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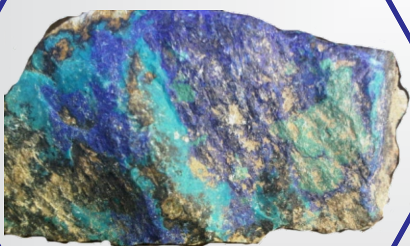

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CONCEPTS OF 3D TERRAIN MODELING AND GEOMORPHOMETRIC ANALYSIS IN MININIG*****

Abstract

This paper describes the concepts of 3D terrain models and their application in mining. The methods of terrain (relief) by spots elevation and contour lines are commonly applied on geodetic plans and topographic maps. Appearance of the technologies has changed the way of modeling and analysis of geospatial data, i.e., applying the concept of digital terrain models (DTM). This approach emphasizes the importance of geomorphometric analyses and monitoring changes on the field in time. Application of 3D geodata models in digital format (raster or vector) becomes increasingly used in mining. Therefore, it is important to describe the concepts and features of 3D geodata models and potential applications and monitoring changes in the field in time and space.

Keywords: *concepts of modeling, 3D model, DTM, geomorphometric analysis, application in mining*

1 INTRODUCTION

There is aged tendency to present the third dimension with sufficient quality during modeling (visualization) of the Earth's surface on geodetic and geographical maps. This was achieved with some success by elevation isolines, hatching, shadowing and relief maps [4]. However, this is changed with appearance of the new technologies and their application, mainly by digitalization of topographic maps, geo-information system (GIS), global positioning system (GPS) recordings, and lately by remote sensing and laser scanning of objects and attributes [2]. Acquisition and modeling of spatial data became more efficient and of high quality.

This paper is directed toward research and application of presentation of 3D methods for reviewing the spatial changes of terrain at the excavation area and changing surface configuration. Mining industry in the Republic of Serbia is one of the lar-

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gest industries during last several decades, mainly related to the production of construction materials and other mineral resources. The main task is to precisely model the surface features (terrain) and monitor changes of mining fields. This includes procedures for management of geo-spatial resources in real and close-to-real time, which should be based in acquisition and processing of series of spatial-time data. Simultaneously, concepts and development of 3D model are based on application of terrain digital modeling technology.

2 OVERVIEW OF THE CURRENT SITUATION

2.1 Presentation the 3D Terrain Model on Topographic Maps

Presentation the third dimension on maps was achieved by various methods with different success. The geometrical method of relief presentation was the most commonly used [2], with isolines and elevation marks. Presentation of terrain elevation with this method is related to geomorphological properties and elevation. Such presentation should provide realistic spatial interpretation on unevenness, distribution of individual shapes and their connections, character and degree of surface articulation of Earth and capability for quality and quantity assessment of terrain. Also, such approach enabled creation of relief maps, beside those printed on paper, which had some practical use for optical analysis of terrain and identification of geomorphological features of the Earth's surface. However, these maps could not be used for analytical assessment and analysis of terrain [4].

Topographic maps also have the other details related to the quality and quantity [4], beside isolines as the main carrier of metrical information. These are symbols and other elements of geographical expression, used for presentation the typical shapes (sinkholes, mines, mounds, hollows in plains, rocks, gravel or soil deposits, rocky ground, gullies, ravines and similar). These shapes are presented on topographic maps by isolines depending on a map scale. Other-wise, they are presented by hatching-hyphens, symbols or conditional marks [3].

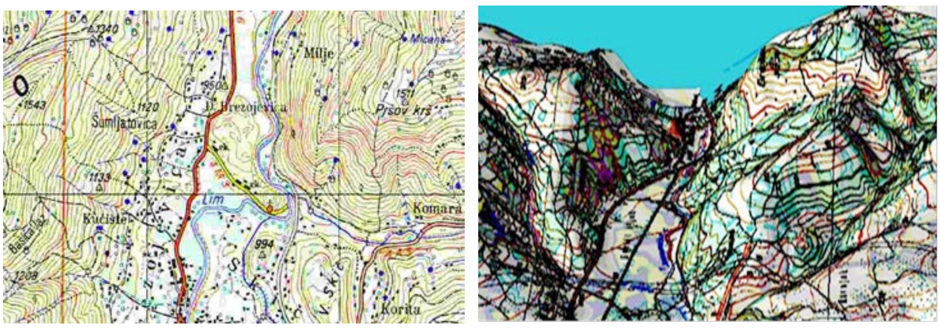


Figure 1 *Terrain presentation on topographic and relief maps* [2]

2.2 Presentation and Visualization the 3D Terrain Model in GIS Environment

Introduction the phrase "digital terrain modeling" is attributed to two American engineers from the Massachusetts Institute of Technology. A definition that they provided in mid-1950-ies is "Digital Terrain Model (DTM) is statistical interpretation of continuous ground surface by large number of selected points with known X, Y and Z coordinates in arbitrary coordinate system" [1].

Since then, numerous similar definitions have been provided in other references, where some related to the similar concepts while the others were quite different, hence requiring attention.

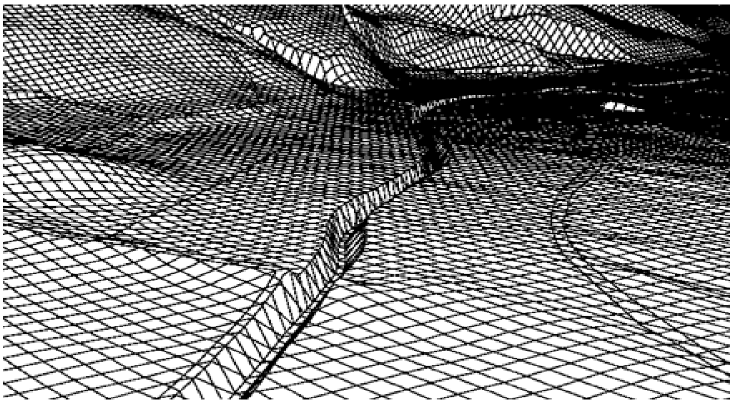


Figure 2 *Digital terrain model [4]*

Therefore, DMT as statistical interpretation of continuous surface of the Earth can be classified in two groups, according to the retention of elevation data. The first group includes points distributed over even mesh, thus representing the Grid. The second group is based on mesh of irregular triangles, i.e. Triangulated Irregular Network), where the three-dimensional points make a mesh of triangles which cannot be overlapped. Both data structures present a derived presentation of DMT [1].

3 CONCEPTS OF TERRAIN MODELING AND POSSIBLE 3D INTERPRETATIONS

Purpose of DMT is aimed to forming a mathematical model for accurate interpretation the terrain surface, thus enabling various analyses and applications. In order to perform the efficient analyses, having in mind that 3D models commonly comprise a large amount of data, a special data organization and structuring is required. Therefore, the process of 3D model development compri-ses from selection and implementation of data structure and suitable development method. Terrain surface is most frequently presented by set of points and lines distribu-ted over the surface in suitable manner and organized in proper structure for easy data handling [1]. Also, the other components of 3D model are methods used for definition of topographic surface in geometrical and geomorphological sense, for given data structure. In general, terrain surface can be presented in three ways:

- isolines,
- by function with two variables, and
- volumetric model.

Terrain interpretation with isolines represents the cross-sections of terrain surface and horizontal planes and selected elevations. These sections are curved lines, which are called isolines, the most commonly used for interpretation the terrain on analogue maps. This mean of terrain presentation has high quality regarding geomorphology, since it encompasses all important attributes of terrain relief [1].

Also, the terrain surface is not explicit in mathematical interpretation the Earth's surface with isolines in digital form. It is implicitly given by sections of the surface with horizontal planes (figure 3). There fore, this approach for modeling of terrain surface is not enough exact method, since it does not interpret the terrain elevation between two successive isolines [5]. This issue is very important at location with typical relief features such as tops, bo-ttoms, water drains, watersheds, excava-tions, etc.

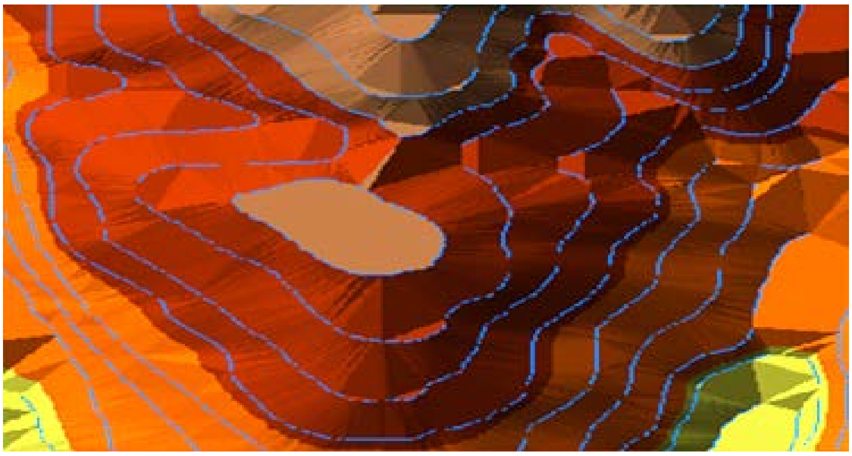


Figure 3 *Interpretation of 3D model with isolines*

The second way for interpretation the terrain surface in digital form is the use of functions with two variables, where these variables belong to the specific domain. Most often, these are functions where for given location (usually planimetric coor dinates X and Y of local coordinate sys-tem, state system or even geography sys-tem) the unambiguous value of elevation is obtained [5]. In this case, it is the 2.5D (2D+1D model. Terrain surface is inter-preted by set of points $(x\ y\ z)^T$, where:

$$z = f(x, y) \text{ explicit form of function } f \text{ over domain: } D \subset R^2 \qquad (1)$$

Terrain models enabling the surface in-terpretation in such manner that several ele-vations can be obtained for single location (x, y), i.e. surfaces described by function f (x,y) in form of vector, called 3D models. With these models, all three coordinates are equally important. Therefore, the terrain surface is then described by function:

$$\begin{bmatrix} x \\ y \\ z \end{bmatrix} = f(u,v) = \begin{bmatrix} f_x(u,v) \\ f_y(u,v) \\ f_z(u,v) \end{bmatrix}, \text{ where: } (u, v) \in D, D \subset R^2 \qquad (2)$$

The most important and in practice co-mmonly used 3D terrain models with such principles are the digital terrain models (DMT), with the main data structure in the form of Grid and TIN (Triangular Irregu-lar Network). These models are presented in Figure 4.

