Analysis of effective tools for modeling mining and geological processes

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Abstract. In modern conditions, modelling of production processes in various industries is not only a highly effective means of planning and visualizing the activities of an enterprise, but also an urgent scientific task. Modern modelling tools allow a wide range of scientific and applied research to be carried out to help plan the activities of the enterprise and identify new ways to gain competitive advantage. The modelling process itself is performed in specialized software packages with a wide range of capabilities.

1. Introduction
At mining enterprises, various software systems can be used to simulate production processes and parameters of the stress-strain state of the geomassif. Some of them allow a fairly wide range of tasks related to planning the activities of an enterprise and modeling key parameters of mine workings to be performed, others are highly specialized and provide solutions for a limited set of tasks.

2. Analytical review of research methods
Midas GTS NX software is used for detailed reconstruction of the terrain and geology [1]. The software package allows you to generate a hybrid finite element mesh, which uses the optimal combination of hexahedral and tetrahedral elements, allowing a site with complex geological and relief conditions to be simulated.

The spatial model can be represented in the form of a set of triangular faces built on the points of the contours of the corresponding elements (wireframe model), an ordered set of 3D cells within the boundaries of the wireframe body model (block model) or in the form of geometric primitives (bodies) with a closed contour that forms a volume (solid model).

Also, Midas GTS NX has both its own CAD modelling tools and the ability to import CAD models created in other modelling environments. The Block Model Converter allows a block model created in Datamine, Micromine, Leapfrog, Surpac and other similar programs to be imported into GTS NX by converting it to a finite element model. At the same time, the converter allows interpreting blocks by various attributes, which in GTS NX will be represented by separate finite element meshes.

Midas GTS NX is used to perform statistical calculations (linear, non-linear), calculations of stability, filtration, dynamic influences, as well as perform combined calculations. Models allow taking into account the rheological properties of rocks, for example, creep, orthotropic behavior of rocks. Loads and boundary conditions can be specified in a geometric or finite element model. The Midas GTS NX program interface is shown in figure 1.
Micromine Mining and Geological Information System (MGIS) is a comprehensive solution for 3D-modeling of deposits, offering tools for assessing deposits, design, optimization and planning of mining operations [2]. The system provides users with a comprehensive view of the project so that they can focus on exploring the prospect more closely. The modular structure of MGIS Micromine allows servicing the business processes of mining enterprises, including the assessment of open pit mining (long-term, short-term), the design of underground mine workings relative to the actually passed (creation of frames of design and actual mine workings from a point cloud and according to mine survey data), planning of underground mine workings (long-term, short-term).

Long-term planning includes accounting for economic indicators, planned losses and dilution, optimization of the schedule, visualization of the mining sequence with division into periods, and reporting.

Short-term planning includes creating a calendar plan, setting up resources, calendars, and generating reports.

The MGIS Micromine interface is shown in figure 2.

ANSYS is an advanced engineering data analysis and numerical simulation software [3]. ANSYS Mechanical uses a family of numerical methods to solve a wide range of problems in solid mechanics, taking into account nonlinear properties of materials, plasticity and contact interaction, including problems.

The functionality of the ANSYS Mechanical package includes models of mechanical properties of materials (elastic, viscoplastic, orthotropic, with hardening and softening, porous, brittle, etc.), importing geometry from any CAD system, importing boundary conditions, and modeling behavior.
calculation of layering, seismic and other types of loads, multi-criteria parametric and topological optimization, convenient visualization of results.

It should be noted high-performance computations using multi-core processors and the possibility of distributed computing on a cluster.

To solve the problems facing mining enterprises, ANSYS Mechanical can be used to determine the stress-strain state of a geomassif taking into account nonlinear models of coal and rocks, to solve contact problems: modeling compaction, shaping and shaping processes, calculating the strength and stability of mine workings taking into account nonlinear behavior rocks.

The use of Ansys Mechanical as a tool for mathematical modeling of the process of destruction of rocks allows the nature of fracturing to be assessed and the parameters of mining to be optimized.

The ANSYS program interface is shown in figure 3.

Figure 3. The interface of the ANSYS program.

EDEM Software is a Computer Aided Design (CAE) Platform. EDEM allows models of granular solid systems with specified parameters to be quickly created. To obtain an accurate representation of the shape of real particles, their CAD models can be imported into the system [4]. Unlike the software systems discussed above, EDEM is a highly specialized modeling environment that allows problems related to the study of bulk media to be solved only, therefore, we will highlight the most significant characteristics of this software product. These features include a simple bill of materials, the ability to transfer interactions and materials to a manageable database, modelling particles imported from CAD templates or from scanned files, overlaying surfaces containing many convex geometric primitives, automatic calculation of particle parameters, including moment of inertia, and masses, rapid creation of simple geometric bodies such as cubes, cylinders and polygons, grouping particles into a random or lattice structure, simple specification of a number of modes such as linear and angular velocity, size and direction.

EDEM functionality allows mechanical, material and other physical properties to be integrated in the process of modelling the molecular system of solids. EDEM manages data about each individual particle (mass, temperature, velocity, etc.) and the forces acting on it.

Modeling the behavior of bulk media by means of EDEM allows the parameters of the use of transfer units, conveyors, mills and other equipment components of mining and ore dressing enterprises to be calculated, the conclusions with a high degree of accuracy to be drawn about the wear of the units after interaction with a conditional bulk medium. The EDEM program interface is shown in figure 4.
3. Results and discussion

As an example, an open pit section was built in the MGIS Micromine program. Data import (geological information about the modeling site) into the project was performed from an Excel file. At the first step of visualizing the ore body using strings (polylines), the results of well drilling were visualized.

To estimate the reserves, the ore body was interpreted and a block model was built. After determining the depth at which open pit mining is expedient, the contour of the base of the future quarry was outlined and its shell was built. The position of mine workings intended for underground mining was indicated using a special tool for creating frames. The result of constructing the open pit section is shown in figure 5.

4. Conclusion

Based on the analysis of the software, it can be concluded that the considered software tools can be used to construct a digital 3D model of a deposit area, create a topology of a mine workings system, simulate geomechanical processes in the development of coal seams, design underground mine workings relative to those actually passed and design an optimal scenario of mining operations.
References

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