

# ADAPTIVE COMPUTER SUPPORTED SURVEILLANCE-MANAGEMENT MODEL OF DEWATERING SYSTEM AT COAL OPEN PIT MINE

by

**Slobodan B. VUJIĆ**

Original scientific paper

UDC: 681.532/.533:662.642:622.015

BIBLID: 0354-9836, 10 (2006), Suppl., 4, 33-42

*The lignite open pit mine of "Drmno", Mining Basin Kostolac, deals within the framework of the Electric Power Industry of Serbia. The imperative condition for coal exploitation in this deposit is closely connected to the protection of open pit mine against ground waters which is based on the complex, spatial and timely non-stationary system of about 200 drainage wells, having the total installed power of pumps of approximately 2 MW. This system pumps out approximately 15.000.000 m<sup>3</sup> water annually.*

*The already existing manner of monitoring and management of the work of wells neither supports in real time the guiding of the process of dewatering according to the optimum regime and enables precise monitoring of electric power consumption nor monitoring the capacity and time efficiency of the system and does not register and does not diagnosis stoppages. The system also fails to enable prognosis and preventive undertaking the corrective measures, monitoring the reliability work of system components, precise monitoring of operation costs, control of costs covering building and exploitation of the system, storage of experience, efficient and effective support to the decision-making process.*

*Both these recognitions and the fact that each ton of the excavated coal is burdened by the costs of removal around 2.5 m<sup>3</sup> water from the working environment, influenced the initiating the idea on introducing computer-supported monitoring-management system of a complex for dewatering of the "Drmno" open pit mine.*

Key words: *monitoring, management, regulation, automation, ground waters, dewatering, open pit exploitation, coal, lignite, Electric Power Industry of Serbia*

## Introduction

The key problem occurring in coal exploitation at the "Drmno" open pit mine within the Mining Basin Kostolac, is evident in enormous water floods of the working environment. Therefore, the imperative represents dewatering, namely removal of ground water and surface water from the exploitation field. In order to perform drainage of the excavation field of the "Drmno" open pit mine, and in the least possible way imperil the

