Slobodan Vujić, Milinko Radosavljević*, Igor Miljanović**, Mihajlo Gigov**

INVESTMENTS AND BENEFITS IN COMPUTER SUPPORTED SYSTEMS FOR REMOTE MONITORING AND MANAGEMENT IN REAL TIME

Abstract

Contemporary computer supported technologies unify a multitude of functions, from geological explorations, through planning, design, mining, auxiliary and logistic activities, monitoring, analysis, decision making to the real time management. This approach requires the information-management systems with a multi-level hierarchy structure, with high monitoring-management efficiency. Accepting the challenges of time, the Serbian mining took the starting position in this technological game timely, with some good ideas and projects, but without efficient realization. There is an opposite example however, in 2000, a computer system for remote monitoring and management in the real time at the "Majdan III" open pit mine was built. Fourteen years of continual monitoring of this systems operation and the quantity of technical and technological data on its functioning, has provided a reliable and objective depicting of the monitoring-management efficiency, investments, costs and benefits. This paper presents the actual results achieved with this system and comparatively analyze investments and benefits for the similar systems in coal and non-ferrous metal mines.

Keywords: mining, computing, monitoring, management, investment, benefit

1 INTRODUCTION

Great investments were made on a global scale into innovation and development of mining technologies in order to increase the productivity and production efficiency. In accordance with these efforts, the mining companies dedicate a special attention to development and application of automation, computer supported systems of remote control and management, and development a new generation of robotic ("smart") machines. Significant progress was made due to the accomplishments in the computer technologies department, but foremost due to the achievements in the communications department, spatial positioning in real time, sensory, regulation technique, systematic and mathematic-model philosophy.

One of the current subjects is the energy efficiency. Automation and process management increase the energy efficiency through decrease in oscillations, an increase in stability and consistency in task completions according to the defined work program of technological system. Lesser fuel consumption results in reduced gas emissions from internal combustion engines that power machines, lower operation expenses and other benefits. Computer supported systems for remote control and real time management enable the ecological monitoring, a reliable and precise change monitoring and change analysis (noise, seismics, dustiness, gas concentration,

* Mining Institute, Belgrade, Serbia, slobodan.vujic@ribeograd.ac.rs

** University of Belgrade, Faculty of Mining and Geology, Serbia, igor.miljanovic@rgf.bg.ac.rs

temperature, level and quality of ground and surface water, etc.) in the area impacted by the mining operations, and in case of emergencies, timely correction operations.

Integration of computer supported systems for remote control and management with the business platforms of mines creates a reliable and efficient ambience for decision making support.

Figure 1 *Illustration the computer supported mine system for remote control and real time management*

Mining production is a sequential series of connected processes starting with excavation (or drilling and blasting), loading, transport to the ore processing and final product transport. Installation of automation and remote management of production line, means usage of sensors providing the data necessary for monitoring and operation management, which is essential for work safety, especially under difficult weather conditions at the open pits (reduced visibility, snow, rain and other weather patterns), for prevention the collisions and truck turn-overs during material unloading at depots, for machine failure and breakdown prevention, efficient planning and equipment and machine maintenance.

Automation and process management has a significant role in the mining economy, it is of immediate use when it comes to cutting costs, increasing the work discipline, temporal and capacitive usage, detection and elimination the loop holes in the technological process, decrease in the consumption of energy and standard materials, over utilization prevention, malfunctions on machines and equipment, etc.

The usage and combination of knowledge of mining engineering and science with the achievements in the computer technology field, robotics, mechatronics, telemetry, satellite positioning, sensory and communication technology, applied mathematics, fuzzy logic, artificial intelligence,

management theory and systems sciences, has achieved impressive, but not final results in this field in a short amount of time. Numerous issues and tasks are yet to be solved as well as issues in automation and process management in mining, foremost the issues with sensors. There are still no sensors comparable to human senses.

