UNIVERSITY OF PETROŞANI
DOCTORAL SCHOOL
PHD FIELD:MINES, OIL AND GAS

Ing. EVA BIRO (KOROZSI)

SUMMARY

PHD THESIS

RESEARCH ON INCREASING SAFETY IN COAL MINING AT E.M. LIVEZENI

RESEARCH ON INCREASING SAFETY IN COAL EXPLOITATION AT E.M. LIVEZENI

Scientific advisor,
Prof. univ. dr. ing. SORIN MIHAI - RADU

Petroşani
2021

CONTAINED

1. KEYWORDS

Further, for a better understanding of the following exposure, it is necessary to list some notions specific to the field approached: *methane, coal layer, methane migration, abatements, relative flow, degassing, computer simulation,*

2. INTRODUCTION

Mining was the basis for the development of the human society, by providing the base of raw materials and materials necessary for carrying out other activities both horizontally and vertically, from an economic point of view, being the main source of electricity production.

In order to ensure the continuous functioning of the entire electricity production chain, it is necessary to constantly supply the thermal power plants with coal and that is why it is important to prevent the situations of failure that can lead to: loss of human life, material losses, respectively to the immobilization of important coal reserves.

Mining aerage is an extremely sensitive and complex field that encompasses a multitude of disciplines, put in the service of achieving and maintaining the conditions of safety and health at work, in the underground environment.

The organization of the mining activity must therefore achieve the compatibility between the exploitation techniques, the new techniques of monitoring and surveilling the processes, and the economic and security requirements.

If for centuries, coal mining has been done under the conditions of resigned assumption of the risk caused by the existence of methane gas in the mining atmosphere, recent periods are characterized by research and searches, in order to find the possibilities of reducing and eliminating, the danger posed by explosions and ignitions of methane, with the help of the latest computer-assisted techniques.

All over the world, there are researches, aiming at knowing all the elements related to the forecasting, emergence and prevention of the danger caused by methane gas, these have shown that no price is too high to reward the technical conquests that underlie the dominion and control of the safety of work underground.

All the studies and researches in this thesis aimed at increasing the security and safety of the coal mining activity at the Livezeni Mining Operation.

The degree of civilization of a country is measured today by the care given to ensure optimal working conditions, for the prevention of accidents at work.

As long as coal mining in our country is still of a state of action, special attention is required on the security of underground jobs, security that is given by the good understanding and design of the aeration networks related to these mining exploitations.

In Romania, the exploitation of the superior coal is carried out only in the Jiu Valley Coal Basin, the largest coal deposit in the area with an industrial reserve of over 300 million tons, this activity having a dominant share in the economy of the area.

The Livezeni Mining Operation is located in the eastern part of the basin and has an annual production capacity at the moment of 170,000 tons of coal.

The methane emanations recorded at mine level are determined by the absolute flow rate qa=15.7 m3 CH4/min and the relative flow rate qr=14.0 m3 CH4/tonne.

The exploitation process takes place at two layers levels: layer 3 and layer 13, at different horizons, the present work being oriented on layer 13, horizon 100, area expected to remain in operation in the coming years.

Methane, has been permanently in the attention of scientists and continues to be carefully analyzed for three main reasons, namely:

- this gas is a natural product and frequently occurs in underground mining excavations;
- it is the cause of several catastrophes which have led to the loss of human life;
- from the point of view of flammability, it is an important factor in causing accidents with great technical and social implications.

It is known that when exploiting the layers, behind the abatements due to the movement of the rocks, areas with a large volume of voids are formed, where real methane reservoirs are formed and which, through the technological methods of directing the mining pressure, can be pushed into the space of the abatements.

The pushing of methane into the abatement space causes the sudden increase in the concentrations of methane in these works, the affluence of the methane manifesting itself in the area of the intersections between the abatement and the exhaust manifold of the vitiated air.

From the point of view of the safety of work underground, the problems can be ordered into two categories, dependent on each other, namely aeration in the classical sense on the one hand, and on the other hand, the emissions of methane in all the forms they involve, namely: forecasting, control, combating.

