MINE SURVEYING ACTIVITIES IN MANAGEMENT OF GEOMECHANICAL PROCESSES

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ABSTRACT. When investigating and managing geomechanical processes, the activities of the mine surveyor are limited to: receiving primary information; office data processing; creation of intermediate and final documents; preparation of recommendations and instructions for conducting process management events in the massif. To make the work of the mine surveyor efficient, all activities need to be automated, i.e. to create an automated system for managing the geomechanical processes in the array. It should be part of the overall system "RUDNIK". It will contain several modules: 1. "MODEL" - model of natural conditions and model of mining. 2. "TECHNOLOGY" - after taking into account the actual conditions for a particular site, the research technology, the measurement methods, the type and accuracy of the instruments, the intervals between the observations, etc. will be chosen. 3. "MASSIF" - based on the results of the measurements, the data on the physical and mechanical indicators of the rocks, etc. The type of the stress-deformable state of the massif will be determined. The proximity of the array state to a known theoretical model of the environment will be assessed according to set criteria. 4. "PROJECT" - prognosis of the anticipated manifestations of the geomechanical processes will be carried out, zones of influence and dangerous impact of the mining works will be determined, etc.

Keywords: geomechanical processes, management, mine surveying works

МАРКШАЙДЕРСКО ОСИГУРЯВАНЕ В УПРАВЛЕНИЕТО НА ГЕОМЕХАНИЧНИ ПРОЦЕСИ

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РЕЗЮМЕ. При изследване и управление на геомеханични процеси дейностите на маркшайдера се свеждат до: получаване на първична информация; канцеларска обработка на данните; създаване на междинни и крайни документи; изготвяне на препоръки и инструкции за провеждане на мероприятия по управление на процесите в масива. За да бъде трудът на маркшайдера ефективен е необходимо всички дейности да бъдат автоматизирани т.е. да се създаде автоматизирана система за управление на геомеханичните процеси в масива. Тя трябва да бъде част от цялостната система „РУДНИК". Ще съдържа няколко модула: 1. „МОДЕЛ" – модел на природните условия и модел на минните изработки. 2. „ТЕХНОЛОГИЯ" – след отчитане на реалните условия за конкретен обект ще се избира технологията на изследванията, методите на измерване, вида и точността на инструментите, интервалите между наблюденията и т.н. 3. „МАСИВ" – въз основа на резултатите от измервания, данните за физико-механичните показатели на скалите и др. Ще се определя вида на напрегнато-деформируемото състояние на масива. По критерии ще се оценява близостта на състоянието на масива до познат теоретичен модел на средата. „ПРОЕКТ" – ще се извършва прогнозиране на очакваните прояви на геомеханичните процеси, ще се определят зоните на влияние и на опасно влияние на минните работи и т.н.

Ключови думи: геомеханични процеси, управление, маркшайдерско осигуряване

Introduction

The development of mining is based on continuous improvement of the scientific knowledge of the extraction environment, the physical and mechanical processes taking place in it, the possibilities for improving the efficiency and safety of the work, for legitimate and reasonable management of the mineral resources reserves.

This implies a very good knowledge of the relationships between the different elements of the complex system of mining. Its management requires constant monitoring of the behaviour of every work place and every process at every stage of underground mining. Analysing the specific situation at a given point in time should lead to a decision on preserving or changing the processes and the links between them to ensure the normal operation of the enterprise.

Regardless of whether the exploitation is conducted in an open or underground way, a number of processes take place in the rock massif, the knowledge of which would lead to making adequate and realistic decisions about the development system, the order of work in the space and the time of the individual jobs, safety measures, in order to reasonably foresee the risks in specific situations.

The notion of the interaction between the different elements of the environment allows solving the problem of building the most adequate models of the processes in the mining production. Decisions in this regard require experience and knowledge in different areas. To study the reasons for the occurrence and the characteristics of the processes in the array, it is also necessary to accumulate a multitude in terms of quantity and type of data (Valkov, 2011).

The knowledge of mining technology, the laws of rock mechanics, the relationships and dependencies of the processes in the array, as well as the accumulated information from multiple observations on specific objects, allows successful solving of the engineering tasks. Modelling options offer variants that are evaluated according to different criteria. Based on estimates, the best one is chosen. It should characterise the trend of change in time and the extent of the

studied phenomena and processes in view of the management of the open pit or underground mine.

