Modeling of a V-type mining support in an advanced engineering environment

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Abstract. Designing technical means using advanced computer systems requires the change in approaches to specific tasks carried out in this process. The solution of this problem is an integrative approach, which allows linking different operating ranges, various tools and complicated sets of requirements into a single operating design system. The elements of this integrative approach is the concept of splitting a technical mean system into three sub-system components. The first is structural sub-system containing solutions and their attributes regarding the structural concept of a designed system. The second is drive sub-system containing solutions of drive systems along with the parameters of their operation. Finally the last sub-system contains information relating to the control system and its settings. Systems attributes include such design features as the geometrical characteristics, material characteristics and assembly characteristics. The subject of the integrated design process is a mechanized mining support. As a part of the project the construction system of a mechanized mining support was divided on the three sub-systems. The structural subsystem includes a canopy, a burst shield and foot parts. Whereas the drive sub-system comprises includes the system of hydraulic props and hydraulic cylinders responsible for the functioning of the support. In the example, presented in the paper, is shown the system of hydraulic props where they are arranged in a V-system. These indicated two sub-systems form the structure of the support. It is complemented by the control sub-system basing on the use of control valves and separator valves and an operator control panel.

1. Introduction
Powered roof support is a part of a mechanized complex used for the special type of mining called a longwall mining. It is a form of underground hard coal mining. It consists on mining a long wall of coal in a single slice. Typically the mined layer is of 0.6 - 1.0 m in thick (it depends on the power of a shearer). In the longwall method the bed being mined (the stratum of hard coal that is currently excavated) is 1 - 4 km long (the range of one wall) and 200 – 400 m wide (the face of a wall). The height of a hard coal bed differs from 0.5 to 10 m. The longwall complex to mine such a bed consists of a shearer, an armored conveyor and about 100 - 200 powered roof supports (figure 1). Taking into account the problem of mining effectiveness it should be stated that this method belongs to the most effective. It is related with big possibilities for mechanization and automation.
Powered roof support is one of the most important part of a longwall excavation method. Moreover it is individually design to adapt its construction to the geological conditions occurring in a particular hard coal bed. This is why its design process requires special approach.

2. **Roof support as a part of a longwall system**

Powered roof support or mechanized roof support is the most important element of longwall complexes. It is design to fulfill some functions considered with the mining operation. To the functions of a mining support it is possible to include among others: protect the mining area, control the caving process, support the roof of a coal pit. A typical powered roof support consists of a canopy, a caving shield, two foot pieces, a lemniscate mechanism and a pair of props (figure 2).

![Figure 2. Typical roof support with one element of an armored conveyor [2].](image)

It has been designed many specific construction of a powered roof support (comp. [3,4,5]). They allow optimizing, in different areas, the traditional construction. To equalize the stress pattern it was applied the larger number of props. In figure 3 is presented a four-props support.
Taking into consideration the variety of constructional forms of powered roof supports and related with them realized functions that are a specific reaction on mining and geological conditions, it should be stated that elaboration of a design of a new support construction is a difficult task. This is why it should be added with modern design approaches.

3. Design approach
The design approach, utilized for this work, was based on the integration of elementary design solutions [7,8,9,10]. This task is realized according to the proposed general model of the structure of a technical mean (figure 4). The conception of a technical mean bases on the assumption that it could be divided in three main components. This components rely to three streams: a “material” one, an “energetic” one and a “information” one. The first one includes the structural elements of the designed technical mean. It role is to integrate other subsystems. The “energetic” system includes the engines and elements related with them. The last one is the “information” system, which includes control elements and the control procedures and program.

Figure 3. Example of a support with two pairs of skew hydraulic props [6].

Figure 4. Structure of a technical mean [4].
The development of the presented designing method could consists, among others, in modular design [11,12,13,14] as well as in artificial intelligence methods application. The last refers mainly to multi agents systems [15,16,17,18]. It is also possible to utilize the solutions characterized to other areas of design activities [19,20,21].

4. Design of the V-type support
The main requirement consider with the design process was to improve the stability of the powered support in comparison with the traditional, two-props one. This was considered with mining the crump coal beds. In such dynamic conditions the typical support proved to be overturned. In figure 5 is presented the behavior of a traditional support under the dynamic roof load.

![Figure 5. Stability analysis of a two-props support.](image)

The constructional ides was based on the assumption that the spacing of props joints on the canopy should be possible large to results in uniform roof supporting and the stress pattern. On the other hand the space at the bottom part of the support should be also large (access to the mining area). This is why it was decided to develop the construction of the roof support basing on the V-type placement of hydraulic props. The virtual model of his support, elaborated in the advanced CAD/CAE environment PLM Siemens NX, is presented in figure 6.

![Figure 6. Virtual model of the V-type support.](image)

The main factor that determines constructional solution is considered with a more uniform stress distribution and general typification of the whole family of construction of powered roof support. The presented one fulfill this requirements.
5. **Strength analysis of the V-type support**

To analyze the obtained construction it was conducted virtual engineering tests. Below (figure 7) are shown the results of the finite elements method and simulation tests carried out in the CAD/CAE class system. For the tests with the FEM method the model support was simplified and the stress distribution is enhanced to show the main nodes of stresses.

![Figure 7](image-url)

*Figure 7. FEM and stability analyses of the V-type support.*

Obtained results show that the proposed V-type roof support is characterized by the higher uniformity of the stress pattern and by the higher stability under dynamic roof loads.

6. **Conclusions**

The presented design is one of group prepared as proposals of new support constructions that allow obtaining additional advantages in comparison with a traditional one. The aim was to optimize the whole family of constructions. The problem of optimization was defined in traditional manner [22,23]. The resulted support characterized with the more uniform pattern of stresses. And, what is more important, with higher stability at dynamic load of the floor. Currently are realized investigations according application new materials for structural elements [24]. They are mainly focused on the utilization of duplex steels [25,26] as a group of cheap, stainless, and weldable materials.
7. References

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