In this context, the development and maintenance of an appropriate aeration, which allows large quantities of fresh air to be circulated to active mining works and which can carry out the dilution of methane with fresh air, up to concentrations 5-10 times lower than the

lower limit of explosiveness, is the main means of preventing and combating explosions underground.

The field of computerized modeling and simulation of mining aeration networks, using specialized, modern software applications, is unfortunately too little touched and exploited in national engineering practice. Internationally, there exist and are used, in most countries with tradition in underground coal exploitation, dedicated software packages, developed for the design of complex airing networks, computer modeling and simulation of any technically possible situation, throughout the operating cycle of mining operations.

The relevance of the work lies in the advantages of using computer simulation techniques, in the control and management of aeration networks, as follows:

- support in choosing the right technical solutions;
- computer simulations allow the user to test in detail any aspect of a proposed change or any set of scenarios, without consuming any resources in the process;
- exploring the possibilities - once the virtual model is realized, the engineer specialized in ventilation systems, can incorporate in it, any modification and can evaluate and observe the effect of these changes, in some simulations, almost in real time, without the need to alter the real system;
- diagnosing problems and obtaining a perspective on the importance of any component of the system and of the variables that qualitatively and quantitatively influence the functioning of the aeration network, lead to an increase in the level of knowledge and understanding of their effects on the performance of the entire system, especially at the stage of mine design;
- important tool for planning changes in the aeration network.

The computerized operation of a mining unit is a process characterized by a continuous dynamics, throughout its operation, as new work fronts open or old exploited spaces are closed.

Computer simulation techniques, with integrated three-dimensional graphic representation capabilities, possibilities of importing from CAD applications, animated visualization of any detail in the network, etc. are very important features made available to the operator.

Starting from the obvious advantages offered by these specialized software packages, the phd thesis has set itself the following objectives:

- the study of the mechanism and regime of the release of methane in an abatement, the exploitation factors that influence the variation of the methane contents in an abatement
- study of methane emissions in the mining works in execution and in the abatements
- general considerations regarding the regime of methane accumulations in the exploited space of the frontal abatements;
- the regime of methane emissions in the exploited space and their possibilities of forecasting
- drainage technologies – capture of gas existing in the coal layer before or during operation
- analysis of the methods, schemes, types and degassing installations used in the coal mines in the Jiu Valley.
- methods to combat methane emissions from the area of the intersections of the abatements with the vitiated exhaust manifold and measures to prevent their ignitions
- generalities regarding mining aeration
- use of IT equipment and specialized programs for solving ventilation networks
- solving the aeration network related to the Livezeni mine - 3D CANVENT
- solving the aeration network afferent to the Livezeni mine – VENTSIM
- simulations performed on the aeration network related to the Livezeni Mining Operation.

According to the project Energy Strategy of Romania 2019-2030, with the perspective of 2050, "the production of lignite and hard coal in Romania depends directly on the national demand for primary energy resources in the electricity generation sector and on the resources/reserves available to Romania. The role of coal in the electricity mix will depend on the competitiveness of the price of the raw material, with a direct influence on the price of the energy produced from this primary energy resource."
"According to the same document, "the need for coal for the production of electricity and heat will be ensured from the production of vulcan and livezeni mines, completed with the necessary import, until the reconfiguration of the unprofitable thermal power capacities from the coal to another more efficient primary energy resource". Also, the strategy document mentioned above, in 2030 provides for a share of coal-fired power production of about 20% compared to about 26-27% at present," notes the Ministry of Energy.
www.replicahd.ro

3. THE IMPORTANCE AND NECESSITY OF THE THEME. OBJECTIVES AND STRUCTURE OF THE THESIS

Objective of the thesis

The main objective of the thesis was to find original tools and solutions to support specialized personnel in the field of occupational safety and health, and other stakeholders in fulfilling the obligations laid down in the national legislation on the prevention of explosion risk.

The intended result is to identify , on the basis of the studies carried out , the difficulties and problems that lead to the risk of explosion, in underground coal exploitations, and the consequent solution of the problems through forecasting and computer simulation.