The baseline information needed to provide rational solutions and relevant analyses is mainly gathered from studies and measurements under natural conditions. In addition to methods known to the rock mechanics to determine the physical and mechanical characteristics of the massif and its behaviour, mine surveying's methods are widely used to determine spatial variations of characteristic points from the rock massif and the ground surface by judging changes in rock massif due to natural or technological factors.

The block diagram, shown in Figure 1, shows a basic model for studying the behaviour of the rock massif and the application of the mine surveying's methods for this purpose.

The possibility to use the results of the mine surveying's measurements to assess the state of the rock massif or object is based on observations in the natural environment, which determines the reality of the obtained values for the specific technical, mining-technical and geological conditions.

Mine surveying's measurements define the characteristics of the deformation processes that relate to larger areas in the rock massif due to the easier and quicker acquisition of the required data than other known methods requiring more time, labour, and specialised equipment.

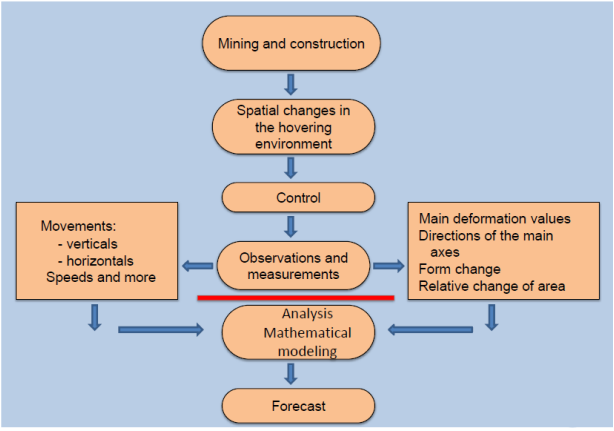

Fig. 1. Principal model for studying the behaviour of the rock massif with mine surveying methods

The main objects of the geomechanical studies in the extraction of underground resources are (Yoffis, 1985):

- the rock massif and the earth's surface;
- mining works;
- mechanical processes induced in the rock massif from natural or artificial impacts;
- the factors affecting the mechanical properties of the rock massif and the mechanical processes in it;
- the means of regulated engineering impact on the rock massif for purpose alteration of its properties and condition.

The rock massif as an environment in which geomechanical phenomena and processes are evoked and manifested is the main object of the research. Its important characteristic is the change in its tense state as a result of the mining works. This tense state is changed from a tri axial - in an unbroken massif, to a two axial or close to it - to the contour of the workings.

An overriding interest in mining geomechanics is "rock pressure". Rock pressure, as a phenomenon, is a collective concept combining the set of tension states that form in the massif due to a number of natural and technogenic impacts. The determining factor is gravity, as a permanent and ubiquitous natural phenomenon, and the additional ones are the tectonic processes, the human activity in the extraction and the construction of different facilities.

The common methodology for exploring the processes in the rock massif consists in the extensive use and analysis of observations in natural conditions and at the same time also in modelling and analytical methods based on the theoretical aspects of the main sections of modern mechanics and the mathematical and physical analogies.

The geomechanical stability of the "rock massif-underground works" system is determined (Ivanov, 2006; 2007) from the interaction of three main factors:

1. Deformed state of the rock massif;
2. Geological structure, structural features and physical and mechanical properties of rocks;
3. Effects of the technological impacts on the above factors.

Surveying and mechanical methods can be used for their determination.

Surveying methods identify the displacements to fixed points (in absolute coordinates) or to points in the area of influence of mining operations (in relative coordinates). Horizontal and inclined lengths, horizontal and zenith angles, line deviations, angular deviations, exceedances determined by geometric or trigonometric level are measured. It is also possible to apply photogrammetric methods (Ivanova, 1991).

The angular-linear and height measurements applied for studying the deformation state of the rock massif are used to determine (fig.2):

- the linear dimensions of the zones in the rock massif with a different deformation state;
- the boundaries of undermine zones and overmine;
- the parameters of the rock movement process;
- the change in the size and shape of the mining works.

During the various stages of the deformation processes, the following are established:

- absolute and relative displacements;
- moving speeds.

