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## USAGE OF THE SYSTEM FOR AUTOMATIC OPTIMAL CONTROL OF VENTILATION AT BEREZOVSKIY MINE OF "BELARUSKALI" OJSC\*



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The article describes the structure of the ventilation auto-control system (VACS) as a part of the main mine fan installation in the mine workings of Berezovsky Mine, Mine Group-4, Belaruskaly.

**Key words:** ventilation auto-control system, air flow reduction, air flow augmentation, automated vent door, district fan, recirculation ventilation.

Belaruskaly is one of the world's biggest producers of potassium fertilizers. Belaruskaly operates the Starobinsky potassium salt deposit and comprises four mines and auxiliary and service departments with nearly 20,000 employees.

The Government of the Republic of Belarus has approved the Belaruskaly Development Program, with its intention to increment ore supply by means of construction and operation of Krasnolobodsky Mine, construction of a mine on Darasinsky site of the Starobinsky deposit, and inclusion of Berezovsky Mine within Mine Group-4 mine take. One of the key issues to be handled at mine planning and construction stages is the required fresh air supply of underground working areas.

The Aerology and Thermophysics Department of the Mining Institute, Ural Branch of the Russian Academy of Sciences, is a party to ventilation planning for the new mines. One of the innovations is the main mine fan installation in Berezovsky Mine, equipped with the optimized ventilation auto-control. Unlike other mines of Belaruskaly, with mine ventilation by surface fans, Berezovsky Mine has underground main ventilation fans meant to air the entire horizon of Berezovsky Mine of Mine Group-4.

The main fan procurement specification set the requirements for the ventilation auto-control system (VACS) for airing of Berezovsky Mine in view of that mining progression will be a very complicated problem owing to variability of numerous factors governing air flow in underground excavations. Each element of a ventilation network has an effect, in a varying degree, on air consumption and distribution in a mine. The situation gets even more

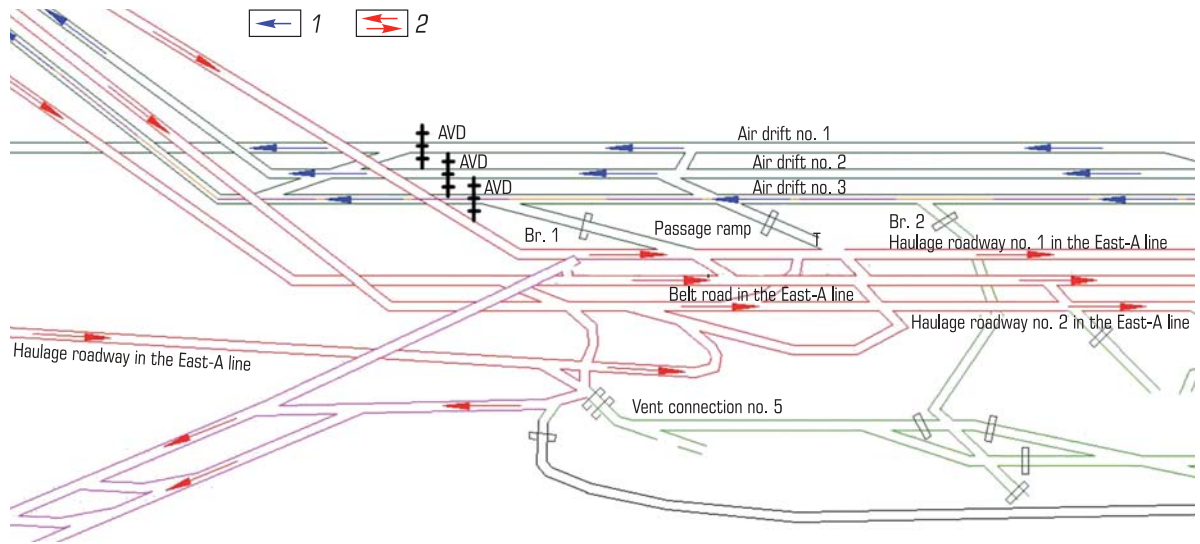
complicated as ventilation network is continuously being modified, and air feed in some working areas may be deficient as a result.

It is worth noting that the modifications due to mining advance are scheduled, time-spaced and, as a rule, come after certain efforts towards ventilation readjustment under new conditions.