Specific objectives

After the in-depth study of the ways of methane release both from the exploitation spaces and from the coal massif affected during the exploitation, studying the evolution of the concentrations based on real measurements during coal exploitation, we continued with the transposition of the geodetic data of E.M.Livezeni, carrying out the computerized modeling of the mining exploitation.

We used the 3D CANVENT program to model and solve the livezeni mine's aeration network in the initial phase. We also used the specialized program Ventsim Visual Advanced for modeling and solving the complex aeration network related to the Livezeni mine, at the present stage.

Thesis structure

The doctoral thesis begins with an introductory part dedicated to exposing the importance, purpose and objectives of the research. The basic body is structured in seven chapters for the presentation of the scientific approach and three annexes, totaling 186 pages,

Each chapter has an appreciable dimension, adequate graphical and logical presentation, and the entire work is supported by inserting 128 figures and 29 tables, as well as a list of 91 bibliographic references cited in the work.

Within the work are presented synthetically and systematically the author's researches, representing the results of the documentation efforts, the results of the experiments performed, the analysis approach and the interpretation of the data obtained from the measurements.

The doctoral thesis is conceived as a unitary whole based on case studies and ends with the methods of surveillance and control of the explosive atmosphere in the underground.

In **chapter I** entitled "METHANE, ORIGINS AND CHARACTERISTICS" highlights a documented presentation on the release of methane in coal mines, especially those in the Jiu Valley, with special attention being paid to the determination of the gas content of the deposit and the methods of measuring the gas releases.

Researches carried out worldwide have shown that a high share in the total balance of methane of the abatements is methane coming from the exploited space. The migration of methane from the exploited space to the abatement is determined by several factors, the most important of which are the control of the mining pressure, the circulation of the air through the exploited space, the pressure difference created by the variation of the air through the mining works related to the abatement, which describes a complex phenomenon.

In chapter II entitled "METHANE EMISSIONS IN MINING WORKS IN EXECUTION AND IN ABATEMENTS " various methods of forecasting of methane releases in mining works in diging were studied. The methane emissions have been studied in detail on concrete cases the variation of the methane concentrations and the danger that methane can present in the exploited space of the frontal abatements, which in conjunction with the modification of the oxygen concentration, the speed of movement of the gas flow and the interaction of coal and rock with the mixture of gases that achieves a heat and mass transfer in the exploited space, they can lead to catastrophes with serious consequences.

All possible influences of methane release were taken into account, such as the density and cracking of the mass in the vicinity of the mining works in operation, the resistance to flow of methane in the crack system as well as the speed of release limited by the coal desorption kinetics.

An important issue is knowing the momentary value of methane content at all points of the abatement aeration circuit. Studies have been made for forecasts of short or medium durations, as well as for non-working periods of emissions at the level of the abatements.

The dependence between the production of extracted coal and the methane emanations was also studied on concrete cases, this study was reduced to establishing the average daily, monthly value of the extracted production and of the absolute flow of methane for one year respectively. Displacement of the envelope of covering rocks, such as accidental factors, can cause high methane emissions, thus eliminating the influence of production.

The verification of the dependence between the methane emission and the variation of the air flow was performed based on the analysis of the results in the case of gradual obturation of the return manifold of the abatement air, the value of the air flow gradually decreasing. Consequently, the variation in the air flow should be regarded as an important factor acting on the emission of methane, which must be taken into account when changing the aeration circuits and thus the quantities of air circulated in the mine.

The prognosis of dangerous methane concentrations is very important for the prevention of events with extremely serious consequences in the case of accumulations of methane in the explosiveness range between 4% and 16%.

In order to recognize as quickly as possible the anomalies in the methane emissions during the beginning of the exploitation of the fronts in coal, it was proposed a parameter defined as the relatively accumulated content (gas production), which is calculated as a coefficient of the absolute methane content that is added daily to the daily added production.

Also, in order to recognize as quickly as possible the layer areas exposed to methane releases in the mechanized training works, researchers in Germany have developed a new method with the help of the computer. The method consists in determining the quasi-value of V30 (QV30) on the basis of the volumes of methane additionally released during cutting operations and the mass of coal cut.