Through the determined displacements in the space of observation points (Tsonkov, 2018) the invariant characteristics of the deformations: can be calculated

- relative change of area – dilation θ;
- form change - maximum displacement γ_m
- main deformation values E_1 and E_2 in the T_1 and T_2 directions of the main axes.

In mechanical methods in the rock massif embed in depth repers or repers in the contour of the work section or on their fastening; devices are used to determine the relative displacements of different points from the surrounding rocks. Specialised equipment is used to define elements of the strained-deformed state of the rock massif or to monitor the behaviour of the system "Rock - Support".

General scheme of mine surveying measurements and their results in underground and open groundwater development in connection with studying the geomechanical state of the rock massif and the earth's surface.

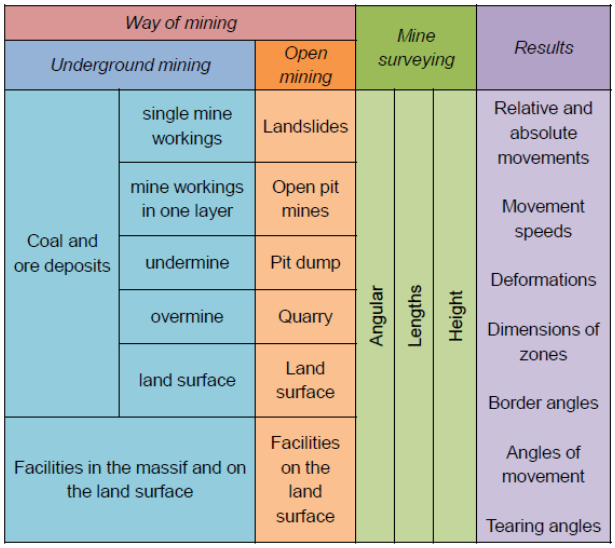

Fig. 2. General scheme of mine surveying measurements and their results in underground and open groundwater development in connection with studying the geomechanical state of the rock massif and the earth's surface

Based on the results of the studies with the two groups of methods, a mathematical model of the studied geomechanical processes can be created.

The model, though idealised in some ways, due to a number of assumptions and insufficient knowledge of the environment, should serve as a description and as a means for managing the researched object.

The matching of the chosen model with the nature of the research process is done through continuous correction after introducing new elements and results from experimental data.

The adequacy of the model is based on the formation of accurate assessments and their correct use for impact on the real object of the study.

If necessary, according to established methodologies, forecasts of the stress, displacement and deformation values at selected rock massif points are made. Actions for rational deployment of preparatory and extraction works, safe mining, reduction of stresses in the massif, ensuring the safety of facilities and objects on the surface and in the massif are recommended.

System for mine surveying activities in the management of geomechanical processes

With the introduction of new techniques and technologies in terms of apparatus, tools and methods of mine surveying mapping (Begnovska et al., 2014) and the processing of huge amounts of data, numerical models have already been created in many mines. They are mainly used to visualise the spatial position of the ore bodies and the layers and mining works. Measurements are made only at distances and angles.

In order to make the work of the mining company more efficient, the results more accurate and complete, and in order to achieve the unity of the decisions and the control of their implementation, it is necessary to create a unified automated management system in the mine. It should contain subsystems or separate modules that can provide adequate real-time management. As part of this system called "MINE", for example, there should be also a mine surveying system for geomechanical processes.

The objectives of the mine surveying system must lead to or be part of the objectives of the “MINE” system.

From a structural point of view, the mine surveying system for geomechanical processes must contain several subsystems.

MODEL Subsystem

This subsystem has two components:

- "model of natural conditions";
- "model of mine workings".

In order to get effective real solutions, the model needs to meet several conditions:

- to be "adequate" to existing nature mineral deposits;
- to be "technological" - to reflect truly and really the dynamics of technological development processes in mining operations;
- to have the "reversibility" property of numerical type and to be able to pass quickly and accurately in graphic mode and vice versa;
- to be "informative" - to allow only unambiguous answers.

The MODEL subsystem has to create and maintain the mining model by converting the information from the surveying image capture into a numerical model (Begnovska, 2016).

This can be done with specialised or non-specialised software.

