DOI 10.52209/1609-1825_2023_1_121 UDC 622.281

Evaluation of Methods for Collecting and Processing Information in the Development of Technology for Carrying Out Workings Using Mathematical Modeling

[1]**HUANGAN Nyrbol,** *PhD, Senior Lecturer, khuangan-nur@mail.ru,*
[1]***BALABAS Anna,** *Master, Teacher, 19chinatown@mail.ru,*
[1]**BALABAS Lydia,** *Cand. of Tech. Sci., Associate Professor, l.balabas@yandex.ru,*
[1]**TRIKOV Valentin,** *Senior Lecturer, alice1231@yandex.ru,*
[1]*NPJSC «Abylkas Saginov Karaganda Technical University», Kazakhstan, Karaganda, N. Nazarbayev Avenue, 56,*
**corresponding author.*

Abstract. *The article analyzes the literature sources on the methods of collecting and processing information and creating mathematical models. Semantic descriptions of mathematical models based on research works of authors from near and far abroad have been compiled. The tasks of mathematical modeling and creation of information blocks for the effective functioning of mining enterprises are defined. A control scheme of the production process has been compiled. The forecast of linear and nonlinear modeling is made. The main criteria indicators of mathematical modeling are established, the regularities of the applicability of mathematical models to geomechanical processes at mining enterprises are given.*

Keywords: *mathematical model, parameter, analysis, geomechanical process, model structure, data processing, array of static information, mining and preparatory work.*

Introduction

Mining operations at the enterprises of the Karaganda coal basin are associated with addressing a large number of engineering and commercial issues based on the search for optimal parameters to create mathematical models aimed at the effective selection of the mining practices. The goal determines the model framework, specific features, the necessity to determine the main and auxiliary elements of the model, a compilation of an object semantic description with the mathematical language, and the presentation of the data being considered as a system of equations and functional dependencies. Prediction of geomechanical processes based on mathematical simulation requires a detailed analysis of the literature to identify the stages of model refinement:

- Choice of qualitative and quantitative features;
- Structural detailing, based on verification and application of iteration cycles;
- Development of adaptive capabilities to use the simulation results.

Review of literature materials including the analysis of computer simulation for the stress-strain behaviour of a marginal rock mass during mine workings of in-mine coal seams.

Mining enterprises with a variety of mining, geological, engineering and commercial conditions operate using flexible, multi-option, structured mathematical models. The entire set of factors influencing the change of the development workings throughout the operation cycle is studied in detail. Models containing arrays of information with a detailed description of the software product characteristics and the mining efficiency are used.

Mathematical model application practice using general software products and databases is described in the publications of A.A. Baryakh, Mining Institute of the Ural Branch of the Russian Academy of Sciences, Perm, Russian Federation. The analysis of A.A. Baryakh's literature sources covers the 1992-2021 period presented at the Scopus [1].

The analysis of the A.A. Baryakh's materials showed that the mathematical model was based on the homogeneity of the empirical material belonging to the same general set of indicators. A high citation index of the author's publications (Figure 1) is related to the possibility of using the models at the production sites of mining enterprises to improve the mining process.

Mathematical model mode of operation for the potash salt mines is similar to the coal mining process. However, the temperature gradient in potash mines fluctuates within the range of 10-15% that leads to a change in the grouping of statistical aggregate by intervals and frequency of each mathematical model interval. For coalmines with high variability in mining conditions, adjustment of the model parameters will delay the outcome. Combinations of data blocks, algorithms, constant and variable parameters, restrictions, and dependencies shall be changed.

Considering the influence of mining conditions when using the models with insufficient basic elements mobility, an analysis of sources describing mathematical models of the coalmine workings process, given changes in current parameters, was performed.

The papers of Mr. Syd S. Peng, West Virginia University, Morgantown, United States [2] for the period from 1993 to 2022, presented at the Scopus with a citation ranking shown in Figure 2, consider the status of the mining works preparation, and management and design models for coalmines.