In chapter III entitled "REGIME OF ACCUMULATIONS OF METHANE IN THE EXPLOITED SPACE OF THE FRONTAL ABATEMENTS" Following the researches carried out, it was pointed

out that, in the method of exploitation with long poles on the direction in retreat, the exploited space has a lower share in the total methane balance of the abatement than in the case of the exploitation method with a long front in advance.

The researches carried out worldwide have shown that a high share in the total balance of methane of the abatements is represented by the methane coming from the exploited space;

The migration of methane from the exploited space to the abatement is determined by several factors, among which the most important are the control of the mining pressure, the circulation of the air through the exploited space, the pressure difference created by the variation of the air through the mining works related to the abatement, which describes a complex phenomenon;

The measurements made at the Livezeni mine revealed methane concentrations of 31.6% near the head gallery, decreasing towards the central area to 10.8% and 0.2 – 3.3% vol. respectively;

The values of the methane concentrations measured in the exploited space were influenced by the multitude of factors, among which Imention: thecurtcircuits of air throughthe exploitedspace, theinclination of the layer, thegassing of the exploited space.

The results of the measurements were processed on a computer, taking into consideration , for the most correct description of the process of accumulation of methane in the exploited space , four types of functions:

$$y = ax^2 + bx + c$$

$$y = ax^3 + bx^2 + cx + d$$

$$y = ax^b$$

$$y = a \cdot (x+1)^b \cdot e^{c \cdot x}$$

The analysis of the results of the measurements carried out in order to establish the methane accumulation regime in the exploited space, as well as the processing of the results revealed that with the advancement of the abbatement on the direction, the concentrations of methane increase slowly to a maximum value, after which a slight downward trend is observed up to a distance of about 80-100 m, after which an increase in the concentrations of methane is observed;

The maintenance, respectively the slight tendency to decrease the concentrations of methane accumulated in the exploited space is explained by the circulation of air that existed through the exploited space due to its permeability.

The air circulation through the exploited space is possible due to the fact that the subsidence process of the rocks ends, according to the data after about 80– 100 m, flowmetric measurements showing that an air flow between 60 – 120 m^3/ min penetrates the exploited space;

The higher methane concentrations of the abatement are measured in the area of the intersection between the manifold of the evacuation of the air from the abatement and the abatement, which is due to the fact that in addition to the methane coming from the coal layer in operation in this area, the methane driven by the air circulation through the exploited space also reaches the major contribution to the increase of the methane concentrations;

Following the data processing, as well as the calculation of the correlation coefficient "R" between the methane concentration, the distance between the measurement points and the abbot resulted that the process of accumulation of methane in the exploited space is most correctly described by the function:

$$y = a(x+1)^2 \cdot e^{cx}$$

As a result of the multitude of factors that influence the regime of methane accumulations in the exploited space, it is not yet possible to establish precisely a law of accumulation of methane from the exploited space.

In order to ease the researches and to catch several variable factors, we will try to reshap the whole problem of the accumulations of methane in the exploited space and to combat them on a toretic model by trying to apply the theory of similarity in the study of methane accumulations in the exploited space.

The physical (theoretical) model under study refers to an abatement field with a front length of 80 m, which advanced in the direction of 100-150 m, a distance that is sufficient to establish the regime of accumulation of methane in the exploited space. Within the model, the height of the area of influence of the abatment was approximated to 30 m, a distance at which it was considered the existence of an accompanying layer that would enter the area of influence of the abating and would release methane at a certain overpressure.

The sources of origin of the methane that accumulates in the exploited space are: the coal that remains accidentally or willfully in the exploited space; the surrounding gas-bearing rocks and the exploitable or unexploitable coal layers that are located in the area of influence of the abatement.

In order to determine the volume of gas releases from the nearby (accompanying) layers, it is necessary to study and know the following parameters:

- The dimensions of the area of influence of the abating on the surrounding massif and the formation in time of this area;
- The character of the change in the initial pressure of the gas in a close layer, from the initial pressure to the final remaining one;
- The duration of the degassing process of the near layer that is depending on its position, the permeability and porosity of the filter area;
- The value of the initial and remaining pressure of the gas in the near layer.

