions of the system are available due to the universal AutoCAD graphics package, which offers a vast array of functionality allowing you to quickly create spatial as well as canonical diagrams.
9) Built-in library of ventilation blocks prepared on the basis of Polish Norms with an automatic positioning and the graphic layers control (each block type and its attributes are placed on the appropriate layers).
10) Working on the graphic layers with the possibility of their unrestricted configurations and the transmission of the spatial frame to other mine departments.
11) Advanced mechanisms of controlling the accuracy of the provided data:
    a) Double sidings
    b) Proper creation of the mathematical model (closing of the mesh)
    c) Indicating the unstable fans operation (characteristics)
12) Clear and unambiguous method of showing the propagation of fire fumes (or other hazardous gases) in the percentage and volume terms, with a clear indication of the smoky and safe headings.
13) Indication of the places where observation posts and those protecting the danger zone are created.
14) The speed of data processing and vast array of options enables simulations of fire development, and allows providing the fire depression value to the calculation.
15) The ability to simulate a fire along with indicating the number of sidings with the outbreaks of fire.
16) The database section allows printing out the properly sorted (by any size) fire risk area, and due to the introduction of siding descriptions - the list of endangered sidings and observation posts.
17) The system platform (WINDOWS, ACAD) that was chosen by our company several years ago, resulted in an easy migration of the current versions of mathematical and graphical models to the modern IT tools that have become world standards and promise a safe development in the long term.
18) Works with any dispatch system
19) Modern database platform using the client-server class technology allows for multi-accessible (multi-station) work
20) Ability to define various permissions for the system users, for example: can edit or view only.

Benefits

Reducing the risk for people employed in the underground headings

- Indicating the danger areas in the case of detecting the fire fumes or other hazardous gases (CO, CO2, CH4)
- Generating lists of smoky sidings (or containing other gases)
- Generating a list of nodes where observation posts should be created
- Showing the propagation of smoke or gases on the mine spatial diagram along with indicating their concentrations, and areas for the creation of observation posts
- Work in real time with constant monitoring of the dispatch system indications
- Automatic clearing of the network and determining the danger area using the data from any number of sensors that indicate the exceedances or states of emergency
- Easy-to-use mechanism for manual simulation of smoke during a fire action in the numeric and graphical mode

Reducing the costs of ventilation activities

- No need to build expensive dams for the test regulations purposes
- No need to carry out measurements involving the measuring groups
- Unlimited number of fast simulations of any ventilation solutions
- Carrying out simulations that are free of any hazardous situations (e.g. releasing the methane bubble to the fields of lower methane categories or with electric traction)
- Costless and safe simulations using any fan characteristics
- Identifying the possible threats arising from the ventilation control methods (pumping the fans)
- Showing the mine ventilation possibilities in the case of using reversion of the general fans

Documentation

- Thanks to the vast possibilities offered by the AutoCAD graphics package, it is possible to create the whole technical documentation of the mine, along with 'the mine fire-fighting plan', which is based on the continuously updated mine spatial schema.
- The new network version of the system gives you to possibility to get live updates
- Applying the administrator control over users to secure versions of the models

