MANAGEMENT OF THE VENTILATION NETWORK AT VULCAN MINING UNIT

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ABSTRACT*: Healthy and safe working conditions in the underground especially in those areas with hazard of potential atmospheres, shall depend mainly on the production implementation and the management of the ventilation system. Improving the management of the ventilation system involves thorough and complex analyses of the ventilation network, i.e. a huge amount of data to be processed only by IT. This paper shows an analysis of the ventilation network at Vulcan Mining Unit, with the use of the IT to simulate certain situations that may come up in the ventilation system*

KEYWORDS: ventilation, ventilation networks, aerodynamic parameters, fans

1 INTRODUCTION

The best management of the ventilation network used by a mine involves the use of the IT with the view to performing relevant analyses and to successfully preventing the occurrence of hazardous situations. Expert software can simulate the occurrence of the alterations that may come up in the ventilation system considering certain possible hypotheses.

2 GENERALS

For getting the best possible working conditions in underground, it is necessary to provide the primary protection, i.e. a suitable ventilation. The purpose of this ventilation is to: [1], [3]

- provide the concentration in oxygen necessary for the personnel currently working in underground;
- dilute the explosive and/or toxic gases existing in the mine network;
- diminish the heat emitted inside mine workings, both due to human activities and to thermal gradient.

A good ventilation of each mine working involves the best possible repartition of air flows along each branch of the ventilation network. In this spirit it is necessary to settle the ventilation network of each mine. An example of complex ventilation network is the one belonging to Vulcan mine. [2]

3 DESCRIPTION OF THE VENTILATION NETWORK OF VULCAN MINE

The ventilation network of Vulcan mine was quite complex. At present it has diminished because of some accidents (such as explosions) and due to the depletion of the useful mineral deposits. Therefore, the ventilation network includes four ventilation shafts: Chorin Shaft, Prokop Shaft and X Shaft - Valea Arsului. It also includes three ventilation raises with the related ventilation stations (B'Allomas Raise, Karollus Raise and Ionaşcu Raise) and underground mine workings located on four levels (level 315; level 360; level 420; level 480). These mine workings are made of main cross sectional galleries, directional galleries, diagonal galleries, plain cross sectional galleries, inclines, working faces, connection raises.

The whole ventilation network includes 251 junctions (knots) and 300 branches. [2]

4 PROVIDING THE SOLUTION FOR THE VENTILATION NETWORK OF THE MINE [2], [4]

For providing the best solution available for such a complex ventilation network, we have used the Hardy-Cross method for successive approximation. This method represents the grounds of an expert software CANVENT designed in Canada . [4] This software helped us to provide the solution for the ventilation network as well an optimization of the air flow distribution within the ventilation branches.

The settlement of the ventilation network related to Vulcan mine made necessary to run several stages:

a) Marking the junctions of the ventilation network on the spatial diagram;

b) Determining the geodesic coordinates of the identified junctions;

c) Inputting the geodesic coordinates of junctions and the existing branches into the database of the software;

d) The carrying out of measurements in situ; these measurements include:

1. measurements of the aerodynamic parameters of mine workings;
2. measurements of the geometrical parameters of mine workings;
3. measurements of the physical parameters of the air;

e) Calculation of aerodynamic strength specific to each branch;

f) Inputting the values of parameters specific to the ventilation network into the expert software CANVENT;

g) The 2D or 3D drawing of the ventilation network;

h) Balancing the ventilation network;

i) Settling the ventilation network. Both the direction and the optimum distribution of the air flows along each branch are being identified in this stage;

j) Getting the results.

This final stage provides the data on electronic support or paper regarding the graphic settlement of the ventilation network.

5 SIMULATIONS IN THE VENTILATION NETWORK [2], [3], [4]

CANVENT software allows to simulate certain changes that may come up in the ventilation network. Hence, the following situations have been simulated out the ventilation network of Vulcan Mine:

a) removal of the air outlet circuit from no. 4/3/VI towards Terezia raise (360 - 420);

Simulation no. 1 - removal of the air outlet circuit from no. 4 / 3 / VI towards Terezia raise (360 - 420).

This simulation involves the placing of sealing structures on the connectivity gallery with the raise no. 3 bl. VI, branch 100-101 and on the raise no. 4 floor, branch 92-93.

The placing of these sealing structures removed the following branches from the ventilation system: 92-93; 93-94; 94-95; 95-96; 96-97; 97-98; 98-99; 99-100 and 100-101.

As a result of this removal and to maintain the specified flow rate at the longwall no. 2, bed 3, bl. VI, the regulating door on the transverse gallery, level 420 (branch 75-101) was eliminated.

The alteration carried out for this simulation are shown in Figure no. 1.