The relationship between the geological study and the information on the environment and the numerical model of the mine works is carried out by the model of natural conditions. It binds the numerical spatial arrangement of mining work with that of the underground treasures, its properties, the physical and mechanical state of the massif, the type of rocks, the geological disruptions and all other natural assets. This requires continuous updating of both models.

In general, the model of mining works and the model of natural conditions form the information level - the "database" of the system.

The ***MANAGEMENT subsystem***

This subsystem must have three modules: "MASSIF", "TECHNOLOGY" and "PROJECT".

Module "MASSIF"

Based on the results of the measurements, the data on the physical and mechanical indicators of the rocks, the knowledge of analogous conditions, etc., the type of stress-strained state of the rock massif is determined. The proximity of this state to a certain theoretical model of the environment - elastic, plastic, rheological, model of continuous, layered, block etc. is assessed. Upon confirmation of such proximity, further forecasts, recommendations and events are made on the basis of this theoretical model. If no close theoretical model is found, the medium is considered stochastic as it is.

Module "TECHNOLOGY"

With the application of modern scientific achievements and optimisation methods, after taking full account of the actual conditions of the particular site, in accordance with the technical norms for conducting measurements (Ivanova, 2012), it is possible to choose the way of observation, to design an observation station (location, number of observed points, stabilisation, etc.), to define the intervals between the measurements, the measurement accuracy, etc. The module should also choose suitable measuring equipment.

Module "PROJECT"

After determining the type of strain-strained rock massif condition and after analysing the results of experimental studies and measurements, it is possible to:

- forecast the expected displacements and deformations;
- determine the dimensions of the zones of influence and of dangerous influence;
- determine the degree of undermine of the rock massif and on the Earth's surface;
- assesse the state of the sites, facilities and the rock massif as a whole;
- define the parameters of the supports.

The module should offer actions:

- to reduce the harmful impact of mines works;
- to prevent accidents in the mine;
- to ensure normal and safe work;
- for environmental protection;
- rational use of the stocks of underground minerals.

Figure 3 shows a block diagram of the system for mine surveying activities in the management of geomechanical processes.

Since information on the environment of occurrence of geomechanical processes is always insufficient and incomplete, much of the decisions and forecasts will be taken and done by the operator. This will be based on his experience, knowledge and engineering intuition. The "human-machine" dialogue is an important link in the management of geomechanical processes.

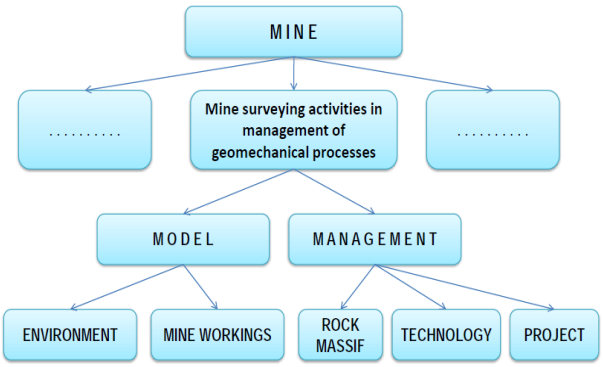

Fig. 3. Block diagram of the system for mine surveying activities in management of geomechanical processes

The geomechanical process management system will not exist on its own. As an important unit of the "MINE" system, it participates and will actively support the management and planning of the development of mining operations. The complete and accelerated use of the available information, the application of the most suitable methods for its processing, the avoidance of intermediate processes and the optimal solution (Mazhdrakov, 1983) of the assigned tasks determine the effectiveness of its work.

Conclusion

In recent years there has been a change in mineral extraction in Bulgaria. With the concession of different types of mineral resources' deposits, investments in the mining industry have been increasing, the introduction of new high-yielding mining equipment, increased production, and full seizure of stocks have been put in place. Extraction works are carried out at a greater depth, often in very complex mining, technical and geological conditions.

In line with these changes, mine surveying in mining and quarrying companies seeks to assist and technically direct the proper development and maintenance of mining. Together with proven methods and technologies, new instruments and apparatus are based on the achievements of modern science and technology. Their capabilities provide high accuracy, huge data, speed and reliability of the information received.

In order to achieve the desired results in terms of quantity and quality of the mining company's output, it is necessary to have good specialists, reliable and productive modern equipment for all units in the enterprise, high level of safety technique, good organisation and control.

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