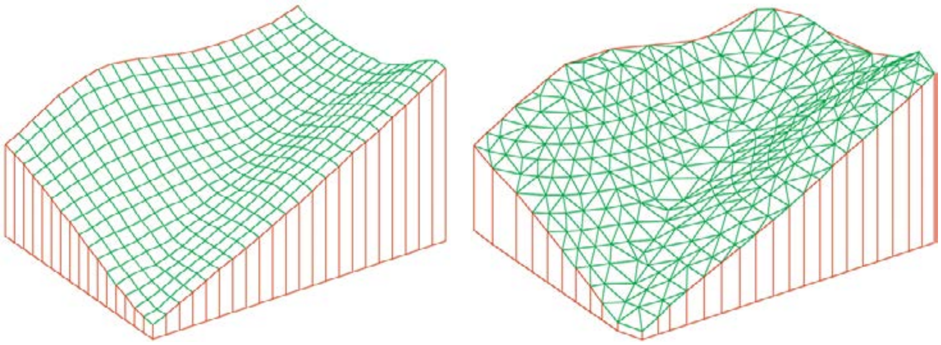


Figure 4 *Presentation of 3D terrain model in the form of Grid (left) and TIN (right)*

And, the third way for interpretation the terrain surface is volumetric model, in which spatial objects are interpreted by volumetric components [1]. Typical example is application the voxel (volumetric component, frequently in shape of cube or prism) with sufficiently small dimensions. This is similar to interpretation the appearances on digital raster images (or raster GIS) with sole difference that digital images are 2D [1]. However, this model is interprets terrain as a single body comprised of interconnected voxels set. These data model can be used for interpretation of tunnels, caves, buildings and structures, settlements, etc.

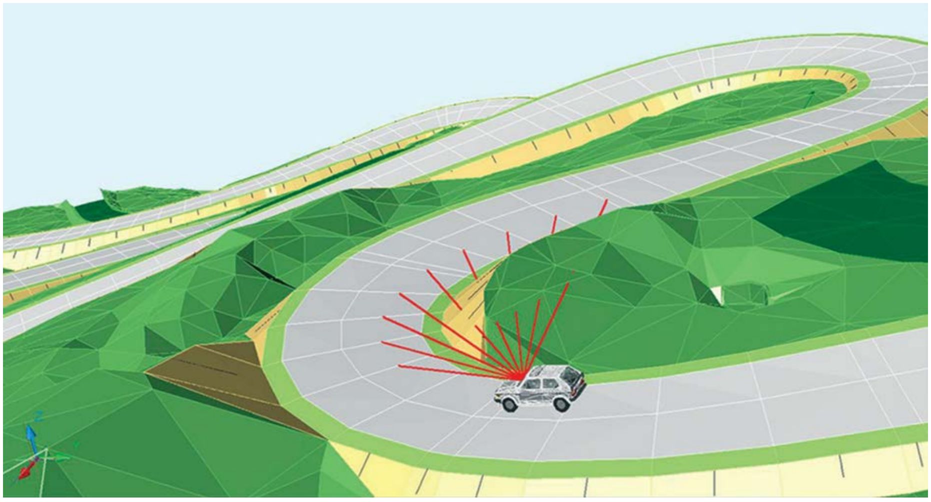


Figure 5 *Interpretation of 3D model in volumetric form*

The second type of volumetric models is the models based on interpretation the objects in space by division of space into non-overlapping tetrahedrons. This is analogous to the TIN interpretation of objects in 2.5D models, with two variables function. Finally, it should be noted that the volumetric models are mainly used for interpretation the infrastructural objects and populated places, especially cities and roads (Figure 5). Also, such models are used in construction, urbanism, geophysics, and seldom for terrain surface.

4 GEOMORPHOMETRIC ANALYSES IN MINING

Various industries require numerous analyses before, during and post operational activities on the field, for example, selection of location for implementation the projects in mining and power industries. This is difficult and long task, if it is done in classic work procedure [6]. Thereby, the quality of results depends on the surveying plan or topographic map, equidistance of isolines and their accuracy, number of profiles and accuracy of graphical interpretation, as well as education of the person reading the elevations from the surveying maps.

Development and visualization of 3D model of geo-data in digital form enables numerous geomorphometric analyses [7]. This paper describes the standard approaches to analysis and examples which can be performed with various software and applications developed for mining industry (Figure 8), such as:

- uninterrupted oversight on terrain surface (relief and sight, on site elevation read out);
- design and execution of works on terrain surface (construction, mining, energy);
- calculation of volumes (volume of earth and development of profiles between points);
- simulation and 3D animation (development of plans of terrain and mining basins);
- geomorphological analysis and soil classification (inclination and terrain exposition, geology);
- determination of soil types and seams in the Earth's structure (remote detection).

Figure 6 *Overview of the open cast mine*

4.1 Impact of the Earth Relief on Visibility between Two Points

Visibility analysis between two points on the Earth's surface can be significantly speeded up if there are 3D models and suitable technologies. Thereby, any visible point is marked with 1, and nonvisible with 0. In this manner, a file is created ready for further analytic and graphical processing, i.e. visibility between two locations on surface of the Earth. For example, let's assume that point O is a viewing point with known coordinates x_0, y_0 and elevation h_0. A task is to determine whether point P is visible from point O. By intersection of line trough points O and P with headings parallel with axes x and y, the coordinates of all amid points from 1 to 5 are provided. Elevations of these points are obtained by interpolation between the neighboring points of 3D model, shown in Figure 7 [3].

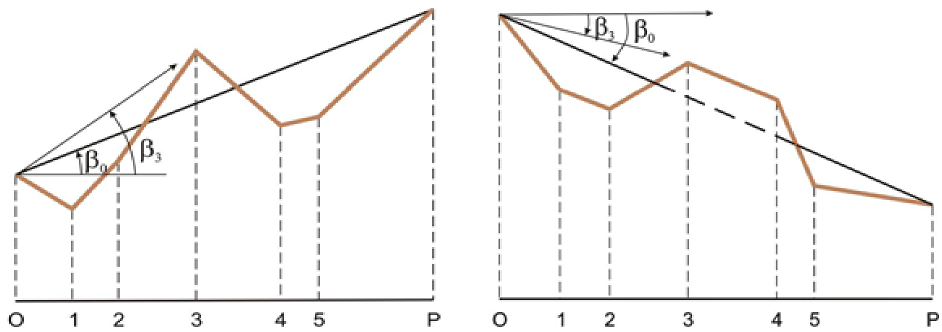


Figure 7 *Visibility between points O and P if $h_0 < h_p$ or if $h_0 > h_p$* [3]

Further on, it is checked whether elevations of all amid points intersects with line trough points O and P. In case of no intersections, there is visibility between O and P. However, if only one elevation has intersection with line OP there is no visibility. Also, if neither condition is met then it is necessary to calculate tangent of angle β_0 from point O to point by formula [3]:

$$\tan \beta_0 = \frac{h_p - h_0}{\sqrt{(x_p - x_0)^2 + (y_p - y_0)^2}} \quad (3)$$

An example, presented in Figure 8, shows the selected location (point) and determined visible territory which are of lighter color and nonvisible one of darker color [7].

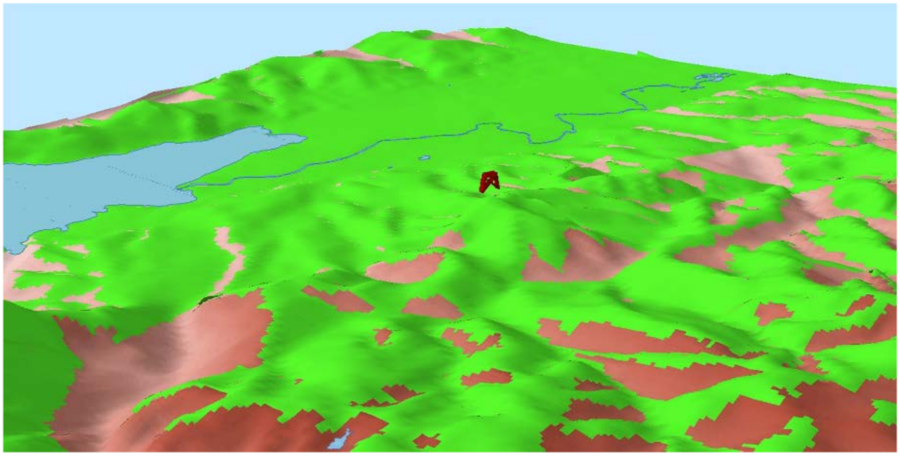


Figure 8 *Terrain which is visible and nonvisible from selected location*

4.2 Terrain Inclination

Terrain inclination (S) is an important topographic parameter. It is defined by gradient, i.e. vector which indicated direction of largest growth of scalar function z=f(x, y). Also, inclination can be defined as the change intensity of elevation in direction of largest slope [6].

$$S = \sqrt{\left(\frac{\partial z}{\partial x}\right)^2 + \left(\frac{\partial z}{\partial y}\right)^2} = \sqrt{z_x^2 + z_y^2} \qquad (4)$$

Terrain inclination in a point is defined as an angle in vertical plane between tangential plane on terrain surface and horizontal plane in selected point. This example is shown in Figure 9.

