PRIOR ESTABLISHMENT OF WORK ENVIRONMENT CHARACTERISTICS IN CASE OF THE OCCURRENCE OF AN UNDERGROUND EXPLOSION

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ABSTRACT: *The explosion-type phenomenon is an extremely complex physico-chemical process leading to the physical change of objects and objectives met on the propagation pathway as well as to the chemical change of underground atmosphere in the area of influence.During the development of the explosion-type phenomenon, due to the energy of the dynamic wave, there are generated significant mechanical effects at the level of the affected mining works as well as at the level of ventilation constructions. In addition, due to intense burning reactions at high temperatures, there occur major effects related to the composition and concentration of the underground atmosphere in the area of influence.Changes, respectively perturbations occurring after the event at the level of underground works or coal faces, endanger the entire working staff and may lead to the occurrence of similar phenomena. An explosion has direct effect upon the ventilation network due to the change of operational parameters of main ventilation fans. This leads to a different post-event natural repartition of air flows at branch level. Also, the underground atmosphere in the coal face changes, fact which leads to the increase of the potential risk of a new underground explosion occurrence, respectively to major difficulties regarding the withdrawal of work staff affected and of specialized intervention staff.Prior establishment of post-event work environment is performed through simulations on a ventilation network using the Australian VENTSIM VISUAL ADVANCED software.*

KEYWORDS: ventilation network, explosion, work environment, VENTSIM modelling software

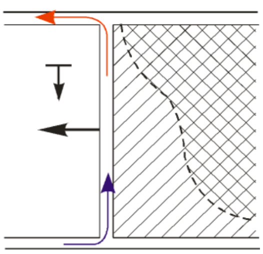
1.REGIME OF METHANE RELEASES FROM FRONT COALFACES

Methane release within a coalface is a complex phenomenon depending in value and intensity on a series of natural-geological and technological factors [2]. Of the geological factors there can be mentioned: gas content of the coal bed in exploitation and of the surrounding rocks, presence of accompanying coal beds, physico-mechanical properties of coal and surrounding rocks, geometric parameters of coal beds, tectonics of the deposit, exploitation depth etc., and of th e technological exploitation factors there is highlighted the applied exploitation method, volume of achieved production, advancing speed of the coalface, direction of exploitation, manner of directing the surrounding rocks pressure.

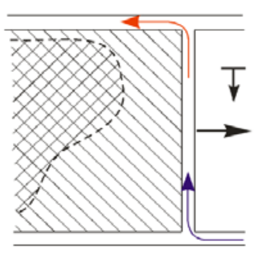
Methane releases generally have an uniform character, however existing situations in which methane concentrations increase sharply up to values higher than average values, sometimes exceeding the values allowed by the OHSR. These sharp increases are due to several causes, the most frequent ones being disturbances within the general and partial ventilation and methane migration from the goaf.

Regime of methane releases from front coalfaces

Repartition of methane concentrations in the goaf depends on the advancing manner of the coalface and of their ventilation manner, presented in Fig 1. a) and b).



a) Retreating coalface with U type ventilation



b) Retreating coalface with Z type ventilation

Fig. 1

In exploitation methods with long poles on the direction, methane arising from the goaf has a smaller share within the total methane balance of the coalface. This is due to initial degassing of the coal bed following the shaping of the exploitation pole through preparation workings and due to a higher aerodynamic resistance of the goaf generated by the compaction of rocks as results of the mining pressure redistribution. The compaction process of rocks within the goaf ends at a distance of 80-100 m behind the edge of the coalface (Fig.2). At this distance, the movement of rocks from the roof and their fissuring decreases, having as a result the decrease of goaf permeability level, fact which hinders the migration of methane.