In Chapter IV entitled "I.T. EQUIPMENT AND SPECIALIZED PROGRAMS FOR SOLVING VENTILATION NETWORKS"

Simulation of mining networks have become widespread in the mining industry. There are a number of computer programs for the analysis of ventilation networks that are currently used to design, analyze, and operate ventilation systems. Most of these ventilation programs have a graphical representation of the ventilation network and the related amounts, such as head losses in the branches, fan characteristics, heat transfer calculation, natural ventilation

In Chapter V entitled ,, SOLVING THE AERATION NETWORK RELATED TO THE LIVEZENI MINE WITH THE HELP OF 3D-CANVENT "

Since the modeling and simulation program allows the option of viewing the network in a three- and two-dimensional system, for the representation of the aeration network of the Livezeni mine presented in the drawings no. 5.1 5.4, the coordinates of each node were taken from the topographic maps related to each horizon, maps provided by the specialized service within the mining unit.÷

A number of 201 nodes were entered, the coordinates of each node representing the*"input data"*presented in Table 5.1. /105/, /106/,107/.

After the introduction of these nodes, the next operation was to link the nodes to each other by branching. The numbering of the nodes was made according to the direction of air circulation, from the surface (introduction of air underground) to the main ventilation station (evacuation of the vitiated air).

This resulted in 267 ramifications,

In chapter VI entitled "SOLVING THE AERATION NETWORK RELATED TO THE LIVEZENI MINE WITH THE HELP OF – VENTSIM"

After modeling the aeration network in 3D Solid system, the specific technical data are introduced for each branch, namely the profile and shape of the mining works and of the aeration constructions. The next stage was to introduce the aerodynamic parameters specific to each branch.

After going through the steps presented above, the ventilation network is balanced and solved, after which the animation is activated both for the air currents specific to each branch and for the fans related to the main air station. In this phase, the information specific to each branch is available, respectively the modeled and solved network is prepared for carrying out any necessary simulations.

In Chapter VII entitled ,, CONCLUSIONS AND PERSONAL CONTRIBUTIONS"

- The methane gas that accompanies the coal deposits, was formed as a product, in the successive stages of the anaerobic transformation process of the plant material, into coal, at high temperatures and pressures, during the in-carbonification process, without the intake of oxygen from the outside.
- The amount of methane that is formed depends on the composition of the material subjected to metamorphism and the conditions under which this process was carried out, especially temperature and pressure. Methane in coals and rocks is stored in two forms, namely: in the form of free gas, and in the form of bound gas.
    - The pressure of the methane gas contained in the coal massif is one of the main factors that determine the methane content of the layer, the influx of gases in the mine and the dynamics of the emissions.
    - The storage capacity of methane in a deposit is the volume of gas, which under certain conditions can be retained by the unit of mass of that layer.
- In the virgin massif, methane gas is found quartered in the free state and sipped, in the system of open pores, the system of voids and cracks, which communicate with each other, the gas pressure is constant if the massif is not under the influence of mining works.
- When the mining works are excavated, the balance in the massif breaks, creating a decrease in the gas pressure and as a result, in the direction of the mining works, a migration of free gas takes place.
- The main factors of influence of methane emissions that are taken into account at the level of an abatement, are: air flow, production, front length, speed of advancement, way of deviating, pressure routing mode.
    - Knowledge of the flow and intensity of methane emissions, it is necessary to judiciously choose the technologies for the execution of mining works and to identify the most effective means of fighting against dangerous accumulations of methane.
    - For the elaboration of the forecasting relationships of their release of methane in the mining works in diging, the main sources of degassing of the methane are based and the contribution of each of these sources is analytically expressed.
- The emissions of methane at the level of an abatement, respectively the characteristics and degree of cracking around it, depend only on the distance and position of the area relative to the excavation, on its shape and dimensions, on the initial field of the stresses but also on the thickness and nature of the layers.