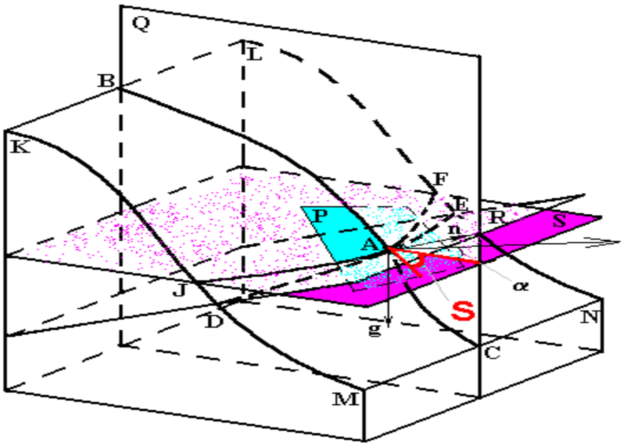


Figure 9 *Calculation of inclination angle*

Considering that the most of the Earth's surface is under inclination, angles are representing and have impact on gravitational force thus generating numerous geomorphological processes. Among other things, terrain inclination has influence on surface water flow velocity, soil moisture and saturation, intensity of geomorphnological processes and similar. The following must be considered in calculation of terrain inclination [10]:

- larger resolution of DMT results with greater accuracy of calculated terrain inclination;
- the average value and dispersion of calculated inclinations decrease with increase of distance (dimension of grid cell) of DMT;
- impact of DMT resolution is larger along the typical terrain shapes (steep slopes, edges of the mine, cuts, ridges and similar).

Inclination angle in case of TIN represents maximal value of inclination change along each triangle, while in the case of Grid there are several ways for calculation of inclination according to each cell of the Grid and its neighboring eight cells. During the process of terrain angle determination with Grid, the input is terrain surface raster, while the result is a raster containing tje calculated inclination of each cell in input raster. In case of TIN, calculation of terrain inclination is done over each triangle, also resulting with raster. Smaller value of inclination, whether it is TIN or Grid, indicates flatter terrain, while the larger value indicates steeper one [6].

Also, the angle of terrain inclination has significant impact for determination the properties of any area for operational activities, especially mining activities. Terrain inclination can also be expressed in degrees, as shown in Figure 10.

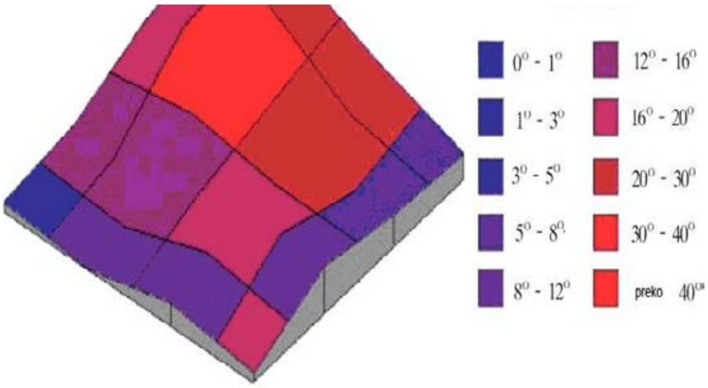


Figure 10 *Terrain inclination*

For easier analysis and reviewing development potential of a geospatial area, general terrain classification was provided in relation to the terrain inclination [3]. The example is given in Table 1.

Table 1 *General classification of terrain in relation to inclination*

Inclination angle	Terrain type in relation to inclination angle
to 1^o	Flat terrain
1^o - 3^o	Very mildly leaned terrain
3^o - 5^o	Mildly leaned terrain
5^o - 8^o	Fairly leaned terrain
8^o - 12^o	Inclined terrain
12^o - 16^o	Very inclined terrain
16^o - 20^o	Moderately steep terrain
20^o - 30^o	Mildly steep terrain
30^o - 45^o	Very steep terrain
over 45^o	Highly steep terrain

Development of science and technology has enabled performing of some human activities under fairly unfavorable relief conditions. This is, for example, case in mining industry. However, terrain inclination remains unavoidable feature with large impact on development of industry, agriculture, transport, etc.

4.3 Accuracy of Terrain Elevation Interpretation

Accuracy verification of 3D data model (obtained as previously described, including visualization of 3D model - Grid and TIN), is done using coordinates from the existing catalogues of points or in relation to the control point using GPS technology. Visual methods can be also used for verification the geomorphological features for given location, beside numerical methods of quality check of 3D data model. Accuracy assessment is performed by formula for standard deviation [6]:

$$\sigma_H = \sqrt{\frac{\sum (z_i^* - z_i)}{n}} \qquad (5)$$

where:

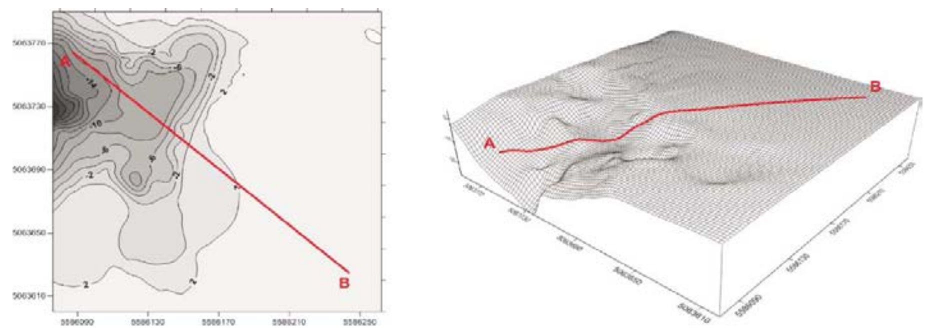
- z_i^* - value of interpolated elevations;
- z_i - value of measured (control) elevations;
- n - number of control points.

Accuracy assessment of terrain interpretation in fact is verification and quality of 3D model, obtained from digitized isolines from the existing maps or some other available techniques for data acquisition. During development of 3D terrain model, there are also interpolation methods, which can be used for improvement the data quality. One of these is geo-statistical method called "kriging", commonly used in mining industry [8].

4.4 Graphic Interpretation of Terrain Changes and Comparison of Vertical Profiles

Intersection of vertical plane and obtained 3D terrain interpretations can show the differences in model surface in different time periods. Also, this approach can be used for determination a difference in the amounts on the bottom of the mine in one period. Line of arbitrary selected profile is shown in two dimensions and three dimensions (Figure 11, a and b), as an example of interpretation the isolines and 3D model for two periods, obtained with same method of 3D terrain model creation [8].

a) for the first period



b) for the second period

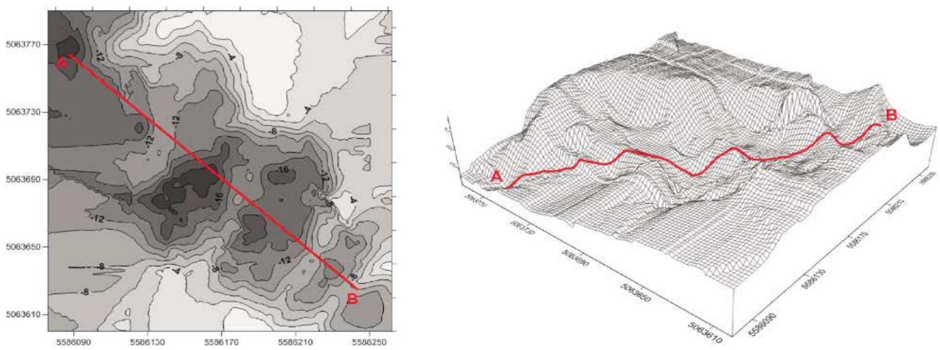


Figure 11 *Profile on the map and 3D model: a) and b)*

Figure 11 presents a graphical interpretation of 3D model comparison in different time interval, obtained with same data modeling method [8]. These interpretations can be used for reviewing differences and changes in terrain configuration and determination the excavated volume from the mine.

5 CONCLUSION

It should be noted that the main weakness in interpretation of relief on topographic maps is discretization and discontinuity in terrain elevation interpretation. In order to present the continuous Earth's surface, comprised of infinite number of points with location and elevation, it is necessary to digitize the area thus completing the model with elevation interpretation. Thereby, selection of method for development and presentation of 3D model has a significant impact on final result of terrain elevation model.

Actual interpretation the Earth's surface has an importance beyond the surveying. This is truth for numerous other industries and activities. The topic of this paper is research and application possibility of various modeling methods and terrain analysis in mining. Mining basins and open pit mines have a specific topography. Their features are sudden transition of relief features, both spatial and in time, which is interesting for analysis and interpretation of surveying data, i.e. terrain modeling in function of time. Thereby, available technology enables integration of different surveying instruments and technologies into single system, in order to obtain accurate and reliable information and to link those with operational efficiency [8].