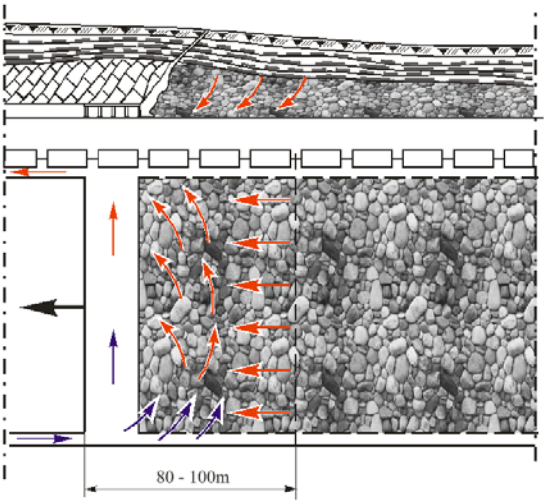


Fig. 2. Methane migration through goafs

Regime of methane releases from undermined coalfaces

The undermined coal bed exploitation method has several characteristics related to methane releases, as follows:

-methane release arises both from the coal bed in exploitation (basic release), as well as from surrounding coal beds from the roof an floor of the one in exploitation (additional release);

-rocks movements occurring during the operation of the coalface generate crushing or shearing phenomena which have as effect the change of coal structure, releasing adsorbed and absorbed gas.

Depending of the production extracted from the coalface during its' exploitation, gas emission rises up to the double of the initial value. Due to the fact that the width of the undermined coal bed is high, the height of the crushed and fractured area increases, case in which the methane emission from neighbouring coal beds increases significantly. Gas accumulation takes place in the upper part of the supporting and nearby the coal discharge window, so that the concentration of methane may reach 3-5 % vol. and sometimes even 25-85% vol.

Another factor which has to be taken into account for the actual appreciation of gas-dynamic regime is represented by the methane concentration within the air exhaust current, depending on time Fig. 3.

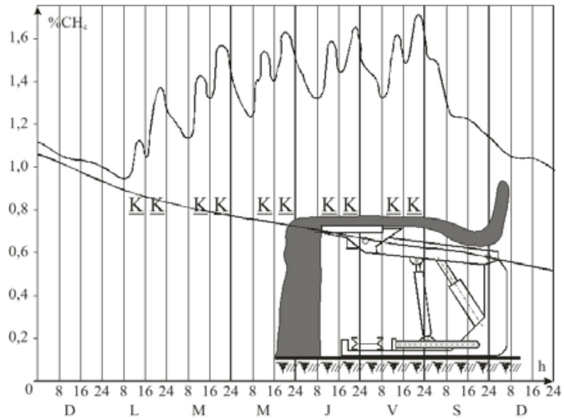


Fig. 3. Variation of methane concentration from a coalface depending in time;
K – productive activity

2.WORK ENVIRONMENT CHANGES ESTABLISHMENT

In normal energetic coal exploitation in underground occur different types of gases in variable concentrations in the work environment. The most representative and the most hazardous for work staff are methane, carbon monoxide and carbon dioxide.

Larger quantities of gas are usually releases in active coalfaces during technological processes and during coal spontaneous combustion processes.

Establishing gas concentrations before the event

In order to establish gas concentrations at the level of a coal face, there are performed specific measurements during a one week period. Maximum concentration is recorded during actual exploitation works, and minimum values are registered during the resting period at the end of the week.

After the occurrence of an explosion type phenomenon, the level of air concentrations is close or identically to the one registered in the resting period of the week.

Establishing gas concentrations after the event

Q_1circulated air flow at the level of the coalface is considered, then:

$$Q_1 = \frac{q_a \cdot 100}{c_1} \quad (m^3/min)$$

in which:q_a–absolute gas flow (methane or carbon dioxide) specific to the coalface (m^3/min);
c_1 – average concentration of methane or carbon dioxide during rest days from the end of the week (%);

After the event, the circulated air flow at the level of the coalface is Q2, obtained by simulation using VENTSIM VISUAL ADVANCED software(m^3/min).

$$Q2 = \frac{q_a \cdot 100}{c_x} \quad (m^3/min)$$

In which:q_a-absolute gas flow (methane or carbon dioxide) specific to the coalface (m3/min);

c_x – average concentration of methane or carbon dioxide after the event (%);

There can be written the following relation:

$$c_x = c_1 \cdot \frac{Q_1}{Q_2} \quad (\%)$$

3.ESTABLISHING THE CHANGES IN THE WORK ENVIRONMENT AFTER THE OCCURRENCE OF AN UNDERGROUND EXPLOSION

Relevant for establishing the work environment after the occurrence of an explosion are information regarding the change of gas concentrations (CO_2, CH_4, CO) and of air flow [1],[3],[4],[5],[6],[7].