A high citation ranking of the Mr. Syd S. Peng's papers is due to the large amount of statistical data and the small discrepancy between theoretical and empirical frequencies. The data for material processing is given for semi-stable soil of workings.

For studying the application practice of the efficient mathematical models, N.A. Samodelkina's papers, Ural Branch, Russian Academy of Sciences, Yekaterinburg, Russian Federation (Figure 3) for the period from 2003 to 2021 presented on the Scopus are of considerable interest [3].

A comparative analysis of the author's papers will allow using the mathematical models that significantly facilitate addressing the time-consuming issues related to considering the influence of mining and geological factors on the mining and development methods and determination of the scope of work for the relevant period. The papers consider the data at the end of the planned working period, which lead to the availability of distinctive characteristics for the operational work planning process; the data processing time will be reduced.

The analysis of the methodology for the development of mathematical simulation took into account the paper of the SRK Consulting Company with the participation of Alexander B. Makarov, Moscow, Russian Federation [4]. A review of the author's paper showed the alternative options to introduce new technologies using geomechanical models of mines. Statistical parameters of technologies are given, time-consumption, time of operations, and mining rate are taken into account. The author's mathematical models enable to use a methodology to

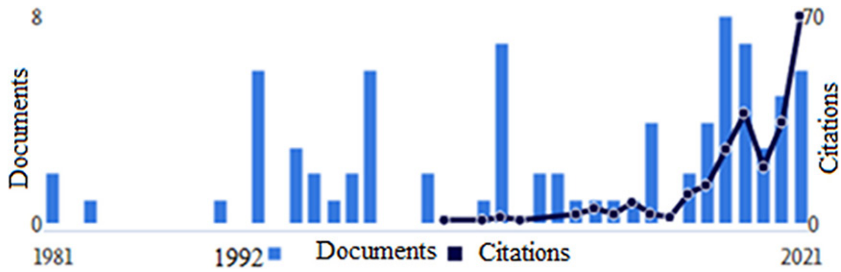

Figure 1 – Mister A.A. Baryakh Citation Index

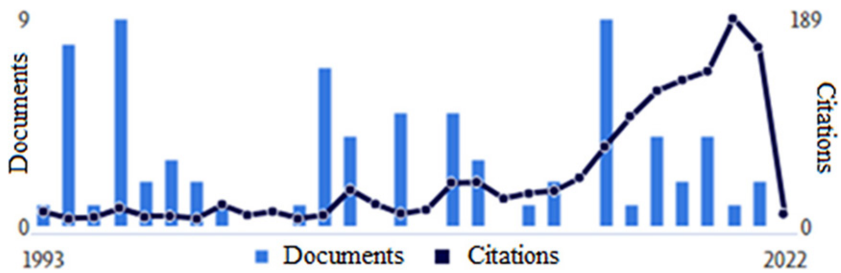

Figure 2 – Mister Syd S. Peng Citation Ranking

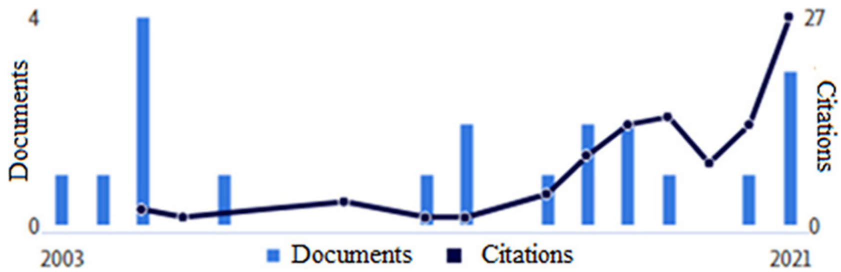

Figure 3 – N.A. Samodelkina Citation Schedule

study the mines zoning related to the danger of mine workings, determination of the Q-Value, acceptable parameters for stopes, and for numerical simulation of geomechanical processes to select an effective mining technology. A static data array considers the process flow features of mining enterprises and technologies to recover minerals, describes the basic conditions, shows changes in the technological situations, and the possibility of simulation with the analysis of various process flows when parameters are changing in real-time [5].