Beside interpretation of terrain and Earth's surface, i.e. infrastructure facilities for the mining industry (such as pits, dumps and other), it is possible to obtain the new information as a result of query and analysis of 3D data model. Also, it is possible to interpret the elevation in given terrain points, to simulate slope slides, etc. Terrain inclination has a significant impact on condition and monitoring the geological and hydrological appearances. Beside this, there is a need for frequent acquisition of profiles, calculation of earth volumes, review of maximal inclination, creation of future terrain interpretations and configuration, optical visibility and similar. Having all of this in mind, as well as frequent changes in terrain surface in time, the concept of digital terrain modeling provides large methodological and technological capabilities for research and execution the mining activities.

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SERBIAN UNDERGROUND COAL MINING - CURRENT STATE AND POSSIBILITIES FOR FURTHER DEVELOPMENT

Abstract

The underground coal mining in Serbia is faced with numerous problems and difficulties for quite a long time. The outputs decrease, the equipment and technologies are obsolete, the investments in development projects are minimal, while the business economy and wages are maintained primarily due to a significant financial help of the Government.

Besides, the status of the Public Enterprise for Underground Coal Mining (JP PEU Resavica), which includes nine Serbian underground coal mines, is still unsolved. Such situation only prolongs the agony, and the only way out is the restructuring of the company and transition to the market economy.

***Keywords**: underground coal mining, JP PEU Resavica, restructuring, market economy*

1 INTRODUCTION

Since 1992, the all underground coal mines are gathered into the Public Enterprise for Underground Coal Mining, with its head office in Resavica. This company includes eight active coal mines, situated in eastern and central Serbia (Vrska Cuka, Rembas, Ibar mines, Soko, Bogovina, Lubnica, Jasenovac and Stavalj), along with mining construction unit, RGP Aleksinac.

Figure 1 *Coal mines included into JP PEU Resavica [8]*

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** *JP PEU Resavica*
*** *Mining and Metallurgy Institute Bor*

During the years, the company had its ups and downs, but in recent years, the trend of negative business results is more and more obvious.

Although the overall situation with the Serbian underground coal mines is not satisfactory, some of them do have preconditions for further existence, development and profitable operations. The preconditions are mainly related to the coal reserves and other development potentials. On the other hand, some of the mines are faced with possible ending of their mining operations, due to lack of coal reserves and other factors.

In that sense, the restructuring of JP PEU Resavica is inevitable. Final decision has to be made by the Government, as the owner of mining resources and the company.

2 DEVELOPMENT RESOURCES

Development resources are an important precondition for existence and successful operation of any company, as well as economy in general [1]. In the underground coal mining, most important development resources are coal reserves, equipment, technology and human resources.

2.1 Coal Reserves

Total geological coal reserves of the mines included in the Public Enterprise reach 95,457,089 t, while minable reserves are 65,709,717 t. The Soko Coal Mine is in the most favorable situation, since 61% of geological and 58% of minable coal reserves belong to this mine [2].

Table 1 *Geological and minable coal reserves for coal mines of JP PEU Resavica*

Coal mine	Geological reserves, t	Minable reserves, t	DTE, kJ/kg	Energetic potential, GJ	Mton 1 ton=41,868 GJ
Vrska Cuka	1,506,900	1,114,755	21,110	23,532,478	562,063
Rembas	6,535,799	5,264,436	18,100	95,286,292	2,275,874
Ibar mines	2,573,120	2,444,464	14,934	36,506,463	871,942
Soko	58,022,430	38,294,804	18,239	698,458,927	16,682,405
Bogovina	2,033,740	1,862,902	16,615	30,955,150	739,351
Lubnica	13,528,900	10,146,675	14,349	145,594,640	3,477,468
Jasenovac	1,186,200	830,340	16,057	13,332,769	318,448
Stavalj	10,070,000	6,344,100	12,541	79,561,358	1,900,290
Total	95,457,089	65,709,717		1,123,228,046	26,827,841

By the available coal reserves, the Lubnica coal mine is in the second place, after Soko. Then, Stavalj and Rembas come. These four mines make 92% of total geological and 91% of total minable reserves. Other mines are far behind them. Total energetic potential of active coal mines reaches 1,123,228,046 GJ, or 26,827,841 tons of oil equivalents.

The balance reserves are estimated to 860 million tons, and they include active mines, remaining reserves of inactive mines, explored deposits that have not been mined yet, as well as deposits that have been partially mined by surface mining, such as Cirikovac, along with some smaller deposits.

2.2 The Available Equipment and Technology

Generally, the mines included in the Public Enterprise for Underground Coal Mining Resavica are equipped poorly and the technology is very obsolete. Technology of coal production has been practically unchanged for more than fifty years. Furthermore, in some mines, like Bogovina and Rembas, the level of mechanization was higher in 1960's than today. Today, there is no mechanized coal excavation, nor mechanized tunneling.

For years and decades, there were no investments into new equipment. The existing equipment is in poor condition, obsolete and amortized. The main job of technical sector in the mines is to keep this equipment as much operable as possible, so the coal production could be maintained at a certain level. Spare parts are an additional problem, since it is very difficult to provide them for such equipment. The available spare parts are usually of poor quality, obtained from various producers, thus making the maintenance costs very high.

The applied mining methods are also obsolete and low - productive. Most of the mines apply some variant of pillar mining, where coal is mined in narrow stopes by drilling and blasting. Coal is hauled by chain conveyors form the coal faces, and further transport is organized through a system of several belt conveyors.

Due to low productivity, high costs and exceeded manual work, such system of mining was abandoned many years ago in most of the coal mines in the world. Generally, two systems of mining are mainly applied in modern coal mining: long wall mining and room and pillar mining. Development of mining equipment is following these systems. For instance, self- propelled hydraulic support is used in long wall mining, while numerous constructions of continuous miners were developed for the room and pillar mining. Such machines provide high outputs and improved safety, while reducing manual work.

Table 2 shows some of the Continuous Miners used in coal mines across the world for room and pillar mining and effects of their utilization, with their performance, number of room entries and size of the pillars in several coal mines of USA, China and South Africa. The performance given in meters shows the advance of entries, while performance in tons shows the coal output in a certain period of time.

Table 2 *The effects of application the Continuous Miners [3]*

Coal mine	Type of Continuous Miner	Number of entries and room width	Pillar dimensions, m x m	Peak performance	Availability, %
Elkhorn (USA)	12CM 7X2	5 entries, 6 m	12 x 12	3,300 t/shift	96 -98
Monterey No.2 (USA)	12CM 12X2	10 entries, 7 m	15 x 15	2,500 t/shift	97.6
Grandall Canyon (USA)	12CM	2.23 m x 6 m	-	210 m/day	-
Daliuta (China)	12CM 18	6 entries, 6 m	15 x 15	2, 700 m and 92,000 t/month	-
Marrowbone (USA)	12CM 12 14CM 15	7 entries, 6 m	12 x 12	2,000 t/shift	-
Martin County (USA)	14CM 9X2	7 entries, 6 m	15 x 15	3,100 t/shift	97-98
Khutala (South Africa)	12HM 17 12HM 9	9 entries, 6 m	-	125,000 t/month	97-98
Loveridge (USA)	14CM 12	4 entries,4.7 m	28 x61	95 m/shift	-

If geological properties of the coal deposit are favorable, the long wall mining is applied. Following table shows data on applied long walls by countries.

Table 3 *Outputs achieved by long wall mining [4]*

Country	Number of long walls	Average output of longwall per shift, t	Average annual output by longwall, in million t
USA	69	3,475	2,502
Australia	30	2,360	1,558
Great Britain	36	1,667	1,157
China	244	1,511	1,070
Canada	2	1,499	1,138
Germany	66	1,423	966
South Africa	8	1,236	1,020
Polland	350	1,190	744
Russia	432	696	418
Ukraine	429	520	312

Long walls in the USA have provided the highest coal outputs, due to application the newest achievements in mining science, technique and technology, as well as favorable geological properties.

2.3 Human Resources

In a period between 2004 and 2015, the number of employees in JP PEU Resavica decreased drastically, by 23%. In recent years, the number of employees is around 4,000. [5]

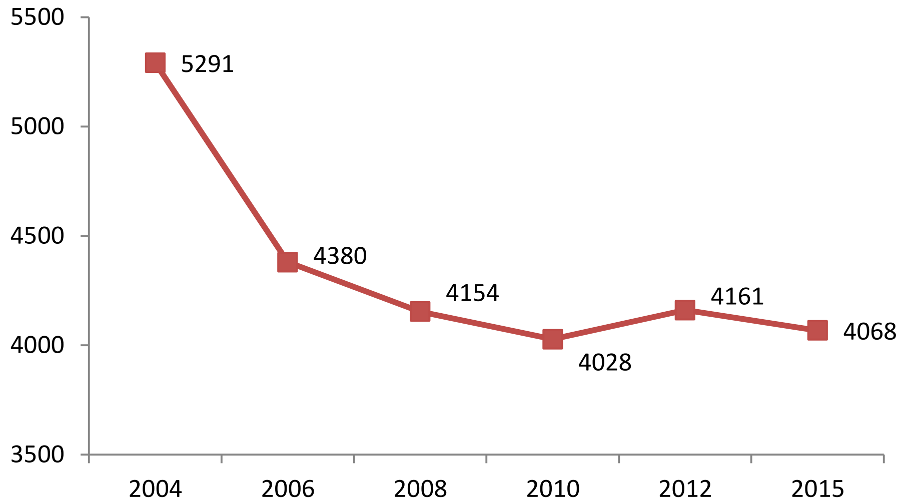

Figure 2 *Decrease of number of employees in JP PEU Resavica*

Rembas and Soko are the leading mines in number of employees, while Vrska Cuka is at the bottom. The average age of employees is around 40. There were many analyses regarding the structure of employees in the company, and they have all shown that there is an excess of non – production (administration) employees, while there is a lack of production employees at the same time. It is expected that this problem would be solved through restructuring the company.