- During the exploitation of coal layers, the gas stored in cracks at high pressures will migrate to the areas of low pressure (the area of the abatements and the exploited spaces), the resulting pressure drop, producing the phenomenon of desorption that occurs as long as the pressure of the gas in the coal is higher than the atmospheric pressure, or until the recompression of the rocks causes the cracks to close.
- Due to the fact that the change in production involves disturbances in the technological process, the dependence between the emission of the methane quantity and the amount of coal extracted comes down to establishing the average daily, monthly, value of the extracted production, and of the absolute flow of methane for one year, respectively.
- The individual knowledge of the factors that influence the emission of methane is the important element that can contribute to the adoption of the most judicious solutions in the field of work safety, but the major desideratum is to know their simultaneous action in perspective.
- The most important aspects regarding the research activity of methane releases carried out in recent years are: the fastest possible recognition of methane emission anomalies, the degassing of the layers in operation through drilling holes, the development of a method for a faster recognition of the areas at risk of metal release.
- The release of methane into an abatement field is a complex phenomenon that depends on a multitude of natural, geological and exploitation factors, and which comes from the following sources: coal preparation mining works, the debating front, coal cut and transported from the abatement, the exploited space.
- a high share in the total methane balance of the abatements is represented by the methane gas coming from the exploited space. The migration of methane from the exploited space to the abatement is determined by several factors, the most important of which are: the pressure control, the circulating of the air through the exploited space, the pressure difference created at the level of the exploited space.
- Measurements taken at the Livezeni mine, at the level of the exploited space, revealed methane concentrations of 31,6 % Vol. near the head manifold, decreasing towards the central area to 10,8 % Vol and 0,2÷3 % Vol. respectively.
- The values of the methane concentrations measured at the level of the exploited space were influenced by the following factors: air loss through the exploited space, inclination of the layer, degassing of the exploited space, etc.
- In the spaces of the abatements, when exploiting the coal layers, due to the displacement of the rocks, areas with voids are formed in which methane accumulates. Over time the rocks are subjected to the phenomenon of subside, and both the volume of voids and the gas permeability of the exploited space decreases.
- The sources of origin of the methane that accumulates in the exploited space are: the coal left in the exploited space, the surrounding gas-carrying rocks, respectively the exploitable or unexploitable coal layers that are in the area of influence of the abatement.
- For a good knowledge of the methane emissions at the level of the exploited space, it is necessary to know the size of the area of influence of the abatement on the surrounding massif, the value of the porosities and permeability of the rocks in the stress-relieving areas, the duration of the degassing process of the close layers, respectively the variation of the gas pressure in the stress relief zone.
- The degassing of methane in the exploited space is a complex phenomenon, which manifests itself after the appearance of cracks, in the massif due to exploitation

influences when a pressure gradient (difference) occurs, which generates the migration of methane to the exploited space where the depression is less than the pressure of the gas from the surrounding rocks and nearby strata.

