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Mining and Technical Monitoring at Coal Mines

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ABSTRACT: The most important element of the physico-technical process of coal deposit mining processes is information about both physical processes in the rock mass (most of all, changes in gas-geomechanical, hydro-geological and ecological states) and mining processes in mines (technological, economic, social, etc.)- It is necessary to create a rather general geoinformation model of physico-technical processes because of the all-round character of the data, and the various methods of data collection, storage and analysis. The approach proposed in the building of a geoinformation system is rather general and allows the construction of various subsystems of mining monitoring on a combined methodical and program basis simple enough to unite them together.

V INTRODUCTION

The reorganization of the economy, transition to market practices and restructuring of the coal industry today require new methods of analysis for all processes in mine control. For appreciation of the dynamics of the changes in the coal industry, the reengineering questions of systems in mine control are gaining in importance. It is with the restoring of information, communication and engineering software of systems and processes that mining will change to modern control methods of technological mine systems. Decision making in this field must be preceded by analysis of data. The data should be regularly updated and should be varied to reflect the state of processes and systems of mining, both in individual mines and m regions as a whole. In these cases, systems of active monitoring of various information sources are being developed. They include modern models of mining data analysis with the capacity for conversion into maps, graphs, animation sequences, object-oriented databases, etc.

2 INFORMATION MODELS OF SYSTEMS OF MINE TECHNICAL MONITORING

For the last few years, there has been a quantitative and qualitative body of streams of information connected to the operation of various sorts of mining monitoring systems. This has resulted in the need to develop by their new paradigm in view of those changes, which today occur in mining computer science.

In the first stage of monitoring system development, for example, in the geomechanical system and monitoring of gas and dynamics in mines, most attention was given to technologies of information collection (sensors for determining changes in various parameters of physical and geomechanical conditions, controllers, transmission data lines, models of primary data processing). In the second phase, elementary databases were developed, models of which were not for the most part practically formalized in any way. This eventually resulted in various monitoring systems that were either simply disjointed or had a complex enough interface. As for methods of primary data processing, it should be noted that in connection with the large variety of methods of monitoring data processing, the construction of a common enough model could not be achieved, such as systems of cartridges DBMS Oracle, pcniiitting floppy change of algorithms of processing for concrete databases and collection of them into a uniform hardware-software complex.

The changes that have taken place over the last few years m the field of information technology and the geocomputer sciences in particular have shown that the presence of huge streams of geoinformation force us today to see it as one of the major factors necessary for solvmg problems in mining and handling by geosystems. Unfortunately, that which is known to be true all over the world, that he who controls information controls the world, is only today receiving recognition in the world of mining.

The huge quantity of geoinformation today appears to be simply lost and, practically, not restored. This is because in the creation of various sorts of automized systems, the conceptual model was incorrectly selected, and information was structured and transformed according to this into appropriate databases. In a number of cases, even with the presence of conceptual data models, they were either lost, or remained without appropriate support, so that they eventually disappeared from the information subspace.

We propose an approach to the creation of modern information models of geomechanical monitoring based on the change in the common scheme of information processing, as shown in Table 1. The table shows that the appearance of new methods of processing and data models is characteristic for modem monitoring. Such methods are:

- intellectual data processing (extraction of knowledge - data mining);
- models of data warehouses oriented with OLAP technology.

Instead of traditional imitative and network models, the transition to object-oriented models proposed is more universal from the point of view of the creation of models of these or other geomechanical and geotechnological processes.

A very general view of the scheme of geotechnical monitoring is represented in Figure 1.

Table I. Methods and models of monitoring systems.

CLASSICAL MONITORING	MODERN MONITORING
Statistical analysis of the data	Methods of intellectual data processing, Datamining
The numerical methods (MFE, BBH and etc.)	The numerical methods (MFE, BIE and etc.)
Analytical Methods	Model of data warehouse
Imitation and network models	Object-oriented models (UML.CASE)
Making decision	Decision making an risk estimation

