

## PRODUCTION MANAGEMENT – INTELLIGENT SYSTEMS FOR SELECTION OF MINING METHOD

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**ABSTRACT:** In the paper are given the authors research results about application of intelligent systems for decision making process in operation of mining method selection. Obtained system prototype enables efficient choice of mining methods and withal makes their rating based on attained level of methods applicability. Nevertheless, it is very important to form the knowledge base, which contains necessity volume of knowledge for decision making process in operation of mining method selection. According to that, knowledge base is very important component of system and its characteristics have an important role in reliability of system.

### ПРОИЗВОДСТВЕН МЕНИДЖМЪНТ – ИНТЕЛИГЕНТНА СИСТЕМА ЗА ИЗБОР НА МИННА ТЕХНОЛОГИЯ

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**РЕЗЮМЕ:** В доклада са представени резултатите от авторските проучвания, относно прилагането на интелигентни системи в процеса на взимане на управленски решения при избора минна технология. Полученият прототип на системата дава възможност за удачен избор на минни технологии и освен това прави тяхната производителност основа за постигането ниво на приложими методи. Освен това, много е важно е да се определи областта, която съдържа необходимия обем от знания, за взимане на решение при избора на минен метод. Съгласно това, фундаменталните знания са много важен компонент от системата и неговите характеристики играят важна роля за надеждността на системата.

### Introduction

The main objective of applied mining method is acquirement of lower ore excavation costs and higher profit [1, 2 and 3]. Depend on applied mining method, important parameters of exploitation can differ, as well as working performance, ore excavation cost, ore loss and ore dilution, ore output and value of obtained metal or concentrate and finally, the profit.

Therefore, the process of mining method choice can be explained as tendency for achieving peak profit [4]. But, decision of application of certain mining method can not be only based on economic effects. There are other factors. Generally, all factors can be divided into three groups as following:

- mining-geological factors,
- mining-technical factors, and
- economic factors.

It is very difficult to insulate one of aboved mentioned groups of factors as the most significant. There are known occasions in practice where mining-geological factors allow application of one mining method, but this method can not be justifiable because economic factors. Also there are occasions when chosen mining method implys application of certain mechanization, but mining-geological factors don't allow the same method.

### PROCEEDING OF MINING METOD SELECTION

Ore excavation cost, as economic factor, have not influence on preliminary selection of mining method. Mining-geological factors and mining-technical factors have higher ascedancy in this stage of selection.

According to Bajkonurov (1969), selection of mining method has two phasis. The first phase comprises selection of excavation systems, in accordance with geological and mining-technical factors. The second phase comprises evaluation of selected excavation systems and selection the most rational one.

Imenitov (1970) also suggests two phasis of mining method selection:

- **the first phase** implys gradually elimination of non-adequate methods. Elimination of methods is based on determination of applicability of each method according to the characteristics of ore deposit.
- **the second phase** implys selection „the best” one from set of applicable methods.

Popov (1970) suggests proceeding of method selection which support the following priority: safety, economy and capacity. According to Popov, proceeding of method selection is following:

- in the first step comprises the selection of applicable mining methods, based on mining-geological and mining-technical factors.

- in the second step comprises selected the most effective method according to techno-economic factors. Techno-economic factors imply profitability of method. Profitability is determined on basis of cost of excavated ore and technological costs needed for ore excavation and ore processing.

Besides mentioned factors, available informations have significant influence on selection of mining method. Lack of needed informations complicates possibility of correct selection. Thereupon, precision (reliability) of method selection depends on accessibility and punctuality of informations.

## OUR PROCEEDING OF MINING METHOD SELECTION

Considered proceedings indicate that preliminary method selection precedes to mining method selection.

Preliminary method selection forms set of potentially applicable mining methods, base on mining-geological and mining-technical factors. Finite selection of mining method is done according to techno-economic factors, where are considered only methods from set of potentially applicable mining methods.

Above mentioned access enables selection the economic most acceptable mining method, by respect of mining-geological and mining-technical factors.

**Preliminary method selection** is based on knowledge and experience of experts who do selection process.

Results of many researches, carried out in the second half of XX century, have proved that knowledge and even experience of experts from certain field, can be used for generating of software, i.e. expert systems. So formed systems possess opportunity of certain proceedings, which are typical for human intelligence. Possibility of mining method selection definitely belongs to those formed systems.

**Finite selection of mining method.** Certain forms of software can be used for finite selection of mining method. One of them, as significant applicable software form, is Decision Support Systems.

Model-driven Decision Support Systems [5] possess adequate model base which can be used for generating of informations needed to decision-maker.

Adequate techno-economic models, which are used for determination of economic effects of applied mining method, can be embed in system model base and used by necessity.