- The mass transfer inside the massif is a spatial and non-stationary process, the flow of methane through cracks and voids, is a flow with mass exchange between the massive and its voids.
- The reduction of the Methane flows that will penetrate the aeration circuits during the coal exploitation period can be achieved by applying the technologies of prior degassing. Given that permeability and the rate of desorption are reduced, the drainage of methane gas must be started long before the start of exploitation.
- Depending on the provenance and the way of extracting the methane gas, associated with coal deposits, it can be classified as follows: methane gas from virgin deposits, methane gas from active mines, methane gas from abandoned mines, respectively methane gas from the general aeration current.
- The general aeration comprises the entire network of active mining works, which are subject to a depression, exercised by the active main fan, located on the surface within the main aeration station.
- At the international level there are several specialized programs used for the analysis of ventilation networks, for the purpose of design, financial and prospective analysis and the operation of ventilation systems.
- Specialized programs, known for modeling and solving complex ventilation networks, are of the following types: Ventsim, MVS, VenetPC, MineFire, DuctSIM, CLIMSIM, Vuma-3D, VentGraph, VentPri and 3D-CANVENT.
- The Livezeni Mining Operation currently has two independent ventilation systems, namely the P.A.2 Main Fan Station and the P.A. East Fan Station.
- For modeling and solving in the initial phase of the aeration network related to Livezeni mines, the 3D-CANVENT program was used.
- For the modeling of the aeration network, 201 knots and 267 branches were used.
- Following the resolution of the aeration network under the action of the main ventilation installations, a flow rate of 53.89 m3/s or 3233.4 m3/min was circulated.
- The air flow achieved at the level of the main fans was 70.89 m3/s or 4253,m3/min.
- The short-circuited air flow with the surface at the level of the main ventilation system P.A. East was 10.28 m3/s or 616.8 m3/minute and at the level of the main ventilation system P.A.2 was 6.72 m3/s i.e. 403.2 m3/minute.
- For modeling and solving the aeration network in the current conditions of the Livezeni mine, the specialized Ventsim program was used.
- For the modeling of the aeration network related to E.M. Livezeni at the current stage, two abatement circuits have been eliminated and 7 circuits have been introduced, respectively new mining works.
- For solving the aeration network of E.M. Livezeni at the present stage, a number of 218 knots and 280 branches were used.
- Under the action of the main ventilation installations PA East and PA2, an air flow of 57.6 m3/s or 3456 m3/minute was circulated at the level of the ventilation network.
- The air flow rate achieved at the level of the main fans was 74.8 m3/s or 4,488 m3/minute.
- The short-circuited air flow with the surface at the level of the main ventilation station PA East was 10.3 m3/s or 618 m3/minute, and at the level of the main ventilation station PA2 it was 6.8 m3/s or 408 m3/minute.

PERSONAL CONTRIBUTIONS

In this phd thesis we have described original tools and solutions to support the specialized personnel in the field of occupational safety and health, and other factors interested in fulfilling the obligations provided for in the national legislation on the prevention of explosion risk.

I believe that the theoretical part, the methodological part and the applicative part, which I developed during the doctoral internship, rendered synthetically below, represent original contributions, in the field of research aimed at, prevention and control of potentially explosive atmospheres.

Personal contributions in the mentioned field include both theoretical and practical aspects.

From the point of view of bibliographic research and analysis of the current stage of the approached topic, we have made an analysis of the migration mode, respectively of the accumulation mode, of the methane gas at the level of the underground mining works and of the exploited space, starting from the fact that the accumulation of metal in the active mining works increases the risk of occurrence of explosion phenomena, we analyzed and deepened the capture, dilution and ventilation systems, in order to reduce the concentrations of methane at the level of active mining works, below the maximum permissible concentration.

From the point of view of the research objectives, we have identified on the basis of the studies carried out the difficulties and problems that lead to the risk of explosion, within the underground exploitations of coal, and we have accordingly established the research objectives within the framework of this thesis.

We have detected the specific objectives and we have clearly established the directions of action for the achievement of the mediator objectives circumcised to the topic of the work, based on carefully selected principles.

We used the 3D CANVENT program to model and solve the livezeni mine's aeration network in the initial phase. We have also used the specialized Ventsim program for modeling and solving the complex aeration network related to the Livezeni mine, at the present stage.

From the point of view of the theoretical research, in order to establish the mode of formation, respectively the release regime of the methane, we analyzed and deepened: the genesis of the methane, the pressure of the gases in the coal layers, the gradient of the relative methane flow, the gas content and the permeability of the coal layers, the forms of release of the methane, as well as, in particular, the mechanism and regime of the gas releases in an abatement.

We helped establish methane emissions in mining work, focusing on the mechanism of methane release, respectively the methods of forecasting methane releases.

We also analyzed the emissions of methane at the level of an abata,j with regard to: the cracking of the massif around the mining works, the areas de-stressed and cracked around a work front, as well as the forecasting of the occurrences of methane from the abatement. At the same time, we analyzed and studied the dependence between the extracted production and the emission of methane, the methods of forecasting the release of methane, as well as, in particular, the forecast of dangerous occurrences of methane in the return of the abatements.