3 PRODUCTION AND ECONOMIC EFFECTS

Business results of the company vary a lot, both by years and by sectors, which is a sign of certain instability.

3.1 Coal Production

From the moment when the company was created, the coal production, with some oscillations, has a trend of constant decrease. From 960,973 t of excavated coal in 1992, it came down to 560,651 t in 2015. It means that the coal production was reduced by 400,322 t, or 42%. [5]

Top coal producers in the company are Rembas, Soko and Stavalj mines, while Vrska Cuka is on the bottom. The dominant type of coal is brown coal. Most of extracted coal is used for production the electric energy and domestic purposes.

There were many circumstances that led to decrease of coal production. As it was mentioned before, poor technical accoutrement is one of the reasons. That is why the production effects are also unfavorable: coal recovery is around 60%, low productivity (138 tons of coal per employee in 2015, 6 – 20.9 tons of coal per employee at coal face, 5.3 – 8.85 t of coal per employee in coal section, 50 – 169 t of coal per shift by mine, etc.

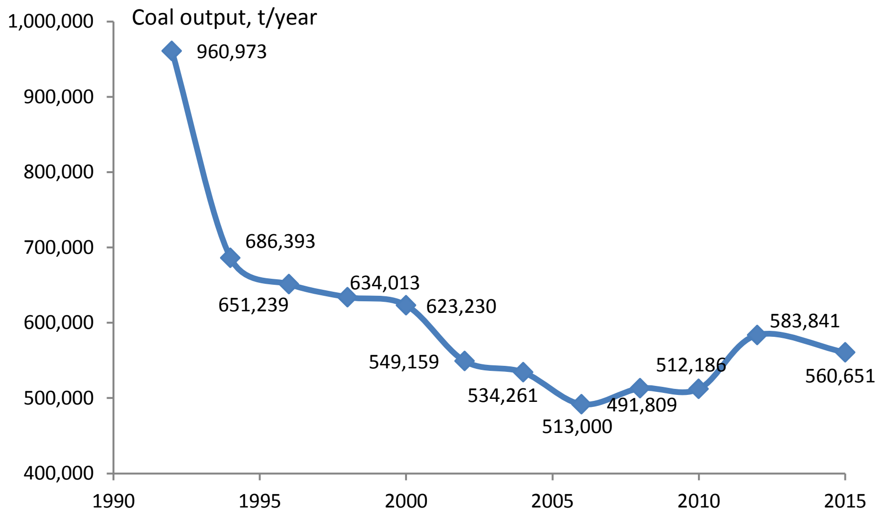

Figure 3 *Coal outputs in JP PEU Resavica from 1992 to 1995*

For example, in the Kazemir – Julius mine in Poland, due to the modern equipment and highly mechanized processes, the effects of production process are following: 500 t is a daily output from a single coal face, with 20 employees on the sublevel coal face (4 shifts with 5 employees), coal recovery is 65-75%, productivity at the coal face is 25 t per day for 6 working hours, the annual output per employee is 1,667 t, etc.

Besides, there is also a problem of lack of employees in production, along with lack of financial resources, both for ongoing production process and investments and development projects. If there is no significant change in this situation, it is realistic to expect further decrease of production.

3.2 Business Economy

The realized production effects have a direct influence to the business economy of the company. In recent years, business results are mainly negative. In last five years, the company managed to gain profit only in 2014 [5].

Total loss in the observed period exceeds 8 billion RSD. Due to such business results in a long period of time, the cumulative loss exceeds the capital value of the company.

It should be added that the loss would be much higher without significant subventions from the government. In some years, these incomes exceeded the value of sold coal. In 2015, almost 70% of incomes came from subventions.

Table 4 *The achieved business results of JP PEU Resavica in a period between 2010 and 2015, in 000 RSD*

Year	2010	2011	2012	2013	2014	2015
Total income	5,678,874	5,833,109	7,850,001	8,250,699	10,587,381	6,537,148
Total expense	7,084,645	7,810,450	9,948,069	8,520,829	7,728,293	8,997,240
Profit (P) / Loss (L)	L 1,405,771	L 1,977,341	L 2,048,068	L 320,130	P 2,859,088	L 2,460,092

Source: Documentation of JP PEU Resavica and Serbian Business Registry Agency

The reasons for such business results are low productivity and high costs. In 2015, the cost price of a produced ton of coal was 13,161 RSD. At the same time, the average selling price, with all subventions, was 13,734 RSD. A difference between these two prices is minimal and inadequate to cover all of the business costs.

It should also be mentioned that the selling price of coal is determined administratively, and it is very low because it is a measure of protecting the life standard for households which use coal for heating. However, this measure is only applied to the coal producers, i.e. coal mines. Price of coal on the market is determined freely. This means that the coal prices at the dealers are 50 to 70% higher than the prices for the coal mines.

Wages in the company are pretty modest, especially considering extremely hard working conditions. In 2015, the average net wage reached 50 thousand RSD, which is some 10% above the average in the Republic of Serbia.

Also, the economy of resources is unfavorable. The company practically does not have its own financial means. Instead, its business economy is based on subventions and borrowed financial means. It makes every day operations very difficult and increases the costs.

4 POSSIBILITIES FOR FURTHER DEVELOPMENT

The current situation in JP PEU Resavica is unsustainable. Production keeps decreasing, while the losses rise. Restructuring of the company is the only solution, along with readjustment to the modern, market based business environment.

A plan for consolidation of the company and further development was made in 2013 [6]. By this plan, the company should be consolidated first, thus making the base for profitable economy and long term sustainable development. In that sense, the investments were planned for mines with best development potentials, in order to raise their outputs (up to 300,000 t of coal for Soko and 2,000,000 t for Stavalj, along with the new Thermal Plant).

Based on the exploration works, some investments would be directed to opening and coal extraction in deposits that are not currently active, or only partially active, such as the Western Field of the Stavalj Mine, Cirikovac, Poljana, Kosa Zabela, Melnica and Western Morava Coal Basin. That way, domestic needs for this type of coal would be fulfilled. Also, the deposits of oil shale and borate minerals are planned for extraction.

Finally, the mines with low-grade coal reserves would be gradually closed. This group of mines includes Tadenje, Jarando, Vrska Cuka, Eastern Field and Senje Mine.

Naturally, such ambitious plan requires the significant financial resources, which are difficult to provide, especially with favorable interest. In that sense the Government, as the owner of the company, has a decisive role and huge responsibility.

CONCLUSION

The underground coal mining is an important segment of entire mining complex in the Republic of Serbia. Although its share in total coal production is minor, around 1.5%, it has an important role in supplying the thermal plants, industry and households with this product. The ucoal mining provides anthracite, hard coal, brown coal and lignite. Coal, as an input, covers 70% of electric energy production in Serbia.

In recent years, the underground coal mining, organized through the Public Enterprise for Underground Coal Mining (JP PEU Resavica), comes through deep crisis. Decrease of production, lagging in technique and technology, business loss, unfavorable economy of resources and similar, are the main characteristics of this company's reality.

The exit from such situation exists. The Government, as the owner, has announced the restructuring. Company itself made a plan of consolidation a couple of years ago. The essence of changes is to invest in mines with good development possibilities in order to modernize them and increase the production significantly, and at the same time to gradually close the mines with low coal reserves and without development potentials. All of these has to be followed by measures of macroeconomic consolidation, with inclusion the eventual strategic partners.

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POSSIBILITY FOR APPLICATION OF GIS TECHNOLOGIES IN RTB BOR GROUP

Abstract

Modern mining is characterized by highly mechanized production, large – scale projects with huge amounts of mined ore and waste, large areas influenced by mining works, large tailings and waste deposits, deep underground mines, constant development of existing and introduction of new technologies, huge influence of global financial and market trends to economy of mines and obligations related to environmental protection. On the other hand, development of IT sector enabled application of advanced systems for management of spatial data and their integration into common spatial information system – GIS.

Main goal of introducing GIS into RTB Bor Group is to improve the processes of mineral resource management and create spatial information system of the copper mines with a geobase, with information from spatial plan documentation, as well as visualization of all graphic and alphanumeric data from geo-database, using GIS portals and Web GIS. Application of GIS system would enable simpler and more comprehensive approach to information in the areas of geological explorations, mining, mineral processing and metallurgy, all included in RTB Bor Group.

Keywords*: mining, GIS, spatial data, geobase*

1 INTRODUCTION

Development of geoinformation technologies enabled the application of advanced systems for spatial data management and their integration into unique spatial information system – GIS (Geographic Information System). By general definition, GIS represents a "…computerized database management system for capture, storage, retrieval, manipulation, analysis and display of spatial (i.e. locationally defined) data" [1].

GIS is a technology that combines location of natural and artificial objects (their spatial elements), with different types of information (descriptive spatial elements), thus forming a unique system of spatial data base – geobase [2]. GIS technology integrates usual operations on geo databases, such as searches, queries or statistical analyses, with unique advantages of visualization and spatial analysis given by plans. Significant advantage of GIS is connection of descriptive, alphanumeric, nonspatial data with spatial data and provides their analysis, processing and presentation.