## INTELLIGENT DECISION SUPPORT SYSTEM

Possibility of integration of decision support system and expert systems has been considered by many authors, among of them are accented Turban, and Čupić in domestic literature. One among possible integration is forming system which possesses ability to do following:

- preliminary selection of methods, i.e forming set of applicable methods by proceedings which are used in expert systems, and
- finite method selection or rating of applicable methods according to techno-economic models.

So formed system doesn't pretend to replace a man-expert, as can be noticed in expert systems. Its role is to help to decision maker to do correct selection of mining method.

## APPLICATION OF SYSTEMS FOR SUPPORT OF DECISION MAKING PROCESS

Considerable number of methods which can be potentially used for excavation in mine and numerous characteristics of ore deposits, which also affect on method selection, make method selection problem very complex. In several method selection cases it is needed a significant amount of knowledge, as well as experience in order to do adequate method selection. Furthermore, some method selection cases require long working time by decision maker.

Considering above mentioned, our research has been directional to forming and testing the system of method selection prototype.

In order to do preliminary method selection of potentially applicable methods, formed prototype (fig. 1.) contains the following:

- Knowledge Base, i.e. Rule Base which determines possibility of application of singular methods, and
- Inference Engine which, base of informations about one ore deposit, generates set of potentially applicable methods according to rules of knowledge base.

Formed prototype contains model base and appropriate subsystem for management in order to do method selection or rating of potentially applicable methods.

So concepted system allows fast and efficient identification of applicable methods, even when user has no enough knowledge about mining methods.

System is interacted and allows to user significant flexibility in process of analysis of economic effects which can be reached by usage of singular methods in concrete ore deposit in process of method selection.

Analysis can be done very fast due to available models in model base of system. In this process there is no needs to user has specific knowledge about applied techno-economic models.

Significance of applied concept is in its help to users of system, especially to users who don't have adequate level of specific knowledge for decision making about mining method selection.

This approach, which is used in making of subsystem for preliminary method selection, i.e. rule base and inference engine, allows method selection even in case of lack of precise informations.

Rules of mining method selection, with different level of reliability, can be done depends on number of relevant factors,

their influences, as well as level of tolerance for defining set of allowed values of characteristics of relevant factors which are applied in rule premises.

In case of usage of non-precises and unreliable informations, as well as in case of absence of needed informations, the rules of lower level of reliability for preliminar method selection can be used. In contrary, precise and reliable informations allows possibility of application of rules for selection with higher level of reliability and than is more accurate selection of alternative methods.

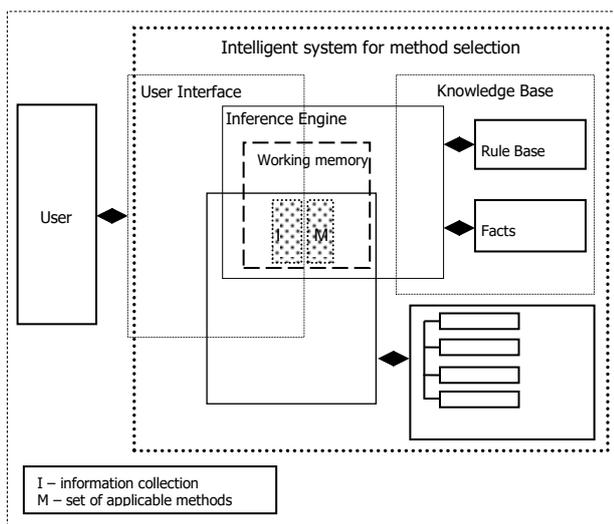


Fig. 1. Structure of Knowledge-Driven Decision Support Systems

Mentioned access partly reflects method selection proceeding in weakly structured fields, considering that even experts who select methods can suggest and recommend application of singular methods according to level of precision of available informations and level of their knowledge.

## CONCLUSION

Up-to-date researches of authors indicate on possibility of application of intelligent systems for decision support in order to make adequate mining method selection.

Formed system prototype, i.e. method selection subsystem, allows efficient methods selection and also rates them according to level of method applicability, based on usage of rules for alternative selection, i.e. knowledge included in knowledge base of system and available informations.

Knowledge base has the most important rule in this process. Knowledge base represents very important component of the system and its characteristics have significant influence on system performances, i.e. decision reliability of system. The further researches will be directioned on completing the knowledge base, i.e. collecting and memorizing needed knowledge volume for making reliable decisions of system.

The second field of researches will be the method of knowledge collection and their memorizing, i.e. forming efficient knowledge base. In this stage are identified some problems which must be solved. Those problems are some forms of knowledge indeterminacy and how to memorize and apply them in order to make adequate selection of mining methods.

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