Regarding the regime of methane accumulations, at the level of the exploited space, we conducted a case study at the level of the front abatement Pan 3-4 str.3, Bl VI-A, from E.M. Livezeni, with the help of measurements made in the exploited space.

Regarding the establishment of the methane emission regime at the level of the exploited space, we analyzed and thoroughly, the size of the area of influence of the

abatement, the porosity and permeability of the rocks, the degassing process of the close layers, respectively the gas pressure in the stress relief zone. We also analyzed the gas emissions from the nearby layers, respectively the flow of methane through the cracks and crevices in the massif.

In order to achieve an efficient ventilation, at the level of the underground mining works network, we studied the specialized programs used to solve the ventilation networks, among which we mention: Ventsim, VentGraph, 3D-CANVENT, e t c.

To ensure the air flows at the level of each branch related to the Aeration Network of E.M. Livezeni, we used the 3D-CANVENT program, for modeling and solving the aeration network in the initial stage. We also used the Ventsim program to solve the air network related to the Livezeni mine, at the present stage.

From the point of view of practical and applicative contributions, in order to illustrate the way of applying in practice the monitoring of gas releases at the level of the exploited space, we have carried out a case study, based on the measurements made at the level of the frontal abating Pan. 3-4, str.3, block VI-A, from E.M. Livezeni, in order to view, respectively, to obtain the optimal flow circulated, at the level of the aeration network.

We performed the modeling, solving and optimization of the aeration network related to the Livezeni mine, in the initial phase with the help of the 3D-CANVENT program.

In order to ensure the applicative character, respectively the verification of the air flows circulated at the level of the aeration network, we have carried out the modeling, solving and optimization of the E.M. Livezeni air network, at the present stage, with the help of the specialized Ventsim program.

From the point of view of the dissemination of the results, during the doctoral period, and of the preliminary documentations carried out, we have published as the first author and co-author several scientific papers, published in specialized journals indexed to BDI, respectively in the volumes of international scientific events.

STUDY LIMITS

The ubiquity of uncertainties regarding the knowledge and reliability of the data used, the measures to be taken to limit the consequences, or minimize the probability of materialization, the degree of subjectivity of the assessments, make it particularly difficult, in the opinion of experts, to precisely formalize the procedures for assessing the explosive risk and the decisions applied. Moreover, we often find that the very level of expertise that exists is a space for experimentation.

The main limits of the research presented in the doctoral thesis, which aims at "Research on increasing the safety in exploitation of coal at E.M. Livezeni", can be summarized as follows: the approach of the extremely complex field regarding the way of formation, migration and accumulation of methane gas, at the level of mining works and of the exploited space, respectively the establishment of efficient measures to prevent the risk of explosion, measures usable by the workers designated in the field of OSH, namely internal services and providers of prevention and protection services, required that the theoretical and applicative study should focus on the set of measurements taken underground. At the same time, the complexity of the field addressed in the phd thesis, led to the simplification of the way of analyzing the ventilation networks by taking into account only the active mining works.

DIRECTIONS FOR FUTURE RESEARCH

As a result of the deepening of the knowledge in the field of research targeted by the doctoral thesis, and of the personal contributions made, the following main directions of

research can be proposed, to which the efforts should be directed, aiming at confirming the researches, and completing / improving, the proposed methods:

- identification of new methods of forecasting methane emissions at the level of active mining works and exploited space;
- analysis of hydro-geological and petrographic factors that influence the release technology, by drilling from the surface;
- the study of the correspondence between the aerodynamic parameters established by the partial aeration project, and the existing real aerodynamic parameters, in the case of partial aeration installations with cascade-mounted fans;
- introduction in the MSSR / 2007, of the CNH, of the need to solve the aeration networks with the help of specialized programs;
- simulation on the modeled and solved air network, related to the Livezeni mine, of the dispersion of methane gas at the level of the entire network;
- stimulation on the modeled and solved ventilation network of the Livezeni mine, of some technically possible situations such as: maintaining only the main Aeration station P.A. East, maintaining only the ventilation station P.A.2.

I believe that multidisciplinary studies in the field, doctoral theses and scientific research papers are still necessary and justified.