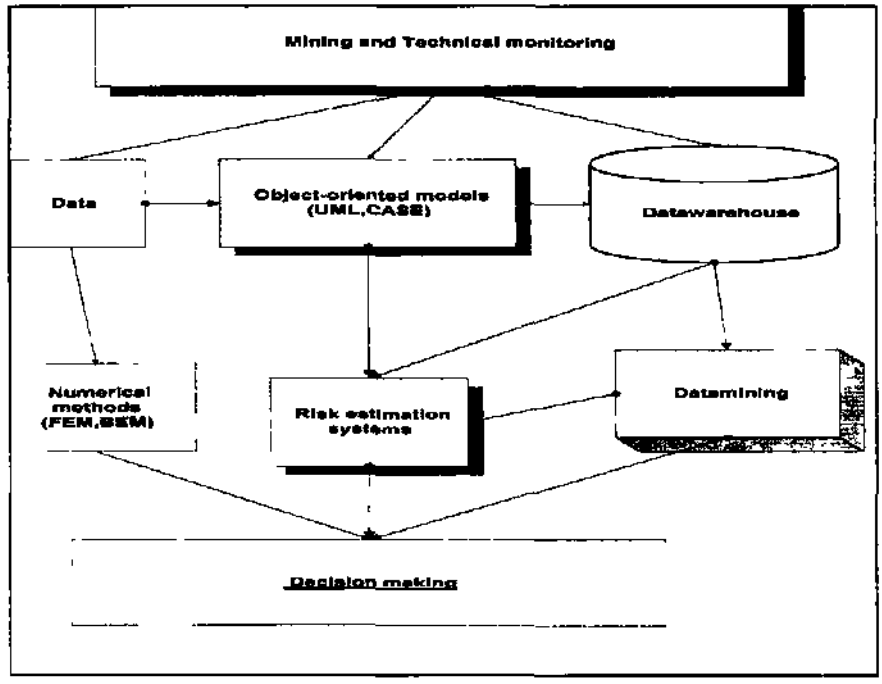

Figure I. New schema of the mining and technical monitoring.

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3 TECHNOLOGICAL MONITORING OF COAL-MINES IN KUZBASS

Technological monitoring is carried out in the Institute of Coal and Coal Chemistry. It contains the basic work indicators of mechanized longwalls in the coal mines of Kuzbass. Computing facilities of database generation and of processing incoming information by methods of classification are developed in order to determine the tendency of the change in the mine technological structure of coal mines (^»efiOpHH, 2000). About 120 Kuzbass longwalls are processed İn terms of mme technological, technical and economic indicators (HJieBCKHfi, OCfiOpHH, 1998).

Each longwall is characterized by:

- a set of X factors-determinants describing the mine geological conditions of longwall work (angle of dip and seam thickness, thickness of main roof and immediate one, bottom thickness, coal hardness, and enclosing rock hardness, seam gas content, water intrusion of seam and constructive parameters of a panel, specific volume of driving and roadway maintenance of a development, main workings and panel);
- a set of Y function parameters ("variables of behaviour"), reflecting indicators of work (average monthly output of a longwall and underground output per man-shift, cost, specifications of longwall sets, transport ways, etc.).

It has been stated (<É>e/topHH, 2000) that the evolution of a mine's technological structure towards increasing the efficiency of longwall work can be considered as follows:

TM—M»M—• MP-+-NMD-*MS

where TM stands for traditional mines without division into panels. Traditional mines are widespread in the Russian coal industry. PM stands for panel mines or mines with division of the mining area into panels. A typical representative of this type is the great Raspadskaya mine in Kuzbass. MP stands for mines-panels. A representative of this type is the Zyryanovnskaya mine in Kuzbass. MMD stands for modular mine districts, with one highly productive longwall.

Each stage of the development of the mining technological mine structure is characterized by a decrease in the number of structural units and simplification. Thus, in mines with one stope, in comparison with traditional mines, the number of units of underground structure is considerably reduced (from 8 to 3). The quantitative estimation of the complexity of the mining-technological mine structure is carried out by a metric of entropy Ho, which characterises the complexity of the transport network of mine workings in the mine (see Figure 2). The quantitative estimation Ho of the structural complexity of the network of mine workings is reduced from 3 to 0.5. The more metric Ho, the more complex is the structure of the mine.

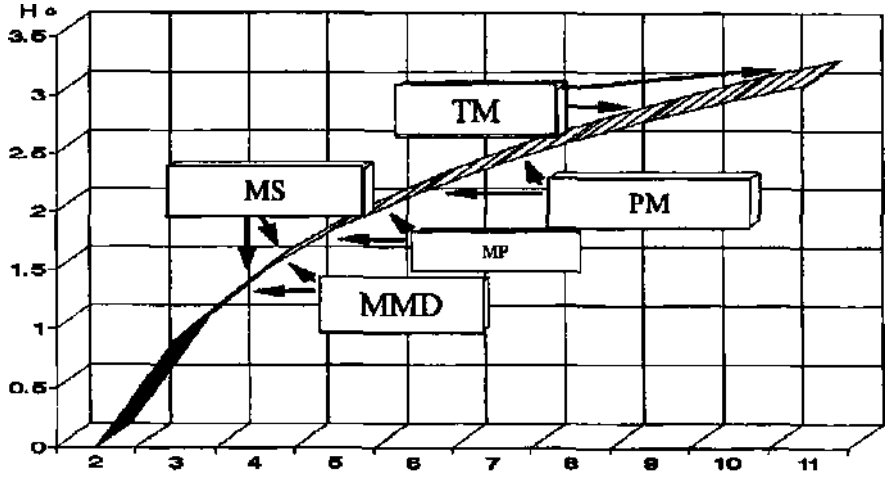

Figure 2 A summary quantitative estimation of entropy H_0, depending on number of units of mining-technological structure of coal mines.