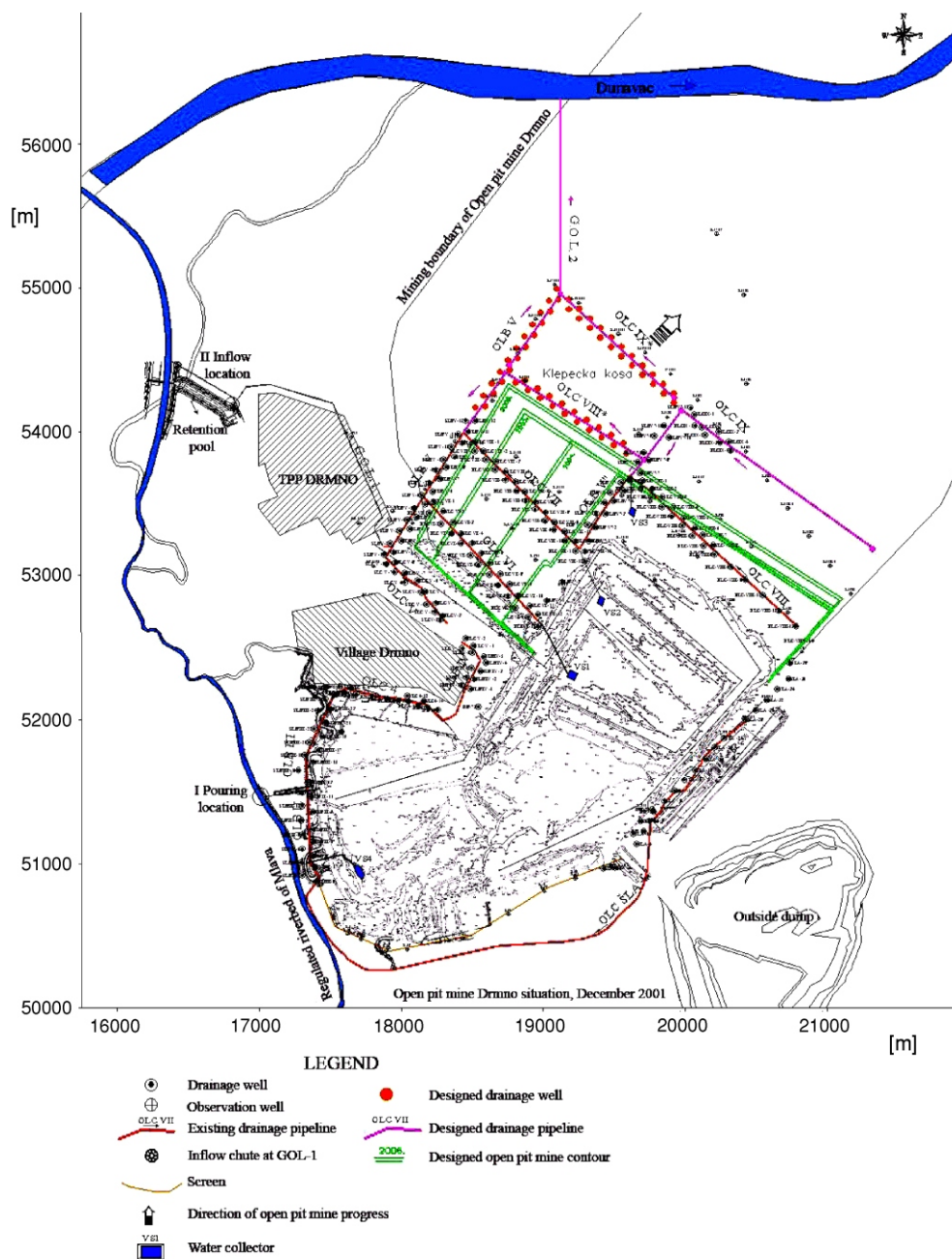


Figure 1. Principal scheme of a pilot system for monitoring and management at the “Drmno” open pit mine (in Gaus-Kruger coordinates)

agriculture and supply with water the surrounding settlements, the combined way of dewatering was applied. The south border of the open pit mine is being protected against the impact of ground waters by waterproof screen (length of about 2.200 m, thickness 0.6 m, depth 12-32 m). The objective of the screen is to protect inflow of ground waters into the open pit mine from south direction, as well as to prevent drainage of the soil towards the villages of Maljurevac and Bradarac. From the north, east and west side, dewatering is carried out by the system of wells.

The system of dewatering the “Drmno” open pit mine regularly includes about 200 wells (more than 300 has been built so far), distributed around the open pit borders in form of barrages, along lines (fig. 1). The number of wells varies during the work, ranging, as a rule, around 50% out of the available number. The wells go down deep from 26-143 m. So far, annually realized outputs concerning pumping of water range from 8.610,000 m<sup>3</sup> to 21.040,000 m<sup>3</sup>. The average coefficient of water floods is 2.07 m<sup>3</sup> water/m<sup>3</sup> overburden or 2.5 m<sup>3</sup> water/t coal. The total installed pump power is around 2 MW, and the power of pump in running is around 1 MW. The number of observation wells within the dewatering system is about 300.