The situation is different when undesirable redistribution of air flow is caused by unscheduled and short-term changes, namely, opening and closing of vent doors, construction and removal of brattice walls, switching on/off of auxiliary mine fans, flow of underground traffic, movement of lift units, winding cages, etc. These changes result in fresh air deficiency in some sections of ventilation network, which requires immediate remedy under well-targeted effort. The same after-effect ensues from increased concentration of harmful agents in return air due to sudden gas emission or fire, which also calls for immediate emergency measures of air consumption control [1].

VACS effects focused and fast response to excessive air flow rate and harmful concentration using available air flow control means. The central unit of the Berezovsky Mine VACS is the ventilation control cabinet equipped with programmable controller Simatic S7-400H with standby station meant for acquisition of data on ventilation network parameters and mine air composition, optimizing control, calculation of response action and instruction issue to control actuators in order to ensure required air flow redistribution in the mine ventilation net branches. The "optimizing control" not only means the required air supply in all areas of a mine but also cost saving and the main mine fan load minimization.

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**Fig. 1. AVD installation sites in the East-A line:**  
 1 — direction of air return; 2 — direction of intake air

AeroSfera Science and Production Association has developed, programmed, arranged and started up VACS in Berezovsky Mine. As per customer's requirements, the Aerology and Thermophysics Department of the Mining Institute, Ural Branch of the Russian Academy of Sciences, has developed the VACS optimizing control algorithm for integrated operation of main mine fans and peripheral units for air flow decrease (automatic vent doors) and increase (district fans). The operation of VACS in Berezovsky Mine is described in more details below.

The mathematical modeling of perfect air supply in working areas on Level -670 m using the AeroSet software [2, 3] has set to install 15 automated vent doors (AVD) to allow VACS redistribute air flow between users as consistent with the design values. For illustration, Fig. 1 shows arrangement of 3 AVD in the East-A line.

Furthermore, it is planned to install 3 AVD in the West-A line, 3 AVD in the East-B line, 2 AVD in the B-2 line, 2 AVD in the West-B line and 2 AVD in airways in the vicinity of shaft no. 4.

Let us dwell on the peripheral units of VACS in Berezovsky Mine, namely, the automated vent doors and district fans.

An automated vent door is the mine VACS actuator designed for automated air flow rate level control in mine workings. Dust- and gas-hazardous mines always use AVD for automatic control of air flows in mine ventilation networks.

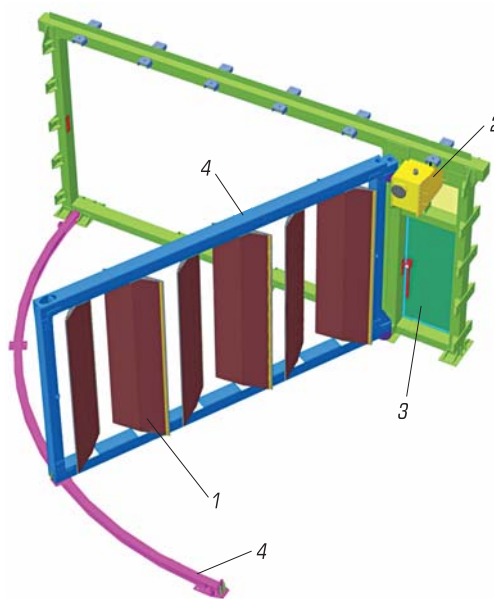
To effect air flow control, the control unit picks up the value of the design (required) air flow rate in a mine working from an information network of a mine, or from an operator's panel. The picked up value is compared with the actual

readings of the air flow sensor included in the AVD configuration, and, based on that, the control unit calculates the required turn of louver boards 1 (Fig. 2). Subsequently, on command from the control, electro-mechanical drive 2 with a built-in rate-of-turn sensor turns louver boards 1. The control unit is equipped with a built-in controller to transmit information on AVD operation in the mine information net and accept any data required.

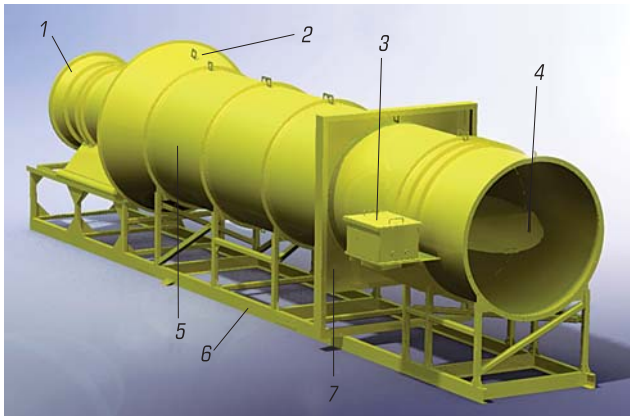
The AVD control cabinets have electrical protection facilities and data interlock and checkout means demandable for safe operation of the cabinets in mines, in accord with the current regulatory documents.