With technical progress, the evolution of the mining-technological mine structure provides conditions for intensive engineering operations, and thus, is a large factor in the efficiency of coal mining underground.

Investigations (OeAOptm, 2000) show that the economic metrics of coal mines at the fiat bedding of seams immediately depend on the productivity of the mechanized slope, which, in turn, depends, except for active factors (technological level of equipment, professional preparation of staff, etc.), on the type and parameters of the mining technological structure of coal enterprises.

For years, districts with autonomous coal winding to the surface were mined in the Kuzbass collieries. Nowadays, mine districts are in the mines: Raspadskaya (panel 5a), Vahrushev (West Taldinsky), Alarda, Kyrgaiskaya, etc. Most of the mining districts are privately owned and highly productive (juieBCKirif, <&e,nopHH ,1998).

The study of work in mines with only one highly productive longwall led to the creation of modular mine technological structure for mines being designed and reconstructed in Kuzbass. Mining systems (MS) appeared not so long ago and at present they are employed in the USA, Australia and South Africa. Since 1995, there have been technical and economic justifications for investment in building MSs in the opening of new coal deposits in eastern Kuzbass (Russia).

The mine technological structure of MSs presents a set of MMDs together with a corridor of communication İn an integrated technological system on the surface. The Kotinskaya mine, having been designed with a modular mine technological structure in terms of main indicators, is classified as a mine with a world-class technical and economic level.

Modular systems of mining in Kuzbass are provided with sufficient coal reserves to a depth of 300 m with an angle of dip of up to 18 degrees. An electronic directory of geological districts has been made. It includes districts with more favourable mine geological conditions in terms of seam bedding, thickness and structure so that highly productive mining systems and new technological schemes can be used, as patented in the Russian Federation. It has been determined that there are 150 geological districts with deposits of more than 3 billion tons.

In the generation process of the electronic directory, two schemes of program realization were developed:

- local - on the basis of hypertext technologies;
- distributed - on the basis of the intranet of the Institute of Coal and Coal Chemistry.

The division of the directory is performed by means of a standard server method and allows the generation of complex forms of inquiry through tables specially developed for these purposes, providing a connection with the database of the directory.

In the working process, various DBMSs were investigated, such as MS ACCESS through the ODBC interface and MS SQL in the Windows NT server environment. The Linux system with DBMS Postgres was chosen because of its high database access speed. When tested as to its capability, it displayed speed of access to the directory's elements 4-6 faster than the Microsoft environment.

The electronic directory is designed not only for workers in the coal industry but also for businessmen intending to invest in coal mining in Kuzbass by forming small (modular) highly productive mines (Internet: www.Kemsc.ru in the interface of the Kemerovo Research Centre of the Siberian Branch of me Russian Academy of Sciences).

4 GEOMECHANICAL MONITORING SYSTEM

The rock mass of coal deposits represents a complex natural environment based on a solid component, saturated by gas and liquid, containing inclusions. Research into geomechanicai processes in rock masses as a result of technological factors (mining of mineral resources) is best achieved by monitoring.

The information geomechanicai monitoring system (Gm MS), which is used in computerized mine planning and mining operations control, is a technical means of geomechanicai monitoring (GmM). It is a complex system of regulated observations, estimation and prediction of changes in the geomechanicai (Gm) state of the rock mass and workings during underground mining of coal deposits. Geomechanicai monitoring at coal mines and the automated system perform data collection, analysis and calculations of geomechanicai (Gm) conditions in the panel during planning, development and execution of mining operations for ensuring the geotechnical stability of underground mining.

These concepts were formulated and published at the end of the 1980s (Bnacemco, 1990), obtained concrete appendices for estimation tasks of rock mass Gm - state İn me locality of coal faces with mechanized support setting (BUTIHHCKH H *op.,* 1991) and were generalized İn the work (Bjiacemco, 1993).

Formulated determinations, composition and structure of monitoring and monitoring systems have been developed (BnaceHxo H up., 1994; Vlasenko et al., 1994), extended to changes in rock mass gas geomechanicai state (GGm) and published (Vlasenko et al., 1993; Gritsko, Vlasenko & Fedorin, 1995; Gritsko et al., 1995), including the materials of the Second and Third International Symposiums on Mine Mechanization and Automation (Vlasenko etal., 1993; Gritsko et al., 1995).

5 CONCLUSION

1. An approach to building a geoinformation .ystem for mine engineering monitoring was developed. Some system elements were realized by a complex program of technological and geomechanical monitoring.

2. Mine technological monitoring of main indicators of mechanized longwall work at coal mines showed that modular mine technological structures are more effective in the mining of flat coal seams.

3. The rational region of geological resources was found to be modular mine districts in the coal deposits of Kuzbass. A database (150 geological districts) and electronic directory of technological solutions for modular structures of mine district opening and development were created.

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