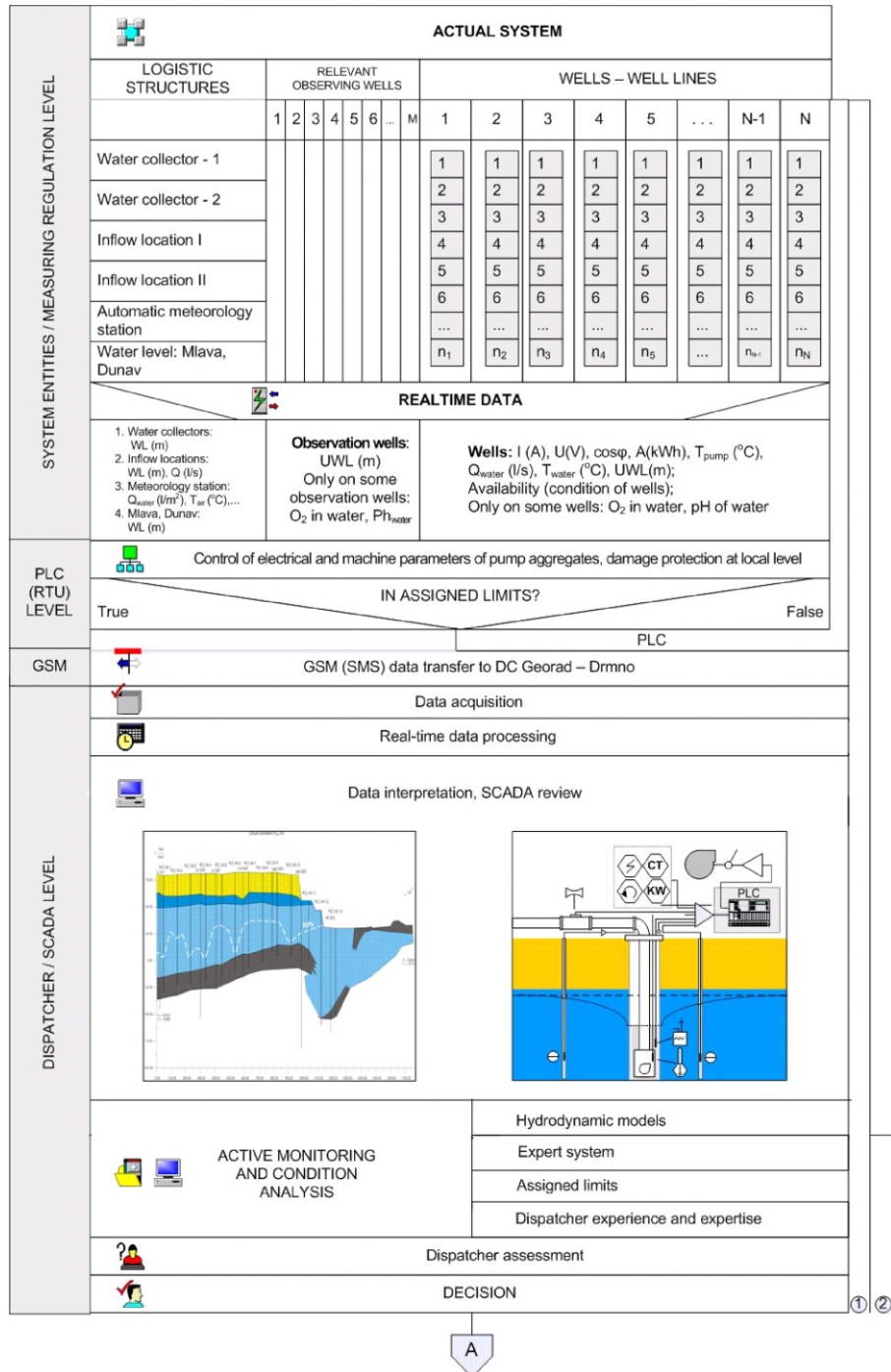
The water from the dewatering system is drained outside the area of the “Drmno” open pit mine by the main drainage pipelines and is let out into the Mlava river, that flows along the west border of the open pit. The outlet pipelines are set between the well lines containing the determined number of inflow manholes.

Non-efficient dewatering, namely insufficiently drained working environment, indirectly affecting the reduction of capacity utilization of the main excavating machinery, that could cause reaching the level even up to 40%, influences the increase in transportation costs (due to the increased moisture the weight of the transported material being higher, *etc.*).

The advance of works towards the west side of the open pit, where more heavier conditions of geological, hydro-geological and engineering-geological works of exploitation are predominant, the problem of dewatering appears to be is more exposed and severe.

The already existing manner of monitoring and managing the wells operations neither supports, in real time, the performance of the dewatering process according to optimum regime nor enables more precise insight into consumption of electric power; it also does not enable “on line” monitoring the capacity and time efficiency of the system, does not enable registration and diagnostics of slowdown, not rendering the possibility of prognosis and eventual undertaking the corrective measures, monitoring the work reliability of the system’s components, precise monitoring of operating costs, control of costs of building and exploitation of system, filling of experiences, efficient and effective support to decision-making process.