In this regard, for establishing environmental conditions after the occurrence of an explosion there is required to perform several steps:

- Simulation of explosive and or toxic gas dispersion, in normal exploitation conditions;
- Establishing the structure of the ventilation network after the occurrence of an explosion;
- Simulation of explosive or toxic gas dispersion after the occurrence of an explosion.

Simulation of explosive and or toxic gas dispersion, in normal exploitation conditions

For performing simulations, there must be chosen a ventilation network, in this case Vulcan mining unit ventilation network, and it has to be modelled and solved using a specialized software such as CANVENT 3D, VENTSIM Visual Advanced, VENTPRI, etc.

For carrying out the simulation in order to establish explosive or toxic gas dispersion, the following steps have to be performed:

- Simulation of CH_4dispersion at ventilation network level;
- Simulation of CO_2dispersion at ventilation network level;
- Simulation of CO dispersion at ventilation network level.

Simulation of CH_4dispersion at ventilation network level

For achieving required simulations, VENTSIM Visual Advancedsoftware has been used Fig.4, Fig.5, Fig.6.

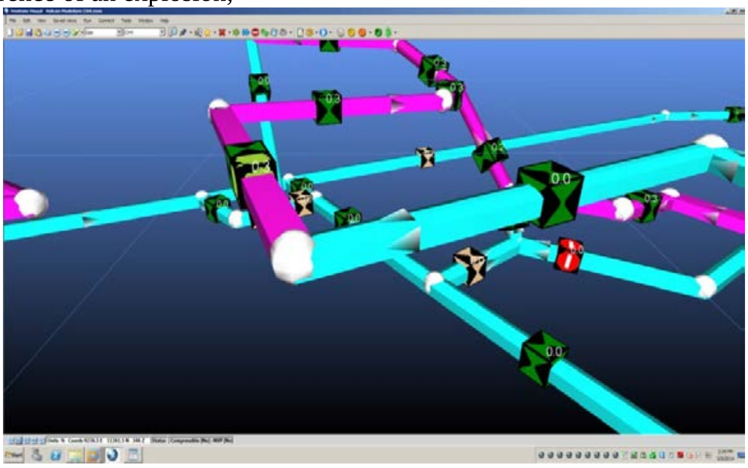


Fig.4. Simulation of CH_4 dispersion at ventilation network level

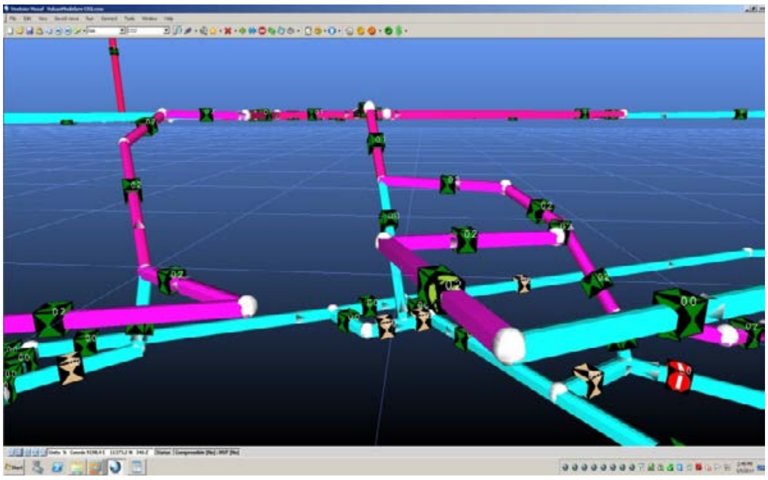


Fig.5. Simulation of CO_2 dispersion at ventilation network level

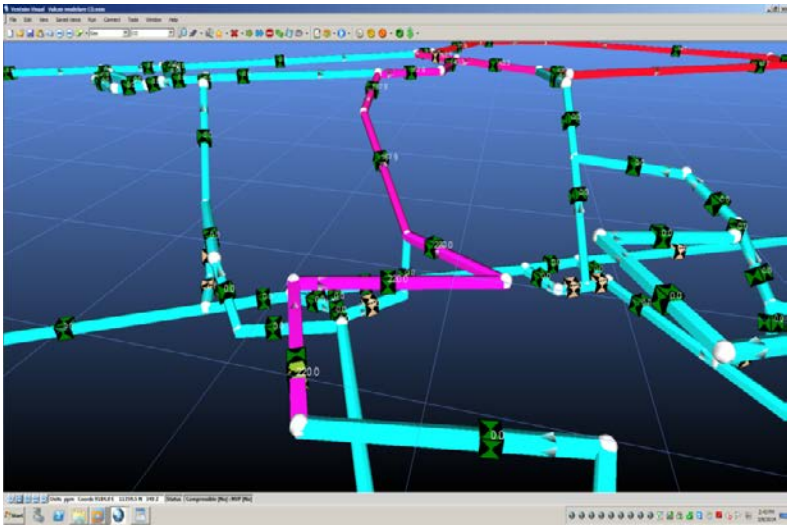


Fig.6. Simulation of CO dispersion at ventilation network level

Results of the dispersion of methane, carbon dioxide and carbon monoxide in normal exploitation conditions are the following:

- CH_4 presence in coalfaces, having an average concentration of 0.3% vol.;
- CO_2 presence in coalfaces, having average concentrations of 0.2 – 0.6 % vol.;
- CO presence in one coalface, having an average concentration of 220 ppm.

Establishing the structure of the ventilation network after the occurrence of an explosion

In order to establish the structure of the ventilation network after the occurrence of an explosion, the following steps shall be performed:

- Establishing the influence of the explosion type phenomenon upon the ventilation network;
- Ventilation network solving with regard to the changes produced by the explosion.

Simulation of explosive or toxic gas dispersion after the occurrence of an explosion

For achieving the simulation in order to establish the dispersion of explosive and or toxic gases after the occurrence of an explosion type phenomenon, the following steps shall be performed:

- Simulation of CH_4 dispersion at ventilation network level;
- Simulation of CO_2 dispersion at ventilation network level;
- Simulation of CO dispersion at ventilation network level;

Change in ventilation network structure brings along the change of airflows at branch level and as a consequence occur major changes of gas concentrations in areas of influence: Fig.7, Fig.8, Fig.9.