We have got the following results that can be compared to the present situation:

- The air flow rate along the fresh air intake at the level 360, branches 22-23; 15-24; 30- 31; 193-194 increased from 33.91 m^3/s to 34.54 m^3/s (from 2035 m^3/min to 2073 m^3/min);
- The air flow rate at the face working with undermined coal layer no. 2 bed 3 bl. VI didn't change significantly;
- The air flow rate along the ventilation incline 360-315 increased from 16.03 m^3/s to 16.98 m^3/s (from 962 m^3/min to 1019 m^3/min);
- The air flow rate at the face working with undermined coal layer no. 4 bed 3 bl. VI changed from 2.1 m^3/s to 2.8 m^3/s;
- The air flow rate at the longwall no. 0, bed 3, bl. VIII, level 376 m and at the longwall no. 0, bed 3, bl. VIII, level 386, didn't change significantly;
- The air flow rate increased from 8.19 m^3/s to 8.76 m^3/s (approx. 34 m^3/min) along the air outtake related to longwall no. 2 bed 3 bl. VI (branch 181-183) level 480;

• The air flow rate diminished from 5.18 m^3/s to 4.01 m^3/s (approx. 70 m^3/min) along the air outtake related to longwall no. 4 bed 3 bl. VI (branch 90-89) level 360;

• The air flow rates didn't change significantly along the air outtake of longwalls no. 0 bed 3 bl. VIII, level 376 m and no. 0 bed 3 bl. VIII, level 386 m (branches 249-208 ; 152-153);

• Virtually, the air flow rates stayed the same in the mine (branches 240-242, 235-237).

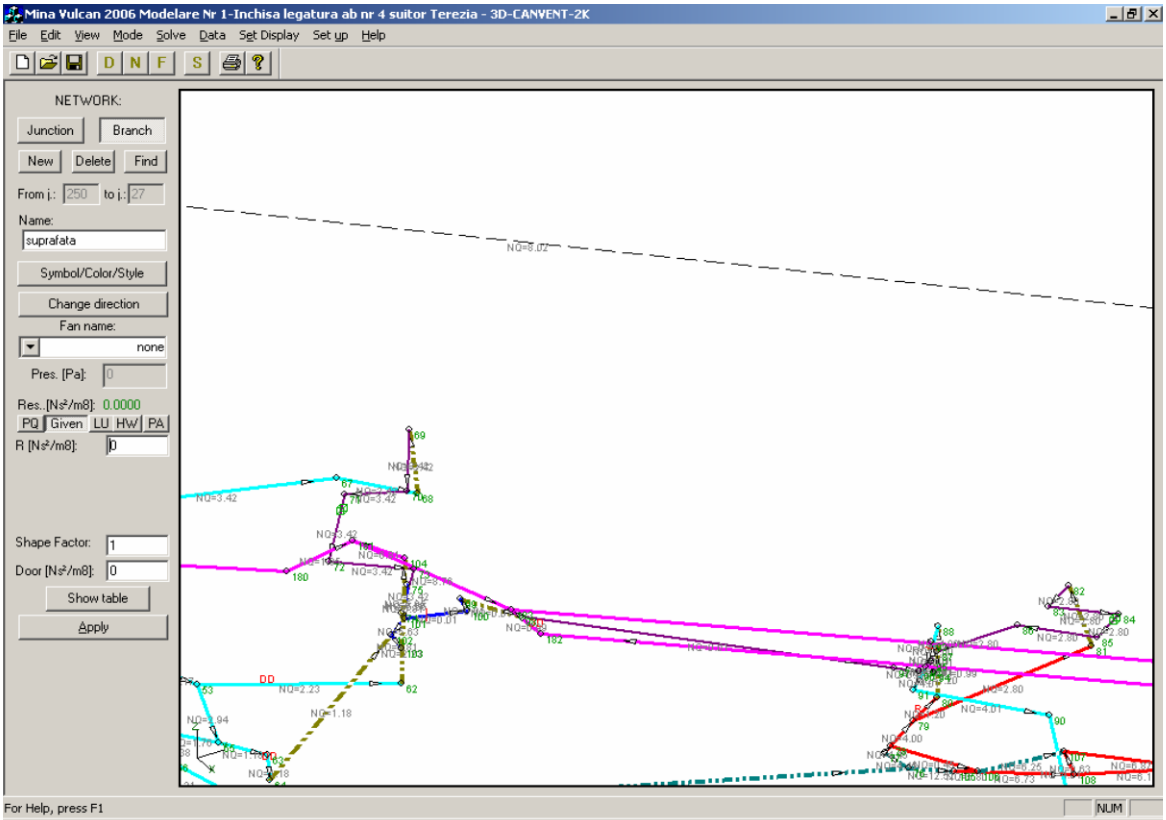

Figure no. 1 [4]

b) the tank from the skip is empty and the door in the gallery that connects the tank with the skip (the upper part of the tank) is open and the collecting tank, level 360, is full;

Simulation no. 2 - the tank from the skip is empty and the door in the gallery that connects the tank with the skip (the upper part of the tank) is open and the collecting tank, level 360, is full.