The above stated knowledge, together with the recognition that every ton of mined coal is charged by costs for removal of 2.5 m<sup>3</sup> water from the working environment, have influence on initiating the idea on development and making of computer-supported monitoring-management system of dewatering complex. Under the auspice of and with the financial support of the Ministry for science of the Republic of Serbia, within the framework of the National program of energy sources efficiency, a pilot project NEEP



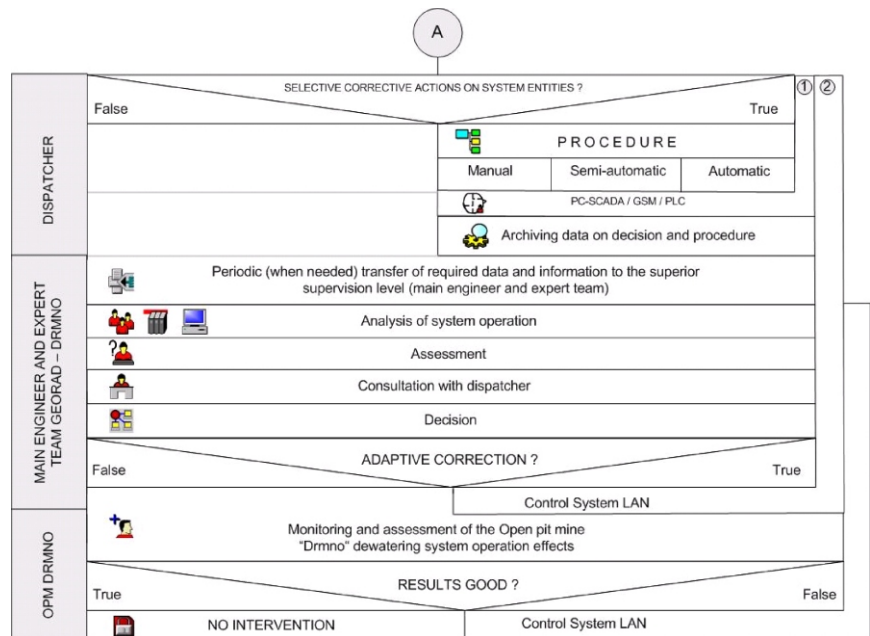


Figure 2. Algorithm of management

154A was realized (fig. 3). The project enabled experimental tests on one well and checking the concept of the system of remote monitoring and management (in real time) of the dewatering complex. The paper also presents the basic review of the system conception.

The Project is jointly realized by the Department of Computers Application Faculty of Mining and Geology, University of Belgrade, Informatics, Belgrade, Directorate for coal production of the Electric Power Industry of Serbia, Belgrade and Public Enterprise Open Pit Mines Kostolac.

### Algorithm of management

Starting from the targets of development and application of adaptive computer-supported monitoring-management system for dewatering of the “Drmno” coal open pit mine to the idea of the pilot project, the algorithm of management (fig. 2), in real time, incorporates and provides monitoring functions over hydrological processes of surface and atmospheric waters, hydrodynamic processes of ground waters in the zone of the operating effect and closer surrounding, monitoring and management function in on-line regime over technological, technical (electro-machinery), logistic and processes dewatering system management. This undoubtedly means establishing of a solid pyramidal hierarchical structure of acquisition and flow of information, conjunction of analytical pro-





**Figure 3. Pilot system at the open pit mine of “Drmno”**

cesses with the processes of hydrodynamic modeling and simulation the dynamics of ground waters flow with the aim to make conclusions and passing of timely and rational decisions.

The algorithm of management integrates into a pyramidal monitoring-management structure also all other accompanying processes, being of importance for efficient managing of dewatering process and technical system for dewatering. Management effects on functioning of the system for supplying with the electric power and technical segment of dewatering system (well), are realized by feedback.

Management algorithm consists of a four-level logical hierarchy, with measuring-regulation level, level of acquisition of signals and data, SCADA-namely executive monitoring-management level, and over-ordinated level of decision-making (fig. 4).

### **Topologies of monitoring-management system**

Three factors have dominant effect on physical and logical distribution of entities of computer-supported monitoring-management system for dewatering of the “Drmno” coal open pit. The first represents a large spatial distribution of executive (wells, water-collectors, inflow sites) and observation entities (observation well, and the measuring posts of the ground water levels). The second is a relatively well classification of executive entities – well lines. The third is a vast spatial and time non-stationary architecture of a real system that changes (slowly) depending on advancement of mining works at open pit mine. The analysis shows that a cluster or topology of the connected star is the most suitable solution for physical (communication) integration of measuring-regulation, acquisition, SCADA and over-ordinated segment of monitoring-management system for dewatering of the “Drmno” coal open pit mine. Such a solution of physical topology conditions a logical, namely a topological transmission of signals (fig. 5).