Conclusions

The analysis of the authors' papers who use the process condition changes in mathematical models is grouped as per the distribution nature and influence of the geological factors on the performance. This is due to the need for minerals mining and processing ramp up, performed through the commissioning of new and expansion of existing mining enterprises. Currently, the most promising form of economic development is the technical re-equipment of production facilities, which ensures an increase in the technical and economic indicators of production performance based on the mathematical simulation. For the development and implementation of efficient models, mining and geological information is collected from stratigraphic columns of coal seams [6], a database for seam thickness, rock beds, immediate and upper roof, depth, and uniaxial compression strength is prepared.

Data on the first bedrocks (plastic deformation zone) is used; data is grouped as per the behaviour of the lithological roof rock varieties located directly above a coal seam. Information is processed with statistical indicators: average value, mean square deviation, and correlation coefficient. Histograms and distribution curves are plotted, and an image of the simulated object outline is obtained (Figure 4).

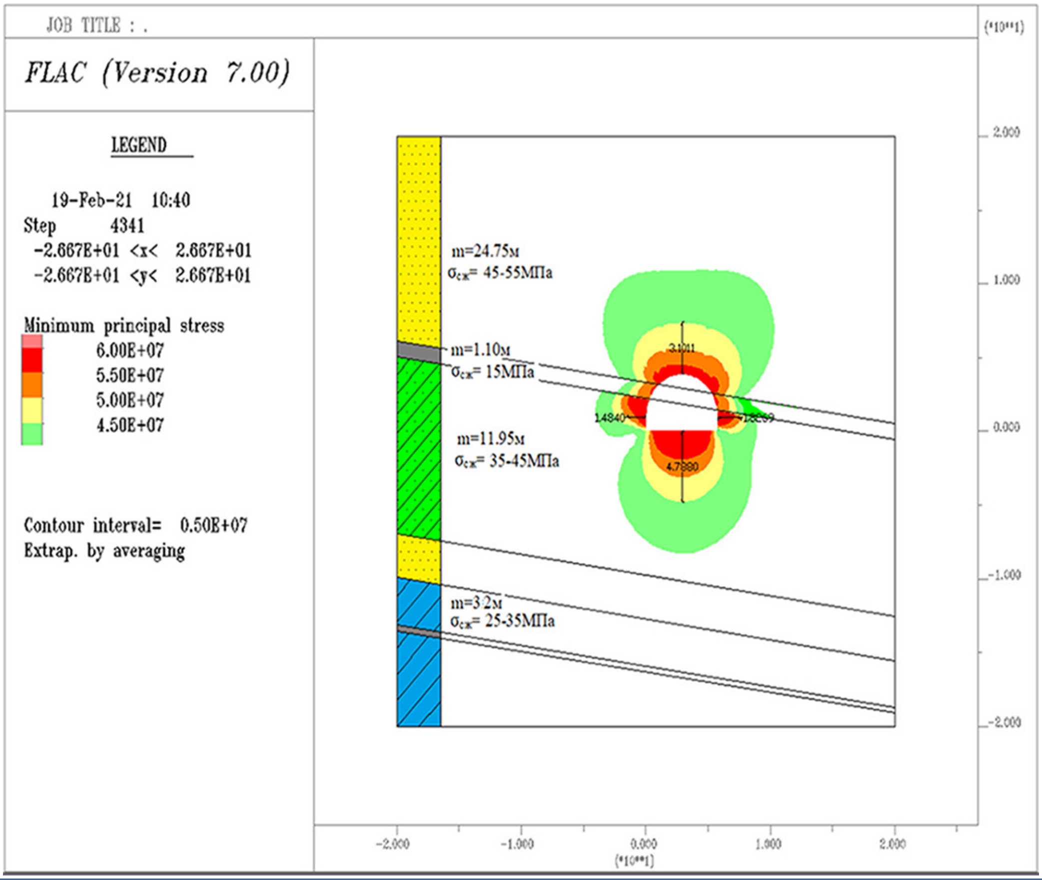

Figure 4 – An Example of the Simulated Object Outline

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Математикалық модельдеуді қолдана отырып, қазбаларды жүргізу технологиясын жасау кезінде ақпаратты жинау және өңдеу әдістерін бағалау

[1]***ХУАНҒАН Нұрбол Хуанғанұлы,*** *PhD, аға оқытушы, khuangan-nur@mail.ru,*
[1]****БАЛАБАС Анна Юрьевна,*** *магистр, оқытушы, 19chinatown@mail.ru,*
[1]***БАЛАБАС Лидия Хизировна,*** *т.ғ.к., доцент, l.balabas@yandex.ru,*
[1]***ТРИКОВ Валентин Владимирович,*** *аға оқытушы, alice1231@yandex.ru,*
[1]*«Әбілқас Сағынов атындағы Қарағанды техникалық университеті» КеАҚ, Қазақстан, Қарағанды, Н. Назарбаев даңғылы, 56,*