To carry out this simulation, we take as closed the circuit between the outtake of longwall no. 4 bed 3 bl. VI, level 360 m and the transverse gallery Terezia raise level 420 m, i.e. simulation no. 2 relies on simulation no. 1.

The removal of the door on the gallery that connects the skip to the upper part of the tank level 387 m (branch 8-15) removed the initial strength of 5 Ns^2/m^8 on the connecting tank, branch 14-15; thus we simulated the empty tank.

Also, we increased strength on the collecting tank, level 360 m (branch 46-48) and simulated the full silo.

The alteration carried out for this simulation are shown in Figure no. 2.

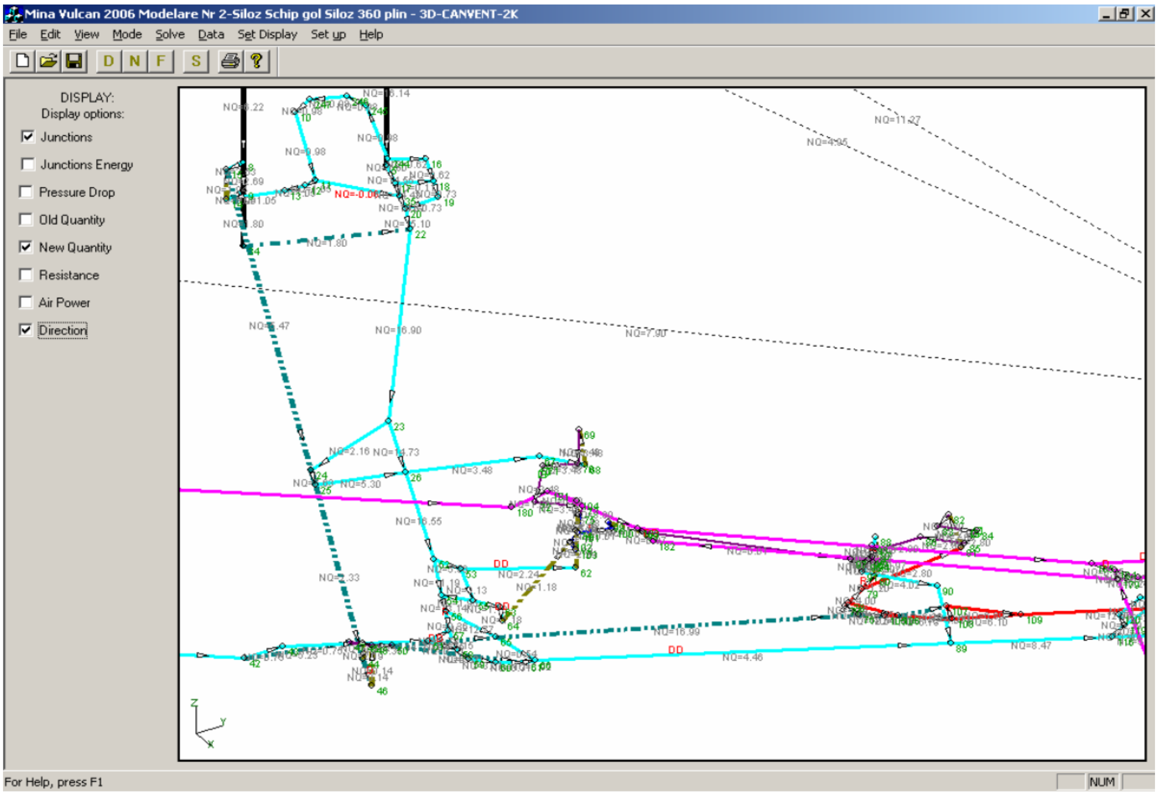

Figure no. 2 [4]

We have got the following results that can be compared to the present situation:

- The air flow rate along the fresh air intake at the level 360, branches 22-23 ; 15-24 ; 30-31 ; 193-194 increased from 33.91 m^3/s to 34,65m^3/s;
- The air flow rate at the face working with undermined coal layer no. 2 bed 3 bl. VI didn't change significantly;
- The air flow rate along the ventilation incline 360-315 increased from 16.03 m^3/s to 17 m^3/s;
- The air flow rate at the face working with undermined coal layer no. 4 bed 3 bl. VI changed from 2.1 m^3/s to 2.8 m^3/s;
- The air flow rate at the longwall no. 0, bed 3, bl. VIII, level 376 m and at the longwall no. 0, bed 3, bl. VIII, level 386 m, didn't change significantly;
- The air flow rate increased from 8.19 m^3/s to 8.80 m^3/s along the air outtake related to longwall no. 2 bed 3 bl. VI (branch 181-183) level 480 m;
- The air flow rate diminished from 5.18 m^3/s to 4.03 m^3/s along the air outtake related to longwall no. 4 bed 3 bl. VI (branch 90-89) level 360;
- The air flow rates didn't change significantly along the air outtake of longwalls no. 0 bed 3 bl. VIII, level 376 m and no. 0 bed 3 bl. VIII, level 386 m (branches 249-208 ; 152-153);
- Virtually, the air flow rates stayed the same in the mine (branches 240-242, 235-237).

c) the tank from the skip is full and the door in the gallery that connects the tank with the skip (at the upper part of the tank) is closed and the collecting tank, level 360, is empty;

Simulation no. 3 - the tank from the skip is full and the door in the gallery that connects the tank with the skip (at the upper part of the tank) is closed and the collecting tank, level 360, is empty.