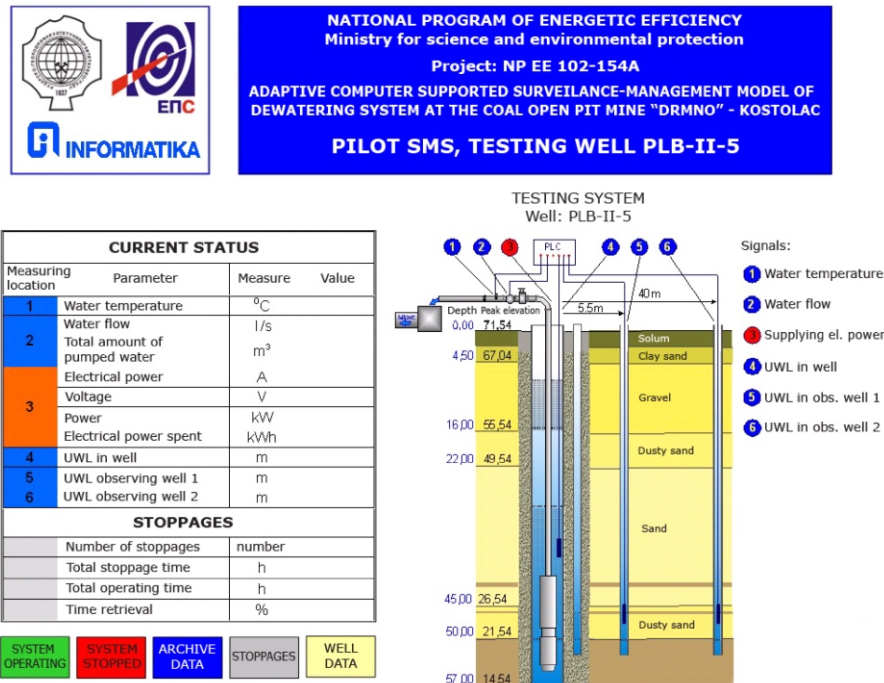


Figure 4. SCADA system

The preconditions of a successful functioning of monitoring-management systems are:

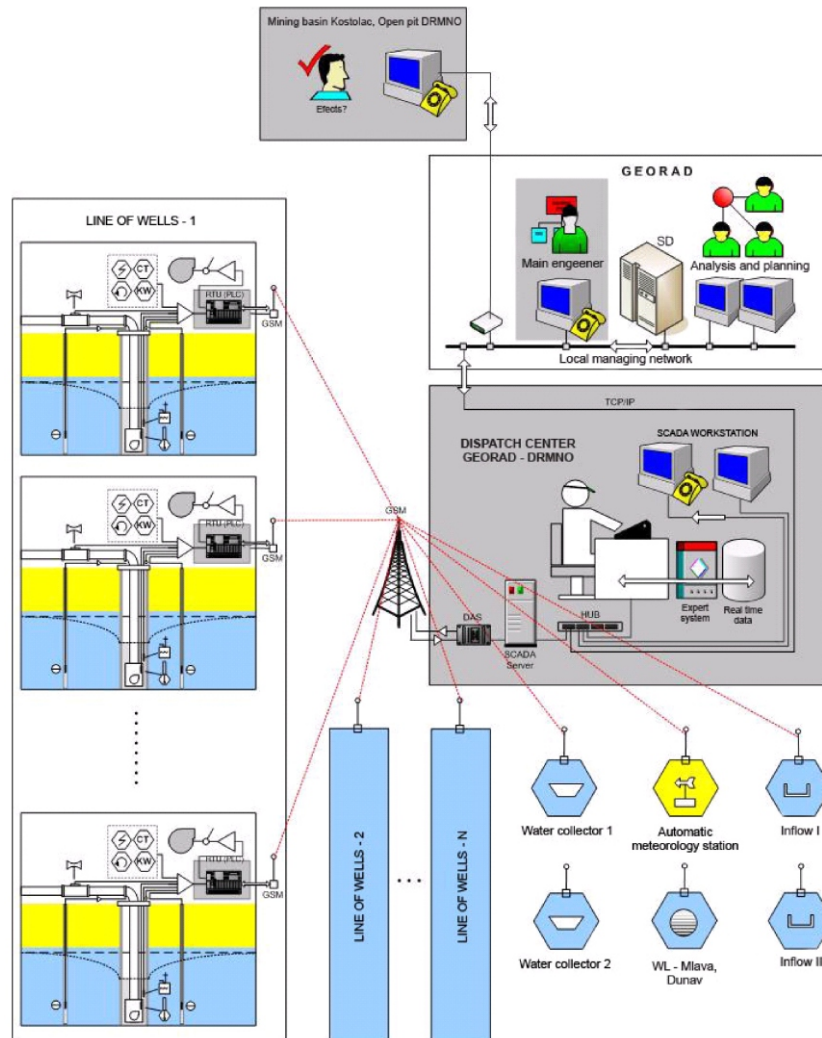
- adequate hydrogeological observation, and
- the corresponding measuring-regulation segments at entities of dewatering system.