A district fan is designed with allowance for the recirculation ventilation requirements as per mining safety specifications and has mine application certifications and permits by the RF Federal Service for Ecological, Technological and Nuclear Supervision. District mine fans support recirculation and auxiliary ventilation. In airways (in case a district fan operates in the recirculation mode), air flow rate meters are installed for continuous recording of air flow rate in the given line. An air mixing box of a fan also has air flow rate meter to control air flow in recirculation mine workings. The district mine fan controller contains data on:

- design air flow rate in a certain line,  $Q_{calc}^{dir}$ ;



**Fig. 2. Automatic vent door:**  
 1 — louver boards; 2 — electromechanical drive;  
 3 — personnel passage door; 4 — pivot frame for equipment to pass; 5 — pivot frame guideway



**Fig. 3. District fan:**

1 — fan, model VME-12; 2 — air mixing box diffuser; 3 — electromechanical drive EMPv-250 of the non-return valve; 4 — non-return valve; 5 — air mixing box; 6 — common bed frame; 7 — shield for building-in in a brattice wall

- maximum permissible recirculation coefficient in this line,  $K_{rec}^{max}$ .

These data are either taken from the district fan operator's panel, or from the surface station operator's panel (in this case, the data are transmitted via the mine information net). In the latter case, the required information on  $Q_{calc}^{dir}$  and  $K_{rec}^{max}$  can also be automatically read from the database of the program "Electronic air flow rate calculation manual" developed at the Mining Institute, Ural Branch of the Russian Academy of Sciences. This program calculates air flow required for airing mine working sites and saves the calculated value in the central database. The data on the required (design) air flow rate can be automatically loaded in the central controller that transmits it to the district fan controller. The latter compares the actual air flow  $Q_{fact}^{dir}$  and the design air flow  $Q_{calc}^{dir}$ , calculates appropriate compensation factor and changes the district fan delivery by changing the fan impeller speed.

In this manner, a district fan continuously maintains the actual air flow  $Q_{fact}^{dir}$  in a given line in full accordance with the design air flow rate  $Q_{calc}^{dir}$  in this line. In addition, the current recirculation coefficient  $K_{rec}$  is permanently recorded as a ratio of the air flow rate in a recirculation airway to the air flow rate in the given line. In case the current  $K_{rec}$  exceeds the permissible  $K_{rec}^{max}$ , the district fan:

- decreases delivery down to a level when  $K_{rec} \leq K_{rec}^{max}$  (if the district fan is not included in the central ventilation control system) and warns the surface station operator about the permissible value excess;

- increases delivery so that  $K_{rec} \leq K_{rec}^{max}$ ,  $Q_{calc}^{dir} = Q_{fact}^{dir}$ ;
- if VACS includes AVD, the central computer allocates AVD so that to fulfill the following conditions:  $K_{rec} \leq K_{rec}^{max}$ ,  $Q_{calc}^{dir} = Q_{fact}^{dir}$  and  $N_{MMF} \rightarrow \min$ , where  $N_{MMF}$  — the main mine fan power.

The operation of a district fan is variable depending on the current structure of a particular mine ventilation control. The simplest operating mode is local airing. The most efficient and

complicated is operation within the VACS structure, with the central control over the main mine fan and AVD (if any), as implemented in the Berezovsky Mine VACS project.

A district fan includes methane sensor for continuous methane concentration control in recirculation mine workings. The sensor switches off the fan upon the methane concentration rise up to 30 % MAC value.

District fans are equipped with a non-return valve to shut down the air mixing box when the fan is de-energized, and prevent from air locking in-between air supply shaft and air-end way. The valve has an uninterruptable power supply which automatically closes the valve under the district fan blackout.

The uninterruptable power supply also powers the fan sensors that transmit data to the surface station operator for 2 h after the district fan de-energization, providing on-the-fly data on emergency situations in the mine.

At the present time, the ventilation auto-control system has been assembled, tested and commissioned in Berezovsky Mine. The project implementation by Mine Group-4 will enable enhancement of annual sylvinitic ore output from 12 to 18 Mt at the half as much energy consumed by the mine ventilation.

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