To carry out this simulation, we take as closed the circuit between the outtake no. 4 bed 3 bl. VI, level 360 m and the transverse gallery Terezia raise level 420 m, i.e. simulation no. 3 relies on simulation no. 1.

We reduced the strength of the collecting tank level 360 m and thus we simulated the situation when the tank is empty. Also, we increased strength on the tank from the skip to simulate the case when the tank is full.

Figure no. 3 shows the alterations made for this simulation. [4]

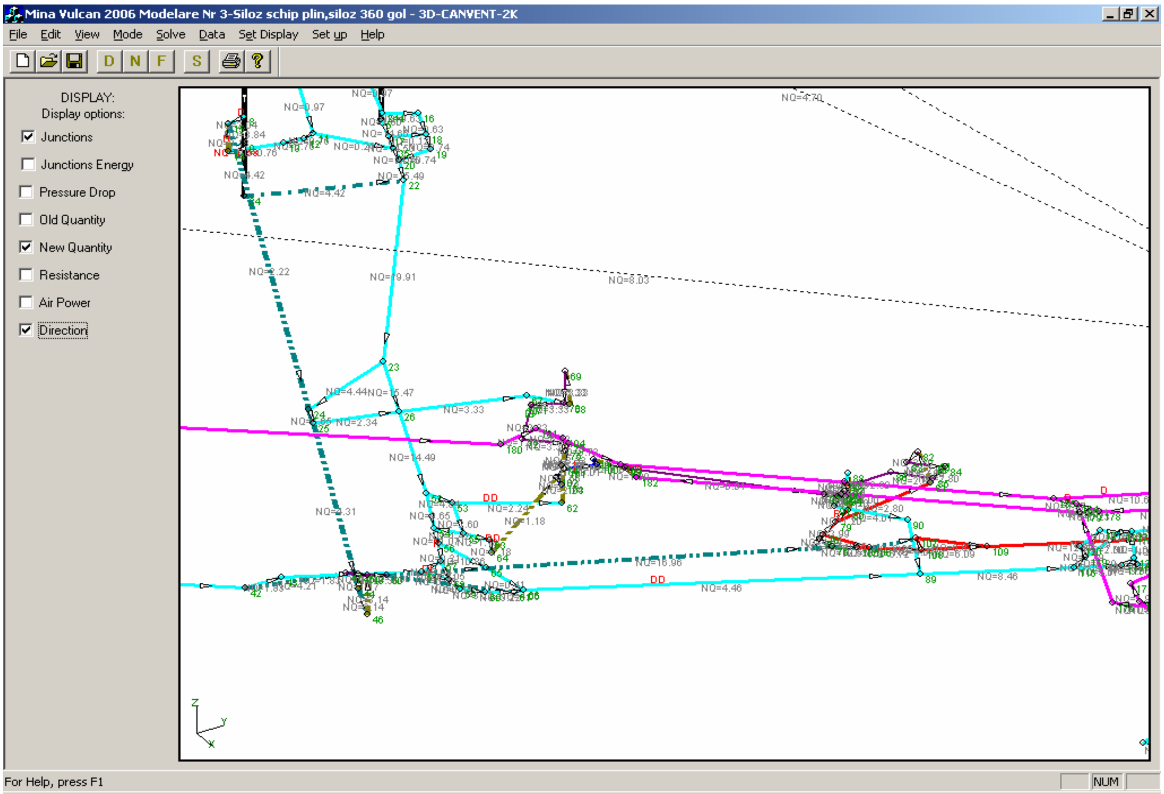

Figure no. 3 [4]

We have got the following results that can be compared to the present situation:

- The air flow rate along the fresh air intake at the level 360 m, branches 22-23; 15-24; 30-31; 193-194 increased from 33.91 m^3/s to 34,46 m^3/s;
- The air flow rate along the connecting raise (branch 25-44) increased from 1.8 m^3/s to 4.31 m^3/s;
- The air flow rate at the face working with undermined coal layer no. 2 bed 3 bl. VI didn't change significantly;
- The air flow rate along the ventilation incline 360 - 315 increased from 16.03 m^3/s to 16.97 m^3/s;
- The air flow rate at the face working with undermined coal layer no. 4 bed 3 bl. VI increased from 2.1 m^3/s to 2.8 m^3/s;
- The air flow rate at the longwall no. 0 bed 3 bl. VIII, level 376 m, ant at the longwall no. 0 bed 3 bl. VIII, level 386 m, didn't change significantly;
- The air flow rate along the air outtake of longwall no. 2 bed 3 bl. VI (branch 181-183) at the level 480 m, increased from 8.19 m^3/s to 8.72 m^3/s;
- The air flow rate along the air outtake of longwall no. 4 bed 3 bl. VI (branch 90-89) at the level 360 m, diminished from 5.18 m^3/s to 4.02 m^3/s;
- The air flow rate along the air outtake of longwall no. 0 bed 3 bl. VIII, level 376 m and of longwall no. 0 bed 3 bl. VIII, level 386 m (branches 249-208 ; 152-153) didn't change significantly;
- Virtually, the air flow rates stayed the same in the mine (branches 240-242 and 235-237).

d) the tanks from the skip is empty and the door in the gallery that connects the tank with the skip is open and the connecting tank, level 360, is empty;

Simulation no. 4 - the tanks from the skip is empty and the door in the gallery that connects the tank with the skip is open and the connecting tank, level 360, is empty.

To carry out this simulation, we considered the simulation no. 1 where the connection between the outtake of longwall no. 4 bed 3 bl. VI, level 360 m and Terezia raise, level 420 m, is closed.

We reduced the strength from the raise of the skip (branch 14-15) and simulated the situation when the tank from the skip is empty. The ventilation door on the gallery that connects the skip to the upper side of the raise (branch 8-15) was eliminated. We also reduced the strength of the collecting tank level 360 m (branch 46-48) and simulated the situation when the collecting tank is empty.

Figure no. 4 shows the alterations made for this simulation.

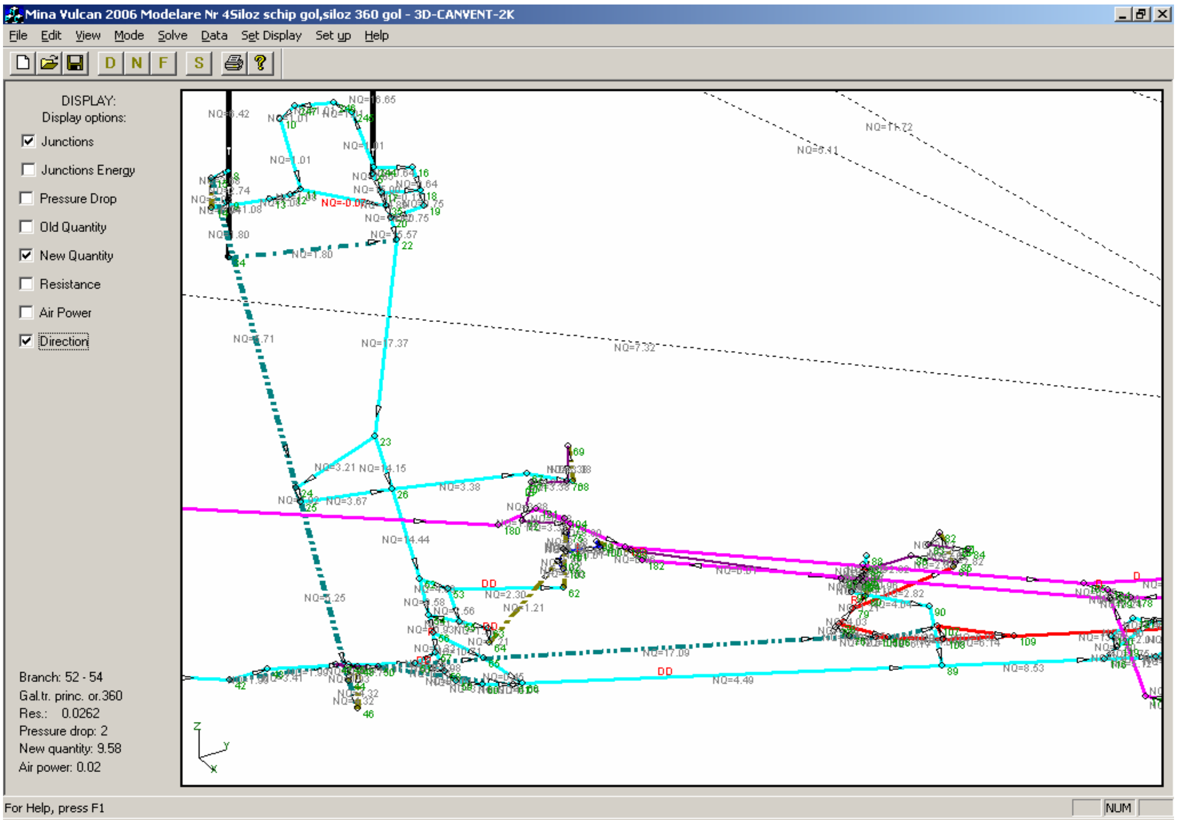

Figure no. 4 [4]