To provide functions of remote control, namely monitoring the operation and management of dewatering system, it is necessary to secure, in real time, the signalization from the facilities of management and acquisition of measuring data such as:

- geometry of current field that changes with the progress of mining works,
- piezometric levels of ground waters,
- flows,
- ground waters quality (temperature, ph value, oxygen),
- consumption of electric power,
- temperature of engine and pump, and
- meteorological parameters (rainfalls, temperature, wind, *etc.*)

Signal system incorporates:

- alarm of the minimum water level in the well,
- signal system of pump engine in operation,
- alarm aggregate out of order,



**Figure 5. Physical topology of monitoring-management system**

- signalization of extreme positions of the cover (open/closed), and
- alarm for outburst into well.

The commands encompasses: the start and stoppage of pump engine, giving the referent level of water and flow of water by continuous regulation of pump engine revolution number.



### **The concept of computer system**

A monitoring-management computer system consists of the following components:

- SCADA system in control-command center (dispatch center),
- outer telemetric stations set in transfer case of pumps,
- measuring and regulation equipment at the management facilities, and
- communication systems, all information are by GSM connection transmitted tot sub defined time intervals to DAS computers in the command center, and *vice versa*, by the same communication ways the signals of management (command) are transmitted.

The system is thus configured to make possible the integration of all functional wholes at the highest level of management, and simultaneously the autonomous operation of each of the mentioned functional technical-technological wholes at other management levels.

### **Conclusions**

It is estimated that introduction of computer-supported monitoring-management system of the complex for dewatering of the “Drmno” open pit mine will reduce the consumption of electric power by 5% at least:

- the increased capacity efficiency of dewatering system by 20%,
- possible more rational building of new wells,
- reduced costs of dewatering system building by approximately 15%,
- increased time recovery of the system,
- improved reliability and safety of the system operating,
- reduced operation costs by around 10%,
- enabled efficient monitoring of HG situation as well as removing of eventual negative ecological effects,
- provided efficient diagnostic of slowdown in work of the system,
- provided prognosis of state and preventive undertaking corrective measures, and
- reduced total exploitation costs of the system by around 15%.

### **Acknowledgment**

This research has been financed by Ministry of Science and Environmental Protection, in the frame of National Energy Efficiency Program, project No. 102-154A (Development program: Energy efficiency in electric power production). Research has also been supported by Electric Power Company of Serbia, Belgrade, and Open Pit Mine “Drmno”, Kostolac, Serbia.

## References

- [1] Vujić, S. *et. al.*: Adaptable Computer-Supported Monitoring-Management Model of the System for Dewatering of the “Drmno” Coal Open Pit Mine (Phase I) (in Serbian), Project 102-154A, Internal Report, Faculty of Mining and Geology, University of Belgrade, Belgrade, Serbia and Montenegro, 2004
- [2] Vujić, S., Modern Trends in Computer-Integrated Technologies in Minerals Industry, IV International Symposium on the Occasion of the 40 Years of Existence of the Department for Machinery in Mining, *Proceedings*, Mechanization and Automation in Mining and Energy Sources, Faculty of Mining and Geology, University of Belgrade, Belgrade, 2002

Author's address:

*S. Vujić*

Faculty of Mining and Geology, University of Belgrade  
7, Džušina, 11000 Belgrade, Serbia

E-mail: [vujic@rgf.bg.ac.yu](mailto:vujic@rgf.bg.ac.yu)

Paper submitted: November 27, 2006

Paper revised: November 29, 2006

Paper accepted: December 1, 2006