**автор-корреспондент.*

Аңдатпа. *Ақпаратты өңдеу мен жинау әдістемесіне және математикалық модельдерді құру бойынша әдеби дереккөздерге талдау жасалды. Жақын және алыс шетел авторларының зерттеу жұмыстары бойынша математикалық модельдердің мағыналық сипаттамалары жасалды. Тау-кен өнеркәсібі кәсіпорындарының тиімді жұмыс істеуі үшін математикалық модельдеу және ақпараттық блоктар құру міндеттері айқындалды. Өндірістік процесті басқару схемасы жасалды. Сызықтық және сызықтық емес модельдеу болжамы сипатталды. Математикалық модельдеудің негізгі критериалды көрсеткіштері белгіленді, тау-кен өнеркәсібі кәсіпорындарында математикалық модельдердің геомеханикалық процестерге қолданылуының заңдылықтары берілді.*

Кілт сөздер: *математикалық модель, параметр, талдау, геомеханикалық процесс, модель құрылымы, деректерді өңдеу, статикалық ақпарат массиві, тау-кен жұмыстары.*

Оценка методов сбора и обработки информации при разработке технологии проведения выработок с применением математического моделирования

[1]***ХУАНГАН Нурбол,*** *PhD, старший преподаватель, khuangan-nur@mail.ru,*
[1]****БАЛАБАС Анна Юрьевна,*** *магистр, преподаватель, 19chinatown@mail.ru,*
[1]***БАЛАБАС Лидия Хизировна,*** *к.т.н., доцент, l.balabas@yandex.ru,*
[1]***ТРИКОВ Валентин Владимирович,*** *старший преподаватель, alice1231@yandex.ru,*
[1]*НАО «Карагандинский технический университет имени Абылкаса Сагинова», Казахстан, Караганда, пр. Н. Назарбаева, 56,*
**автор-корреспондент.*

Аннотация. *Проведён анализ литературных источников по методике сбора и обработки информации и создания математических моделей. Составлены смысловые описания математических моделей по исследовательским работам авторов ближнего и дальнего зарубежья. Определены задачи математического моделирования и создания информационных блоков для эффективного функционирования предприятий горно-рудной промышленности. Составлена схема управления производственного процесса. Описан прогноз линейного и нелинейного моделирования. Установлены основные критериальные показатели математического моделирования, даны закономерности применимости математических моделей к геомеханическим процессам на предприятиях горно-рудной промышленности.*

Ключевые слова: *математическая модель, параметр, анализ, геомеханический процесс, структура модели, обработка данных, массив статической информации, горно-подготовительные работы.*

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