GIS consists of four interactive components: subsystem for data entry, which converts maps and other spatial data into digital form (data digitalization), subsystem for data storage and queries, subsystem for analysis and export system for map plotting, creating tables and responding to queries. Digital model includes spatial and descriptive images of reality and provides a base for operation and communication between users (Figure 1). Spatial images define shape, dimensions and location, i.e.

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geometric properties. Spatial images of reality can be well and concisely presented in a form of graphical presentation, while descriptive aspects, in many cases, are better represented by text and numbers. Graphical presentation enables better understanding of real situation, thus providing high level of abstraction, or description of connections with adjacent objects, while textual – numerical presentation is more suitable for aspects that cannot be described graphically. Digital model has to enable connection of these two presentations.

Main concept of physical implementation of geospatial data is to create simple and undisturbed flow of spatial data to geo databases, where they are stored, and to user. That flow requires corresponding network and technical infrastructure, designed in accordance with norms and standards [2].

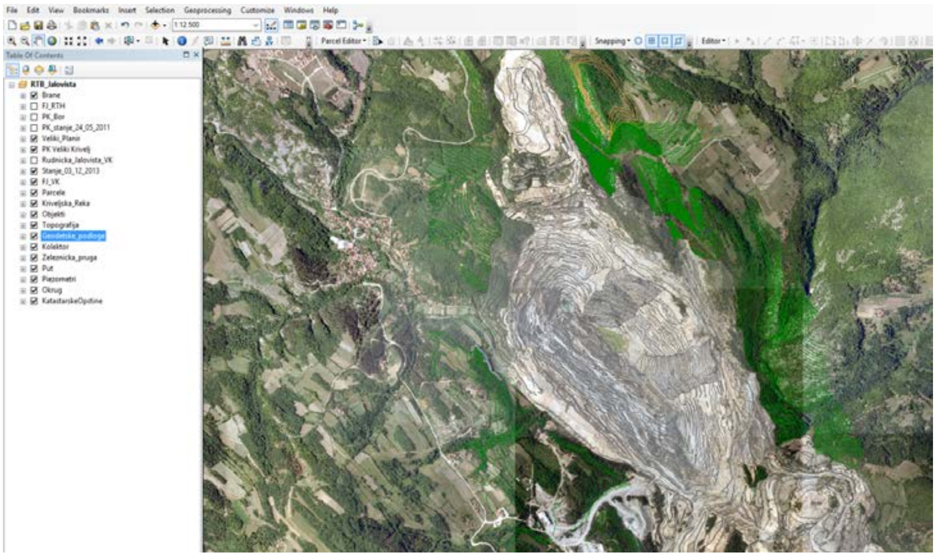

Figure 1 *Digital model of Veliki Krivelj open pit*

ESRI created one of the most complex GIS platforms, ArcGIS® [3, 4]. This integrated family of software provides all the functions needed for design of spatial information system. ArcGIS contains number of software, adjustable to a single or multiple users, on desktop computers, servers, via web connections or on remote devices.

2 MODELING OF SPATIAL DATABASE – GEOBASE

Spatial database or geobase is a basic component of GIS. Geobases represent a collection of geographic data of different types, stored into a catalogue of database system, or a base of management system for related databases, such as Oracle, IBM DB2, PostgreSQL, Infomix, Microsoft SQL Server, etc. More precisely, geobase a collection of logically related data, including: attributes (data for numerical or textual description of geographic entity), geometry (data that define shape, size and spatial layout of the entity) and topology (data that define relations between different geographic entities) [1].

Consequently, there are three main groups of data in GIS: vectors, attributes and raster. There are three main ways to create a geobase. If collections of spatial data that should be included into a common base are already available in some of acceptable formats, then these data are simply imported into a new database. ArcGIS enables import of data from traditional relation databases, XML and Excel documents, as well as vectors from AutoCAD or other CAD software.

3 GIS SOLUTIONS IN MINING

Advantages of Geographic Information Systems (GIS) are modestly used in Serbian mining. On the other hand, increasing complexity of engineering tasks creates a need for computer tools able to provide quality technical support in order to fulfill monthly and annual plans. Main goal of establishing GIS solutions in mining is to improve the process of mineral resources' management and to form a spatial information system of the mines with a geobase, where all the information from maps and documentation are stored, as well as visualization of all geospatial and alphanumeric data in a geobase, via GIS portals and Web GIS [2].

GIS provides creating, classifying, maintenance, presentation and distribution of numerical, descriptive and spatial data on following items: geologically verified deposits; mining, mineral processing and metallurgical infrastructure; cadastre of exploration and extraction areas; cadastre of active mining works and structural objects; cadastre of mining and mineral processing tailings; operative plans of ore and waste outputs at open pits; dispatch monitoring of machines at open pits; any other information relevant for mining and mineral processing processes.

Geospatial data from deferent sources have to be georeferenced to the same geodetic datum and coordinate system [2]. That way, GIS enables information exchange with other geoinformation systems and harmonization of all relevant geoinformation on a local, national, or international level. GIS supports three modes of spatial information management:

- Geo-database – GIS is a comprehensive spatial database (geobase), which consists of groups of graphical data (raster and vector data, topology, networks) and groups of alphanumeric data (tables, reports).
- Geo-visualization – GIS includes "intelligent" maps, which can present mining operations at a wider geographic area of the mine and their interaction with the environment. It is possible to create maps with different layers of spatial information in order to enable easier analysis of geoinformation.
- Geo-processing – GIS provides set of tools for information transformation, from existing groups of geodata into new geodata and geoinformation. Geo-processing applies analytic functions to existing groups of geodata and store gained results into new geodata groups.

Application of GIS enables creating of regional or more detailed maps of active, or new surface mines; monitoring of geology of the area; estimating of ore reserves; planning of annual outputs; monitoring of statistical data on production costs; monitoring of machines (shovels, trucks, conveyor belts, etc.), monitoring of advance of mining operations (ore extraction, waste deposits), etc. Application of GIS is especially important for environmental protection, since it provides constant monitoring of influence of mining operations to the environment, including air, water and land pollution, influence to flora and fauna, health hazards and finally enables measures of environment protection. Also, GIS enables support in different types of projects related to monitoring of any relevant industrial process, easier management of mineral resources and helps in decision making at any level. Finally, GIS provides faster and more efficient operating in daily procedures and information flow, thus making operative management more efficient.

4 GIS SOLUTION FOR MORE EFFICIENT MONITORING OF MINING OPERATIONS AT VELIKI KRIVELJ OPEN PIT

Basic platform of GIS solution in RTB Bor is a unified base of spatial data, where all of the data on industrial area are stored (active open pits, mineral processing plants, smelting plant, tailings, etc.). After the analysis of existing documentation, and based on gained spatial parameters and evaluation of geodata, first step was to create unified spatial database of RTB Bor Group, by converting of digital data into unified system of geo-objects. Knowing the fact that a digital datum does not carry additional information about the object it represents, conversion of data included integration of graphics with analytic documentation of geodetic maps. Efficient storage and acquisition of elements depends not only on structure of data in spatial data base, but also on optimized structures, representations and algorithms for operations with data.

As an example, possibility of application of GIS is shown for open pit Veliki Krivelj, in order to provide simpler and comprehensive approach to spatial information about geological explorations, mining and mineral processing operations inside the RTB Bor Group. Verification of developed GIS model was performed on data gained from RTB Bor Group documentation related to Veliki Krivelj. GIS integrates geospatial and alphanumeric data into geo-database, with detailed information on open pit and tailings. Thematic classes included systematization of data in geobases of ArcCatalogue. These data are related to geological exploration works and dynamics of mining operations at the open pit, and they are important segment that requires visual presentation in ArcMap. Geobase, as a key segment of GIS, is a repository for space – time groups of data for planning, monitoring and managing of mining operations at open pits, enabling not only visualization, but also the analysis of stored data.

Storing data in a geobase was performed in two different ways: by importing relevant data from Excel tables utilized in Gemcom software package and by graphical data gained from Mine Surveying Department of RTB Bor Group, and their conversion into shapefiles needed for visualization in ArcMap.

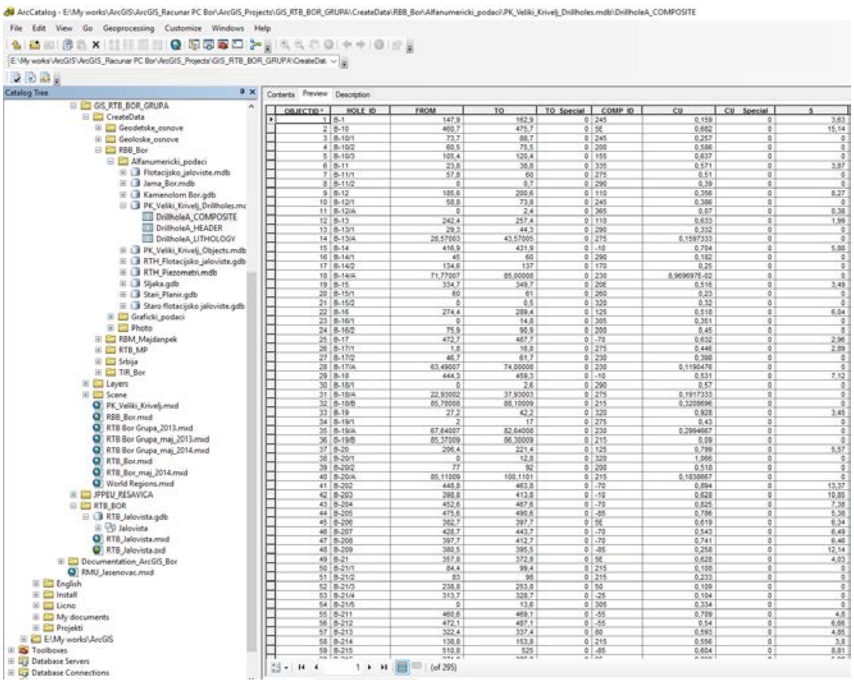

Figure 2 *Creation of geobase for Veliki Krivelj in ArcCatalogue*

Geobase design for Veliki Krivelj started with creation of individual databases (Figure 2), with defined object classes for objects with similar structure, behavior, relations and semantics. Thus, geobase for Veliki Krivelj includes data on: geological explorations, chemical and geotechnical analyses of the cores, infrastructural objects, natural objects, operation points (pit, level, waste deposit), utilized equipment, raster bases (orthophoto images, topographic maps, elevation DMT model).