We have got the following results that can be compared to the present situation:

- The air flow rate along the fresh air intake at the level 360 m, branches 22-23 ; 15-24 ; 30-31 ; 193-194, increased from 33.91 m^3/s to 34.85 m^3/s;
- The air flow rate along the connecting raise (branch 44-45) diminished from 1.8 m^3/s to 0.92 m^3/s;
- The air flow rate on the connecting gallery (branch 8-15) increased from 2.18 m^3/s to 3.68 m^3/s;
- The air flow rate at the face working with undermined coal layer no. 2 bed 3 bl. VI didn't change significantly;
- The air flow rate along the ventilation incline 360 - 315 increased from 16.03 m^3/s to 17.09 m^3/s;
- The air flow rate at the face working with undermined coal layer no. 4 bed 3 bl. VI increased from 2.1 m^3/s to 2.8 m^3/s;
- The air flow rate at the longwall no. 2 bed 3 bl. VIII, level 376 m and at the longwall no. 0 bed 3 bl. VIII, level 386 m, didn't change significantly;
- The air flow rate along the air outtake of the longwall no. 2 bed 3 bl. VI (branch 181-183) at the level 480, increased from 8.19 m^3/s to 8.79 m^3/s;
- The air flow rate along the air outtake of the longwall no. 4 bed 3 bl. VI (branch 90-89) level 360 m, diminished from 5.18 m^3/s to 4.05 m^3/s;
- The air flow rates along the air outtake of the longwall no. 0 bed 3 bl. VIII, level 376 m, and of the longwall no. 0 bed 3 bl. VIII, level

386 m (branches 249-208 ; 152-153) didn't change significantly;

- Virtually, the air flow rates stayed the same in the mine (branches 240-242 and 235-237).

e) the tank from the skip is full and the door in the gallery that connects the tank with the skip is closed and the connecting tank, level 360, is full;

Simulation no. 5 - the tank from the skip is full and the door in the gallery that connects the tank with the skip is closed and the connecting tank, level 360, is full

To carry out this simulation, we take simulation no. 1 as the starting point.

We also increased the strength: on the tank of this skip (branch 8-15) to simulate the situation when the tank of the skip is full and on the collecting tank level 360 m (branch 46-48) to simulate the situation when the collecting tank is full.

Figure 5 shows the alterations made for this simulation.

We have got the following results that can be compared to the present situation:

- The air flow rate along the fresh air intake at the level 360 m, branches 22-23; 15-24; 30-31; 193-194, increased from 33.91 m^3/s to 34.33 m^3/s;
- The air flow rate along the connecting raise (branch 44-45) increased from 1.8 m^3/s to 2.03 m^3/s;
- The air flow rate on the connecting gallery (branch 8-15) diminished from 2.18 m^3/s to 1.98 m^3/s;
- The air flow rate at the face working with undermined coal layer no. 2 bed 3 bl. VI didn't change significantly;
- The air flow rate along the incline for acces to the base of the shaft with skip (branch 34-22) increased from 3.19 m^3/s to 4.34 m^3/s;
- The air flow rate at the face working with undermined coal layer no. 4 bed 3 bl. VI increased from 2.1 m^3/s to 2.79 m^3/s;
- The air flow rate at the longwall no. 0 bed 3 bl. VIII, level 376 m and at the longwall no. 0 bed 3 bl. VIII, level 386 m, didn't change significantly;
- The air flow rate along the air outtake of the longwall no. 2 bed 3 bl. VI (branch 181-183) at the level 480 m, increased from 8.19 m^3/s to 8.73 m^3/s;
- The air flow rate along the air outtake of the longwall no. 4 bed 3 bl. VI (branch 90-89) level 360 m, diminished from 5.18 m^3/s to 4.0 m^3/s;
- The air flow rates along the air outtake of the longwall no. 0 bed 3 bl. VIII, level 376 m, and of the longwall no. 0 bed 3 bl. VIII, level 386 m (branches 249-208 ; 152-153) didn't change significantly;
- Virtually, the air flow rates stayed the same in the mine (branches 240-242 and 235-237).

