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MATHEMATICAL MODELING OF THE POWERED ROOF SUPPORT SURROUNDING ROCK INTERACTION

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ABSTRACT. The behavior of powered roof support in different geological conditions is simulated using a dynamic model taking into account the roof convergence, the support-surrounding rock contact and the shield's stiffness. In such a way, the selection of the appropriate support according to the mining-geological is easier to be performed.
Key words: *roof support, mathematical modeling, coal mining*

МАТЕМАТИЧЕСКО МОДЕЛИРАНЕ НА МЕХАНИЗИРАН ГОРНИЩЕТО КРЕПЕЖ В СРЕДА НА СКАЛНО ВЗАИМОДЕЙСТВИЕ
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РЕЗЮМЕ. Имитирано е поведение на механизиран горнището крепеж при различни геоложки условия, използвайки динамичен модел като се има предвид подобно горнище (таван), контактът на крепеж заобиколен от скали и стабилен щит (екран). По този начин, изборът на подходящия крепеж според минно-геоложките условия е по лесен да бъде извършен.
Ключови думи: *крепеж на горнището, математическо моделиране, добив на въглища*

Introduction

The powered roof support represent the key equipment because of its high price and its importance in increasing safety and output level of the face. On the other hand, the powered roof support is the strongest influenced equipment by the geo-mechanical features of the surrounding rocks, the coal seam and the technological factors.

Because the methods used before in this field were focused on the one of the components of this system only, respectively on the aspects related to shield mechanics, taking into account the influence of the rock-mass against the shield structure considered as a rigid body by a presumed load distribution on the canopy, and the problem of the geo-mechanics of strata, ignoring the influence of the structure and stiffness of the shield, in this paper, the authors are trying to connect both components of the problem into the frame of an unique theory.

Computer modelling in shield kinematics and kineto-statics

A computer program of four-bar mechanism and shield structure kinematics was developed, which can be used to the analysis of a new designed shield or an existent shield; output data are available as structural diagrams and representative points loci , as shown in fig.1.

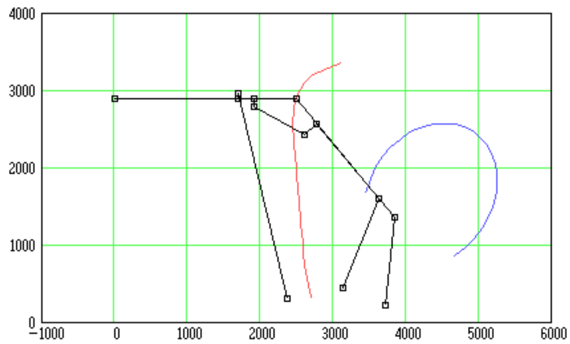

Fig. 1. Computer output of shield structure under analysis

The classical approach of shield mechanics, based on the rigid body theory was modified by the authors in the following manner:

– the loading scheme was modified by taking into account the horizontal force acting between the roof and the canopy which was presumed to be a frictional force, its magnitude being proportional with the magnitude of the vertical force, and its direction determined by the direction of the real horizontal displacement of the canopy produced by the kinematic of the four - bar linkage. It is also possible to consider normal and frictional forces acting on the caving shield.

– two different loading scenarios are considered, according to two main operating situations of a shield: setting of the shield, when the leg force is considered to be an active force and the capsule force, the normal and frictional force between canopy and roof are determined and yielding of the shield, when the maximal magnitude of the normal and frictional force and the capsule force according to maximal yield force of the legs are determined for different values of the location of normal force on the canopy, varying along the canopy with a certain increment.

In both situations the capsule force is considered as an unknown reaction except if its value is greater than the critical value for each direction when the protection valves of the two sides of the cylinder are opening, when this critical value is considered as an external load.

As output of the appropriate computer program we obtain the load-height curves (fig.2) for setting and yield load of the shield, and numeric values of forces acting in main ones of the shield.

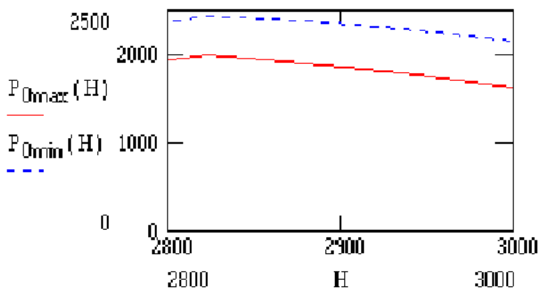

Fig. 2. Computer output load-height diagram of the kinetostatic program

Computer modelling of time-dependent behaviour of shield-rock interaction

The authors are trying to offer a model of time-dependent behaviour of the shield, as a relation with the main technical features of the support and the intrinsic geo-mechanical parameters of the mining environment in which the support will operate.

The mathematical model developed by the authors can describe the evolution of the system, with parameters which are independent from the type or nature of the support and can be determined by regression from the data acquisited by appropriate in-situ measurements.

The main parameters with regard to the strata-shield system are the convergence rate as a function of the support resistance (1):

$$v_k(c, p, n, v_{k0}, P_{max}) = v_{k0} \cdot e^{\frac{c \cdot p \cdot n}{P_{max\,s} \, n \cdot p}} \qquad (1)$$

in which, c - is a constant;
P - is the support load;
p - is the hydraulic pressure in the shield's leg;
n - is the efficiency of the shield, the ratio P/p;
v_{ko} - is the convergence rate of unsupported roof;
P_{max} - is the value of P for not converging roof.

The stiffness characteristic of the shield and of the floor and the roof areas being in contact with the canopy and the base of the shield, are correlated into a geometric compatibility equation.

The influence of the increase of the unsupported area after the cut of a slice by the shearer and the function of safety valve are also simulated with the model which is a differential equation (2) which can be solved by an iterative method using an adequate software with mathematic facilities.

$$\frac{dp}{dt} = \frac{v_{k0} \cdot e^{\frac{c.p.n}{P_{max}.n.p}} - \frac{p}{K_{er}}}{\frac{1}{K_e} + \frac{1 - \frac{n.p}{P_1}}{K_{r'}}} \qquad (2)$$

As results we obtain diagrams (fig.3) representing the pressure, convergence, closure variation over time.

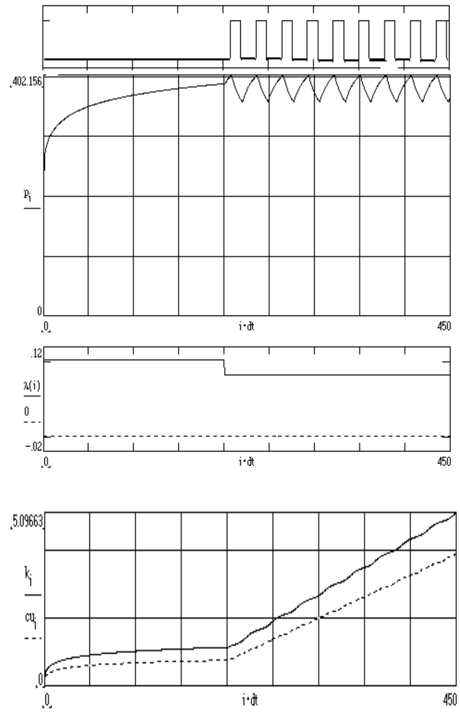

Fig. 3. Typical graphic output of the simulation program

Conclusion

The results obtained by the authors are encouraging to advance in this opened ways to realise a strong tool for the use of the shield designers and mining equipment users to increase their capability to develop and select the most appropriate equipment for the various mining conditions.

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Recommended for publication by the Editorial board of Section "Mining and Mineral Processing"