Figure 3 shows operational environment of Veliki Krivelj open pit, with several thematic layers, presented in the left part of ArcMap panel.

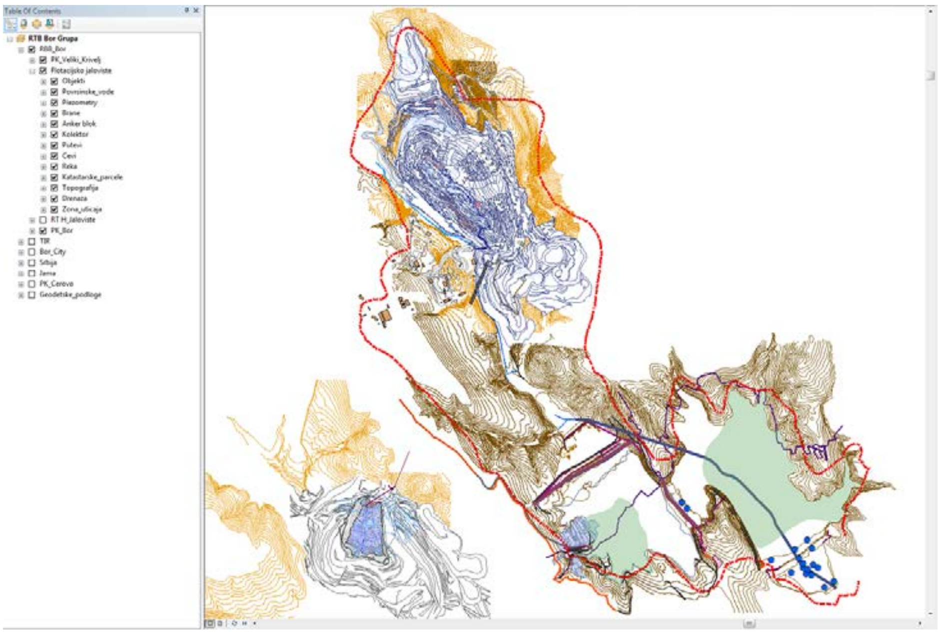

Figure 3 *Current state of mining operations in Veliki Krivelj, with thematic layers in ArcMap*

Spatially referenced geodetic map of the open pit was set as graphical base. After that, polygonal objects were added (open pit limits, tailing contours, structural objects, etc), followed by linear objects (roads, rivers, channels, transport roads) and dotted objects (drillholes, equipment). Each object was georeferenced, i.e. included in Gauss – Kruger coordinate system. This map has a simple symbolization and annotation of objects, but the system enables much more complex symbolization (colors, shapes, line patterns).

Multidimensionality of geospatial data requires different approaches in data structuring and indexing, and consequently application of different mechanisms for their search and analysis. Namely, in traditional relation databases, it is not possible to run spatial queries, such as: “Which drillholes are on 50 m spacing from profile line P1?”; “Which objects are situated inside the area planned for mining in 2017?” and similar. Relations between objects that are the subject of geometric, and not alphanumeric data, cannot be gained by classic SQL queries from traditional databases. Instead, spe cialized geobases are used for that purpose, with built-in system of storing and indexing both alphanumeric and geometric data. GIS technology integrates standard operations on databases, such as searches, queries, or statistical analyses, with unique advantages of visualization and spatial analysis. Power of geobases lies in connecting of geometry and alphanumeric data of spatial objects, thus enabling that each object can be seen on the map and its textual and numerical data can be updated. GIS enables its users to create SQL queries, analyze spatial information, arrange data and maps and present the results of all of these operations. Figure 4 shows the realization of created SQL query over the attributes of Exploration drillholes spatial class.

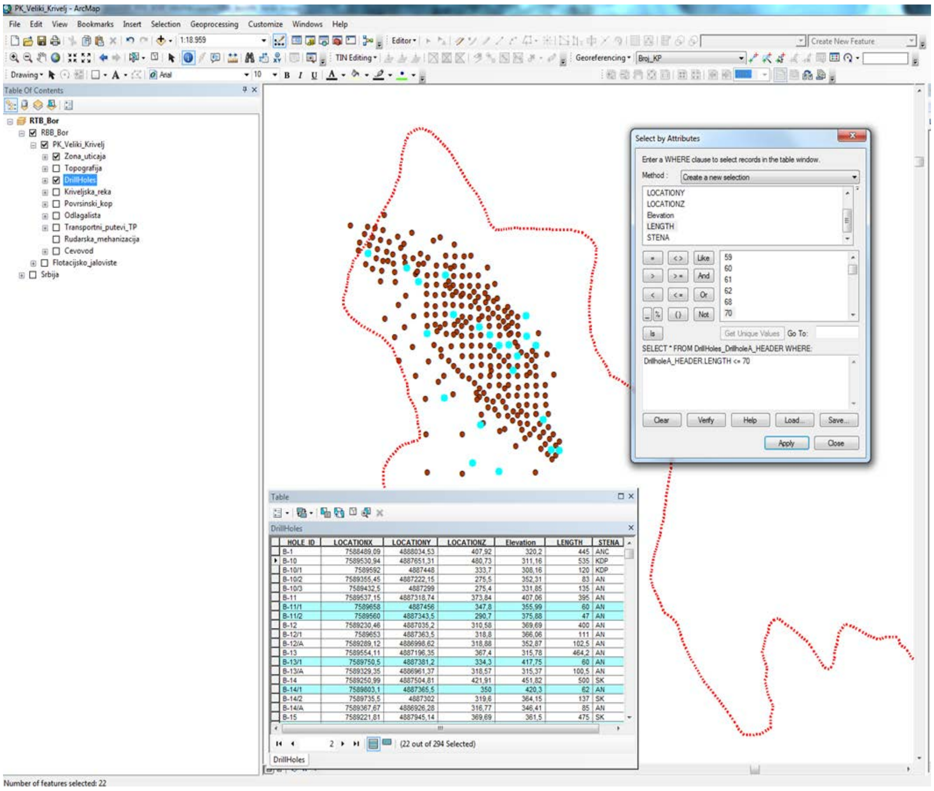

Figure 4 *Realization of SQL query over geobase Veliki Krivelj Exploration drillholes*

Updates of geobase are performed periodically, along with its maintenance, which includes fulfilling of both digital and tabular data.

GIS enables creating of maps for each surface mine level, with layout of drillholes, hydro-geological monitoring, slope stability monitoring, planning of mining operations in ore and overburden, monitoring of costs and positions of mining objects (Figure 5).

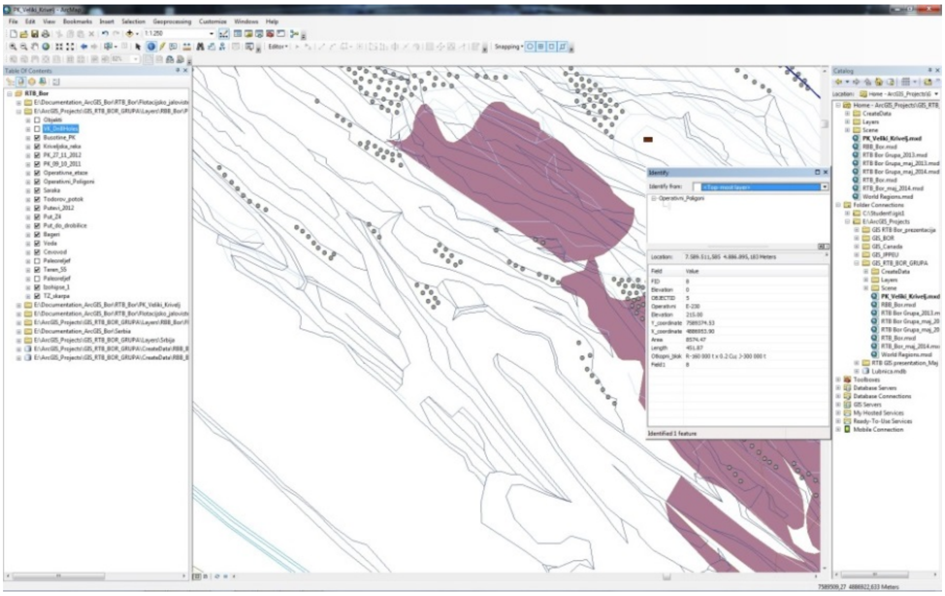

Figure 5 *Map of a single level at Veliki krivelj open pit with thematic layers in ArcMap*

Optimal function of mining equipment requires constant monitoring, which should provide data on machine performances during operation in real time. Intensive development of GIS/GPS/GPRS technologies enabled much more detailed, faster and more accurate monitoring and control of mining operations (Figure 6). Processing and analysis of gained data in a dispatch system enables mine management faster and more successful decision making [2].