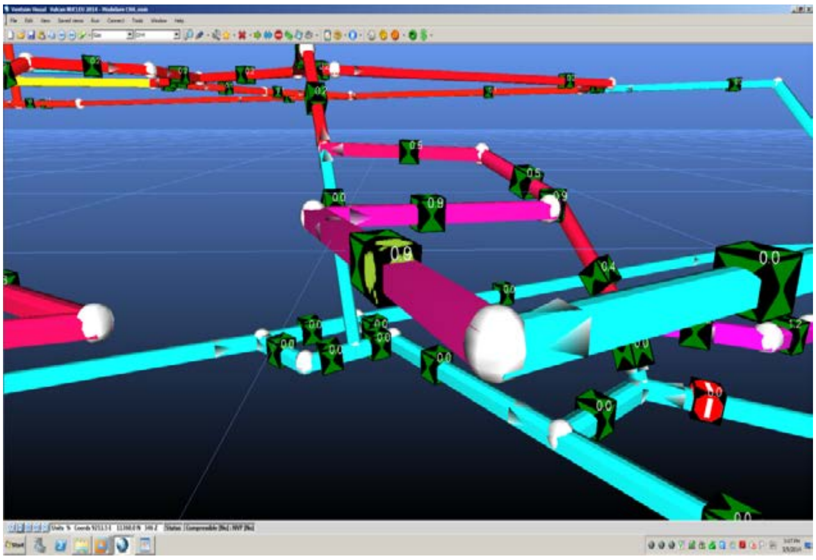


Fig.7. Simulation of CH_4 dispersion at ventilation network level

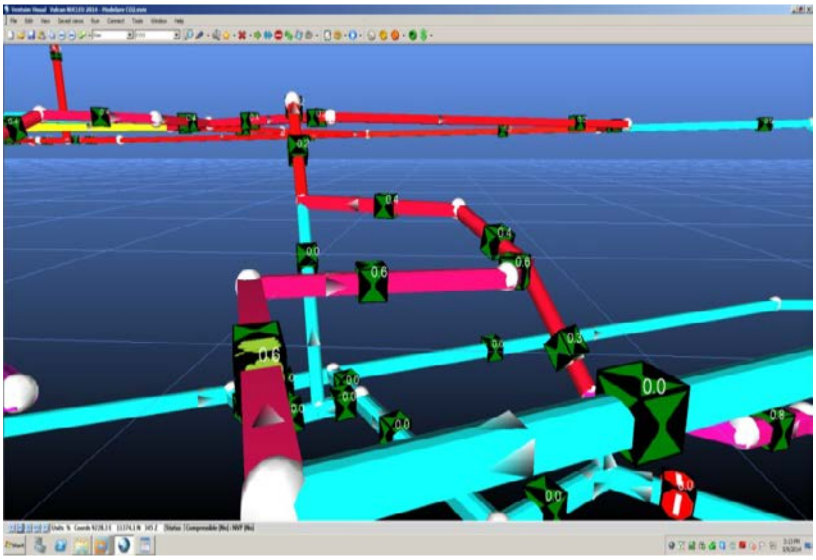


Fig.8. Simulation of CO_2 dispersion at ventilation network level

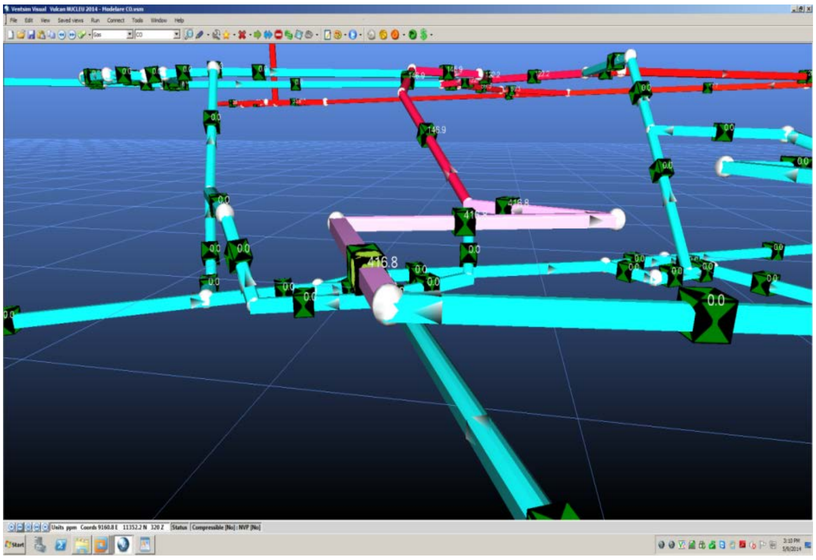


Fig.9. Simulation of CO dispersion at ventilation network level

Results on the dispersion of methane, carbon dioxide and carbon monoxide after the occurrence of an explosion are presented below:

- CH_4 presence in coalfaces, having average concentrations of 0.3%-1.2% vol.;
- CO_2 presence in coalfaces, having average concentrations of 0.2 – 1.1 % vol.;
- CO presence in one coalface, having an average concentration of 416.8 ppm.

4.CONCLUSIONS:

- Methane release within a coalface is a complex phenomenon depending in value and intensity on a series of natural-geological and technological factors

- For establishing the concentrations of methane, carbon dioxide and carbon monoxide after the event, the absolute gas flow method has been used.

- In order to identify the environmental conditions after the occurrence of an explosion, the following steps shall be performed:

- Simulation of explosive and or toxic gas dispersion, in normal exploitation conditions;
- Establishing the structure of the ventilation network after the occurrence of an explosion;
- Simulation of explosive or toxic gas dispersion after the occurrence of an explosion.

- In order to establish the explosive or toxic gas dispersion, in normal exploitation conditions or after the occurrence of an explosion, there have to be performed the following simulations at the level of Vulcan mining unit ventilation network:

- Simulation of CH4 dispersion;
- Simulation of CO2 dispersion;
- Simulation of CO dispersion.

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