2 EFFECTS OF IMPLEMENTATION THE REMOTE CONTROL AND MANAGEMENT SYSTEMS IN MINING

The base functions of computer supported IMS (Information-management systems), i.e. the control and management systems of mining complexes, and the effects that are made through this systems implementation, related to:

- Control of machines and equipment (prevention of failures, malfunctions, and maintenance regiment. Prevention of borderline situations and incidents and operation modes of equipment and machines, which eliminates or reduces malfunctions, failure and equipment damage which extends its lifetime and reduces the maintenance costs);
- Process control (indications of crisis and incident operation modes);
- Process management (machine and equipment management, and process parameters management);
- Optimization the mining parameters of machines and equipment;
- Technical process efficiency (the technical process at a particular level and operation mode);
- The efficiency of reaching management decisions (timeliness and expert grounds);
- Economical usage of available resources (management response to changes in operation conditions);
- Minimization the subjectivity of human factor, especially in conditions of

sudden and critical operation disruptions of equipment and facilities;

- Positive incentive and motivation of workforce (training, development, education);
- Work safety (reduction of the disruptive influence of atmospheric conditions, reduced visibility, snow, rain, etc.);

There is a vast array of useful quality and quantity effects from the control and management systems on technical, technological, economical, job and wider areas.

The resulting key effects are efficiency, productivity and cost effectiveness of the production process, which through direct savings compensates investments in IMS in short-term.

Indirect effects are of special significance (increase in work discipline, responsibility, attitude towards work and work assignments, etc.) since the computer control and management systems have been introduced into the production process. The introduction of control and management systems influenced an increase of motivation of employees for work and development, due to the advantages provided by the system in completion the work assignments, handling of modern technology and enabling independent development of application solution, etc.;

The control and management systems exploitation directly and indirectly influences the creation of objective technical conditions and knowledge and experience accumulation for further development the systems hiring the existing workforce and spreading the system application, and through it the growth of positive effects of investment in IMS.

Investment in computer supported control-management mining systems in mining is not a classical investment endeavor in terms of going into the new production programs, creation of new capacities, cornering

the market with the new products, services, etc. Therefore, starting with the relevant instructions of current international methodologies (UNIDO, World Bank, European economic commission and their approach methodologies to the projects with the goals to increase the production, energy, resource efficiency, etc.), there is and can be no classic investment analysis as with the industrial feasibility studies.

With evaluations such as these, the focus is on the technical-technological solution for the control-management system and evaluation the effects of its implementation for the purpose of improvement the exploitation characteristics of existing capacities and to raise the realization quality of production assignments, with the rational energy consumption, material resource and other savings and positive effects.

Figure 2 Codependence of investments in mining control-management systems, time it takes for a payoff and the mine capacity

Certain elements in these projects cannot be precisely quantified, so an evaluation model is used, based on experiences with similar projects or analogous situations. This also pertains the evaluations of qualitative investment effects.

All of this does not reduce the expert basis, objectivity and the wholeness of the final

evaluation about investment justification for the computer supported control-management systems.

According to our analysis and numerous expert reports regarding examples and practices, the period for repayment the investments in such systems can range from several months to two years maximum, a

3 OUR EXPERIENCE

year on average, depending on the size and complexity of the production system, work conditions, manners and conditions of securing the financing, etc. Figure 2 presents a dependence of amount of investments in SMS (Control-Management System) and the time it takes to repay them on the mine capacity. The amount of investments made into the control-management systems and the time it takes to repay them depends on numerous factors in mining, therefore the diagram should be taken as an orientation indicator.

The open clay pit Majdan III of Potisja from Kanjiža is the first on which the control-management technology with the satellite positioning system and navigation was applied on, and the first mine in Serbia with and integrated computer support system for remote control and real time management, Figure 3.

Fourteen years of operation monitoring and experience with the ECD (excavator-conveyor belt-disposer) complex with a computer supported IMS, enables an argued and objective overview the effects, results and gains.