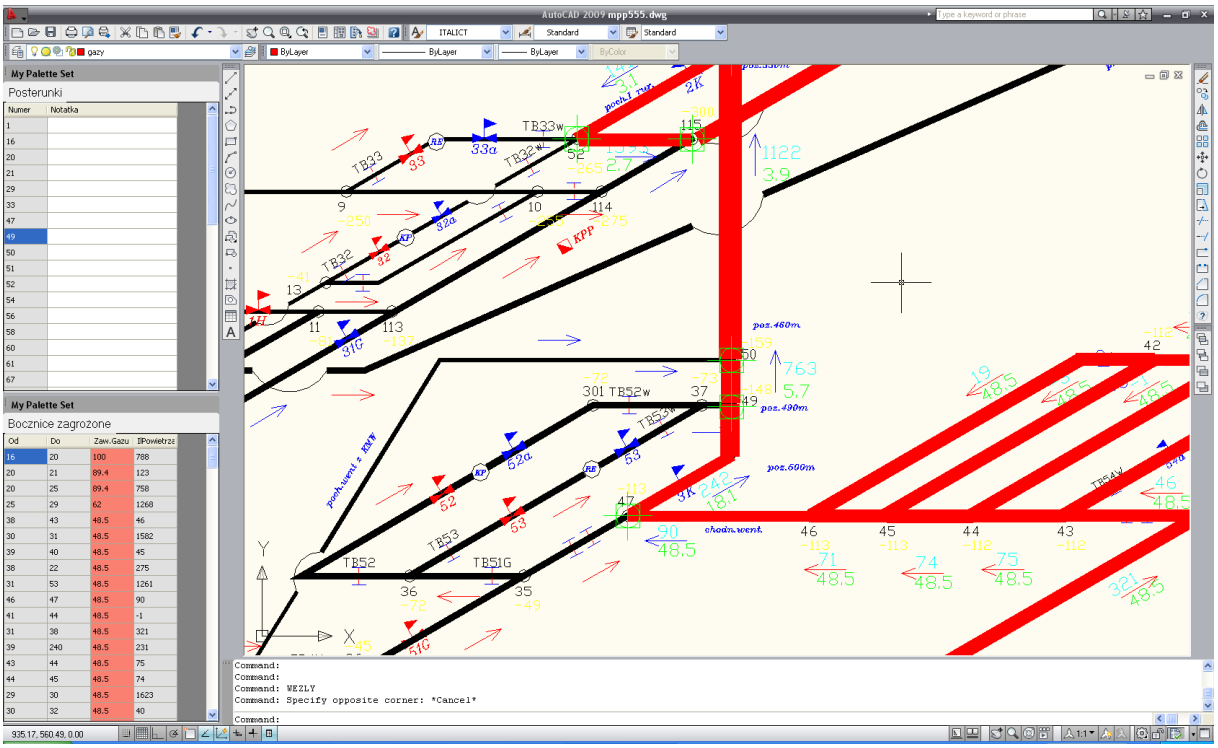
AERO offers

- A whole package of tested software, which first modules have been in use since 1986 in dozens of mines in the Silesia province
- Development proposals of the AERO system due to the cooperation with users and a team of researchers from the Department of Mining Aerology on the Silesian University of Technology in Gliwice
- Practical and theoretical knowledge resulting from multiple deployments
- Technical Support
- Licensing of the new version on multiple sites in a single mine, due to the extension of the package functionality to dispatch system: about 5 concurrent sites: 1 - ventilation; 2 - dispatch center; 2 - operation HQ
- Ability to integrate with other dispatch systems

Clients

What's new comparing to the AERO2010 version:

- Indicates the nodes where observation posts should be created
- Creates a table of nodes (posts) that can be described by a dispatcher or the officer conducting the rescue action (e.g. names of the safeguard personnel)
- Creates a table of sidings - in the case of fire simulation, it generates a list of sidings at risk, along with the risk parameters.
- Indicating a node or siding in the table allows you to quickly find their position in the diagram
- The network calculation time is decreased to less than 1 sec. For the average size of the mine structure.



Chronological list of mines where the AERO system is installed and used

1) KWK Dębieńsko
2) KWK Szczygłowice
3) KWK Staszic
4) KWK Piast
5) KWK Centrum
6) KWK Rozbark
7) KWK Powstańców Śląskich
8) KWK Wawel
9) KWK Bolesław Śmiały
10) KWK Szombierki
11) KWK Wesoła
12) KWK Julian
13) KWK Bobrek
14) KWK Pokój
15) KWK Gliwice
16) KWK Sośnica
17) KWK Halemba
18) KWK Makoszowy
19) KWK Śląsk
20) KWK Andaluzja
21) KWK Jan Kanty
22) KWK Miechowice
23) KWK Budryk
24) KWK Knurów
25) KWK Jadwiga
26) KWK Kleofas
27) KWK Polska-Wirek
28) KWK Sobieski
29) KWK Zabrze - Bielszowice
30) Silesian University of Technology

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