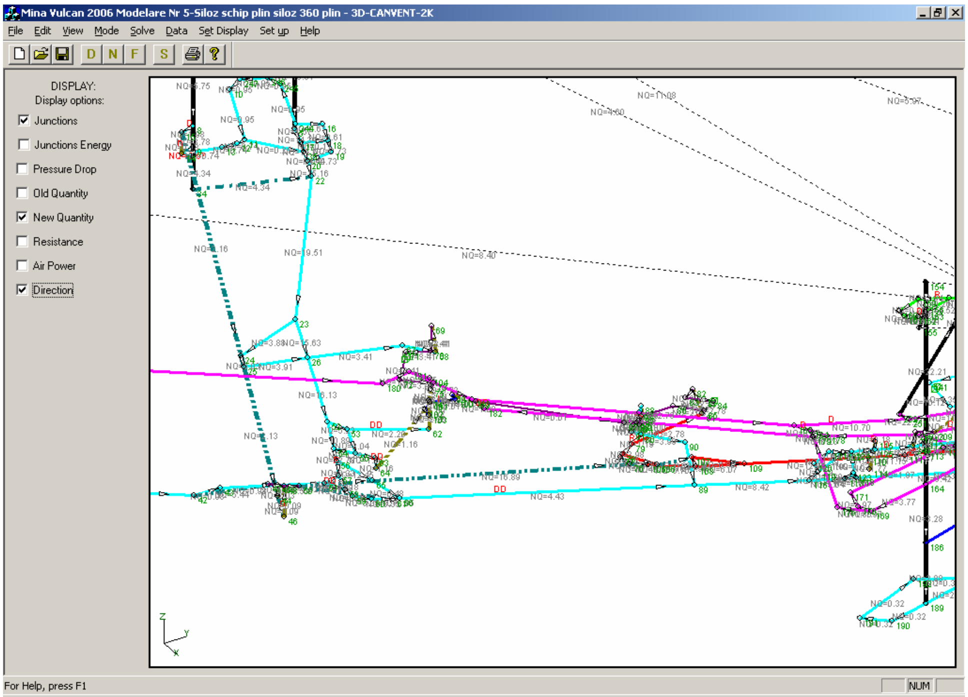

Figure no. 5[4]

f) case when the working face no. 1 / 3 / VIII level 366, is put to operation.

Simulation no. 6 - case when the working face no. 1 / 3 / VIII level 366, is put to operation.

To carry out this simulation, we have taken into consideration the simulation no. 1.

We have also introduced new knots: 21, 26, 49, 139, 140, 168, 175, 177, 228, 230, 241, based on the topographic coordinates got from the topo department of Vulcan Mining Unit. We have also introduced new branches: 12-21, 21-26, 26-49, 49-139, 139-140, 140-168, 168-175, 175-177, 177-228, 228-230, 230-241, 114-241, 241-215.

Consequently we have simulated the existence of a new longwall (no. 1 bed 3 bl. VII, level 366 m) in the current network of the mine, with the air intake on level 315 m on the transverse gallery no. 1 (branch 12-21) and the air outtake is on the raise in the floor no. 2 bed 3 bl. VIII (branch 241-115).

The presence of this new longwall unbalanced the distribution of air flow rates on the circuits related to the ventilation network of Vulcan Mine. Consequently, it was necessary to:

– remove the ventilation door in the transverse gallery no. 2 bed no. 3 bl. BII, level 360 m (branch 115-125);

– place a regulating door in the access gallery to raise no. 2 bed no. 3 bl. VII, roof of level 315 m (branch 110-114);

– place a regulating door in the directional gallery bl. VII-VIII, level 315 m (branch 113-126);

– place a sealing door in the raise no. 1 bl. VIII, level 315-360 m (branch 130-181) for balancing the ventilation network and getting a normal distribution of air flow rates, especially at longwalls.

Figure no. 6 shows the alterations made for this simulation.