Figure 3 Physical topology of remote control and management system of the open pit Majdan III Potisje Kanjiža (1998)

Because the sophisticated control-management and exploitation (ECD) technology are intertwined, many benefits and savings were made, and these are the most significant: transport expenses have been reduced 4 times as much as the costs of cyclic transport at the previous open pit Majdan II; monthly oil consumption has been reduced by 50,000 liters; electricity consumption has been increased but the monthly savings is about 21,600 Euros; the effective operating time at the open pit was increased by 792 hours a year; reliability and system operation safety is high in all weather conditions; maximum efficiency in excavation, homogenization and selective clay deposition has been achieved; negative environmental impacts have been removed, there are no gas emissions or dust, the noise level has been reduced, etc.

Specific investments in the information-management system OP Majdan III

amount to 0.375 Euros per ton of clay at annual level, for t depreciation period investments are 0.095 Euros per ton of clay.

In order to keep up with the competition according to the world standards, technical, technological and organization improvements are not sufficient. An efficient control and real process management system is also required. As the first project of integrated IMS in our country, *Project IMS of the Open Pit Tamnava West Field of the Mining Basin (MB) Kolubara*, its task was to affirm the idea and pave the way for introducing and applying the computer supported information - management technologies in our mining. The IMS of the open pit Majdan III Potisje Kanjiža was designed and built on the ideas of the IMS of the open pit Tamnava West Field, Figure 4, and it can be noticed that the IMS project of the open pit Tamnava West Field has a positive reflection.

Figure 4 Physical topology of remote control and management systems of the open coal pit Tamnava West Field MB Kolubara (1996)

The funding required to construct IMS at the open pit Tamnava West Field are modest when compared to the investments in main and auxiliary equipment and machines. According to the measured production of the open pit Tamnava West Field, the specific investments are 0.078 Euros per ton of coal.

The "cost-benefit" analysis shows that the investment in the computer supported system of control and mine management and flotation of the mining company Rudnik Rudnik, Figure 5, with a production increase by 1% and savings, will be repaid

in less than 18 months. The effects of establishing the remote control and management systems through flotation of Veliki Krivelj in the Bor Copper Mine are identical.

According to the *Project of Control-Management System of the Open Coal Pit Bogutovo Selo of the Mine and Thermal Plant Ugljevik*, the annual production investments are 0.175 Euros per ton of coal, and for depreciation period the installed equipment into the control-management system it is 0.044 Euros per ton of coal. In comparison, the same funds are required to obtain a mid-class bulldozer.

Figure 5 Physical systems topology of remote control and management systems of the mine (up) and flotation (down) of the mining company Rudnik Rudnik (2000)

The specific construction costs of the *Computer Supported System for Remote Control the Open Coal Pit Drmno - Thermal Power Plant and Open Pit Mines Kostolac (TPP-OPM)*, Figure 6, are 0.185 Euros per ton of coal per year, and for depreciation period the equipment of the control-management system it was 0.045 Euros per ton of coal.

At present production levels of the open pit of Veliki Krivelj, Copper Mine Bor, the specific investments in the remote control-management system, Figure 7, are 0.039 Euros per ton of ore. Investments in the remote control-management system of the Copper Mine Majdanpek have a similar effect.

Figure 6 Physical topology the remote control and management systems and management of the open coal pit Drmno, TPP-OPM Kostolac (2007)

Figure 7 Physical topology of the remote control and management systems of the open copper pit of Veliki Krivelj, Mining and Smelting Basin Bor (2012.)

CONCLUSION

Findings, practice experiences and results of numerous engineering analysis in designing the computer supported systems for remote control and management in real time, confirm the profitability of these systems. The investment payout period ranges from a couple of months to two years. With establishment the computer supported control-management systems in mines, the metrics of profitability cannot be reduced to just material correlation of cost and benefits due to the significant exploitation benefits from technical, technological, innovative and safety aspects, it is not possible to quantify them with just monetary value. That is why the analysis and evaluation, when arguing for investments and benefits of control-management systems, must be based on multi attribute principles.

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