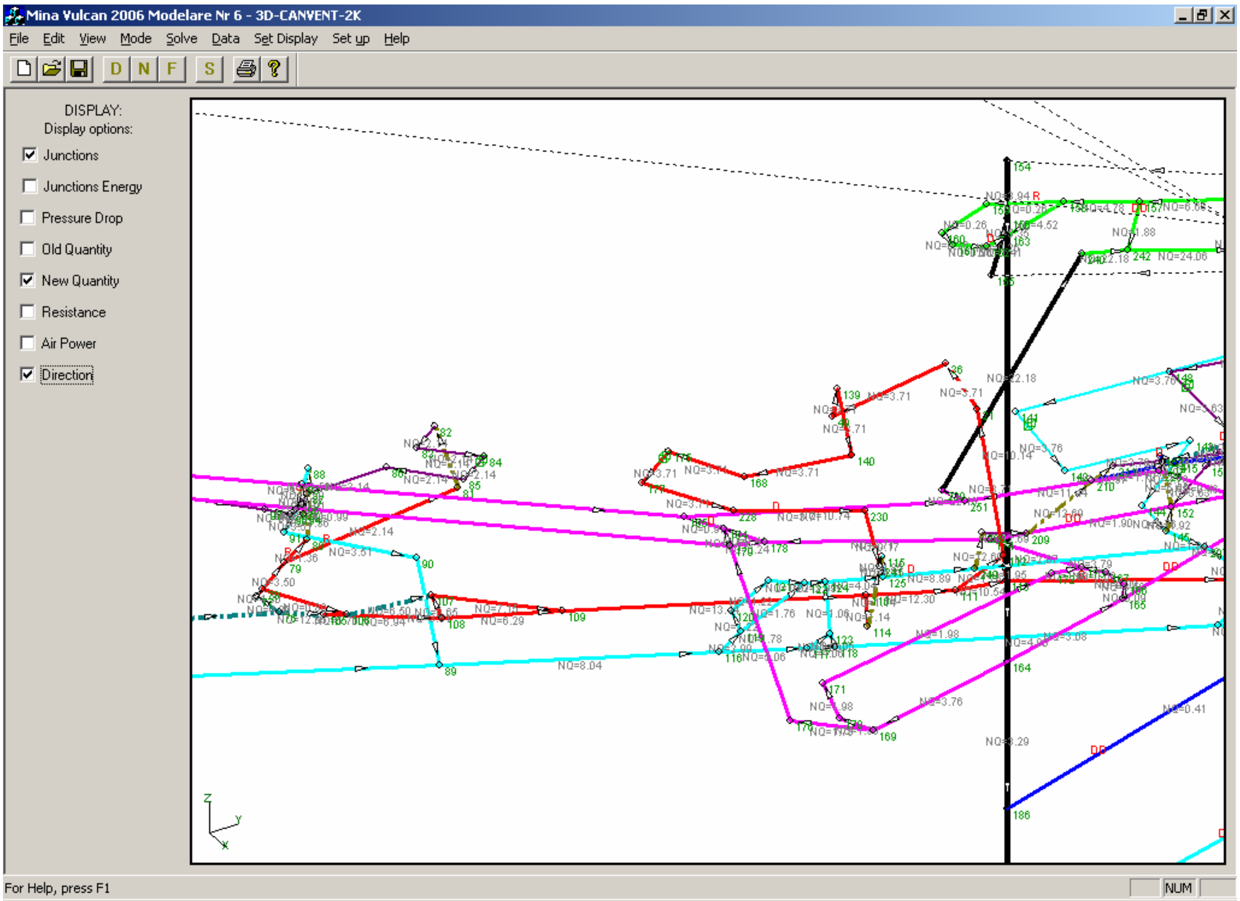

Figure no. 6 [4]

We have got the following results that can be compared to the current situation:

- The air flow rate along the fresh air intake at the level 360 m, branches 22-23; 15-24 ; 30-31 ; 193-194 increased from 33.91 m^3/s to 34.39 m^3/s;
- The air flow rate at the face working with undermined coal layer no. 2 bed 3 bl. VI didn't change significantly;
- The air flow rate along the ventilation incline 360 - 315 increased from 16.03 m^3/s to 16.77 m^3/s;
- The air flow rate at the face working with undermined coal layer no. 4 bed 3 bl. VI didn't change significantly;
- The air flow rate at the longwall no. 1 bed 3 bl. VII reached 3.67 m^3/s, i.e. the value stated in the ventilation project for this longwall;
- The air flow rate at the longwall no. 0 bed 3 bl. VIII, level 376 m and at the longwall no. 0 bed 3 bl. VIII, level 386 m, reduced insignificantly;
- The air flow rate along the air outtake of the longwall no. 2 bed no. 3 bl. VI (branch 181-183), level 480 m, increased from 8.19 m^3/s to 8.79 m^3/s;
- The air flow rate along the air outtake of the longwall no. 4 bed no. 3 bl. VI (branch 90-89), level 360 m, diminished from 5.18 m^3/s to 3.46 m^3/s;
- The air flow rate along the air outtake of the longwall no. 1 bed no. 3 bl. VI (branch 125-249), level 360 m, increased from 7.18 m^3/s to 8.80 m^3/s;
- The air flow rate along the air outtake of the longwall no. 0 bed 3 bl. VIII, level 376 m and of the longwall no. 0 bed 3 bl. VIII, level 386 m (branches 249-208 ; 152-153), didn't change significantly;
- Virtually, the air flow rates stayed approx. the same in the mine (branches 240-242 and 235-237);
- The air flow rate along the directional gallery bl. VII - VIII (branch 113-126) diminished from 10.95 m^3/s to 8.52 m^3/s;
- The air flow rate along the raise no. 1 bed no. 3 bl. VIII (branch 130 - 131) diminished from 2.75 m3/s to 1.18 m^3/s.

6 CONCLUSIONS

- Giving solutions for the ventilation networks with the help of the it is a huge step forward that allows an optimum ventilation and a visualisation of the changes made on the network in real time.
- The ventilation network given as example belongs to Vulcan mine and includes 4 shafts, 3 ventilation raises, 4 levels and several underground workings (cross-sectional galleries, directional galleries, diagonal galleries, inclines, connection raises and working faces).
- The best solutions available for the ventilation network of Vulcan mine have been obtained with the help of the Canadian software called CANVENT. It includes the run of 10 main steps.
- We have been able to perform 6 simulations on this software that involved certain changes which might come up in the ventilation network.
- Giving solutions for the ventilation network with the help of IT allows the best possible solutions irrespective of its complexity.

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