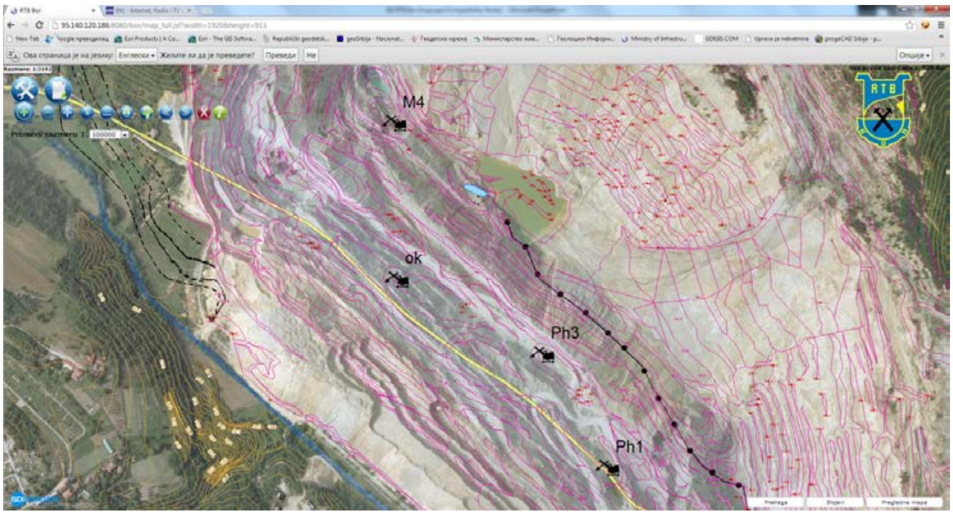

Figure 6 *Monitoring of mining equipment via GIS portal in Veliki Krivelj*

Open pit limits, sanitary zone, zone of influence of mining operations and tailings are also entered into GIS (Figure 7). This enables monitoring of tailings and waste deposits and updating of their advance, estimation of volumes, monitoring of hydrology and management of expropriation with the insight in each individual parcel (Figure 8).

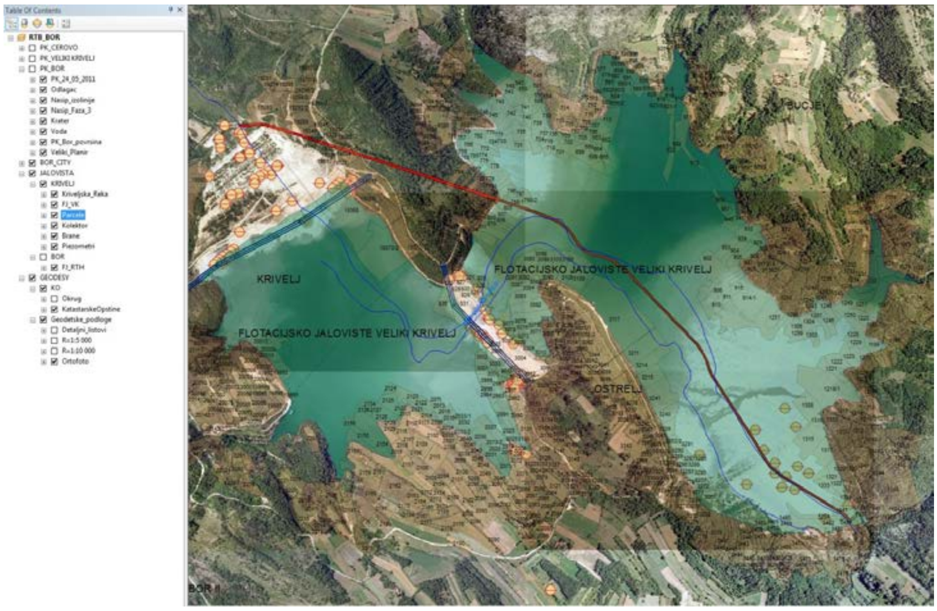

Figure 7 *Tailings of Veliki Krivelj Mineral Processing Plant (Polje 1 and Polje 2)*

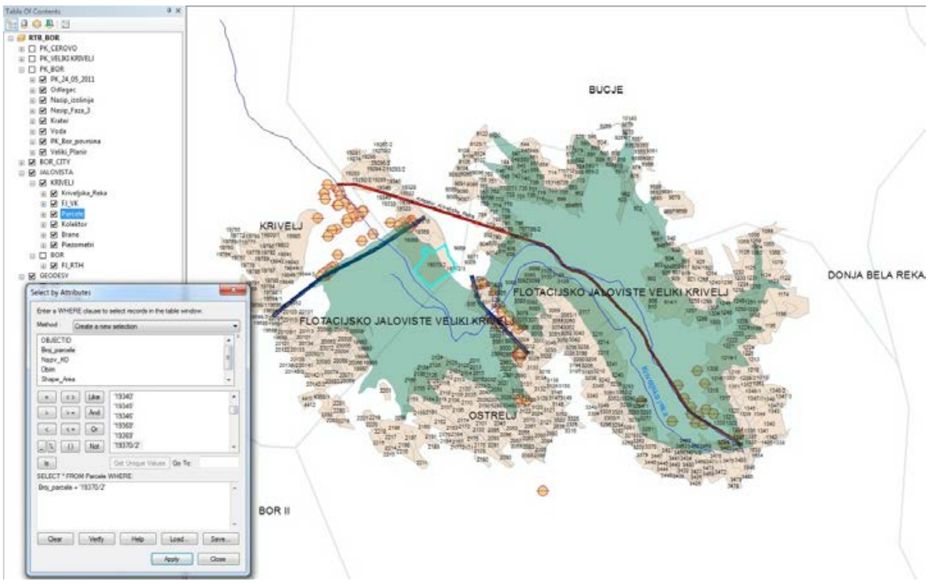

Figure 8 *Tailings of Veliki Krivelj, SQL query for individual parcels*

In order to make the manipulating with geobase simpler, the idea is to present the GIS solution on RTB Bor Group Geoportal, thus enabling users to overview, search, print or download contents of the geobase in any moment via web (Figure 9).

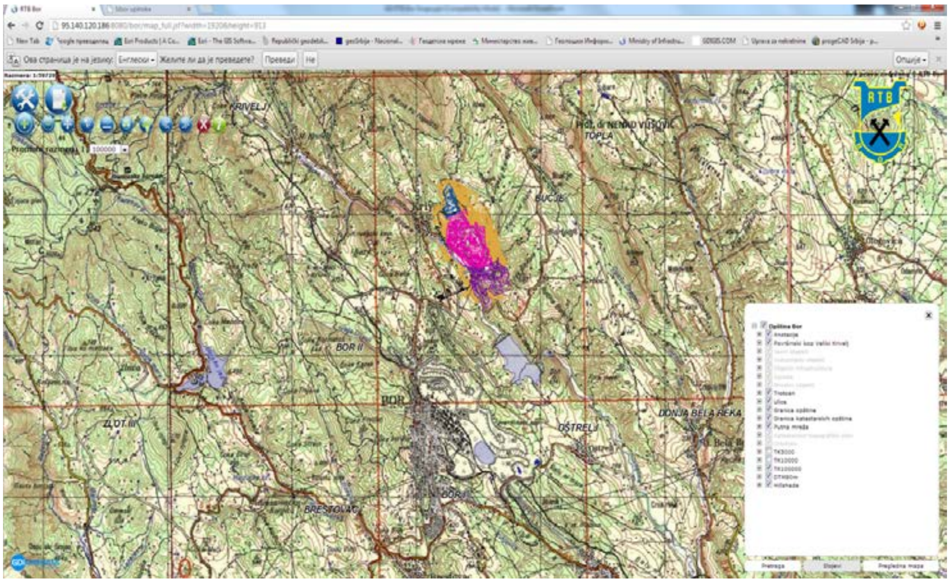

Figure 9 *Web GIS portal of RTB Bor Group, created in ArcGis software*

CONCLUSION

GIS solution presented in this paper is only a first step in design of integrated GIS system for RTB Bor Group. Further activities should be focused to widening of GIS system with thematic classes related to monitoring of production and processing of copper ore, integration with tools for deposit modeling and mine design, monitoring of environment protection, with monitoring of influence of mining operations on air, water and land, as well as planning of protection measures. In order to enable implementing of GIS in RTB Bor Group, it is necessary to make following steps:

- Development of sustainable GIS system, with possibility to widen and be integrated into general information system of RTB. Such GIS system would have to be able to follow the demands and needs of a modern company;
- Establishing of Department of system users, who would be trained for operating GIS tools and able to administrate and improve the system.

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OPENING THE ORE BODY "ČOKA MARIN-1" BELOW K+535 m[***]

Abstract

The need to open the lower parts of the ore body was caused by a number of reasons. One of the reasons is the high price of precious and non-ferrous metals on the stock market, which is far higher than the one used in calculation the technical-economic assessment in the project study on mineral reserves from 2004. Another reason for opening the lower parts of the ore body would be the remaining part of the balance reserves verified by the project study on ore reserves, not included in the main mining design on mining the ore body "Čoka Marin – 1".

***Keywords:** opening, ore body, balance reserves*

INTRODUCTION

The hill "Čoka Marin" (with its peak 648 m), or the area in which the deposit "Čoka Marin: is situated and the ore body "Čoka Marin – 1", is located on the triabudment of the villages Vlaole, Jasikovo and Leskovo (Fig. 1), about 13 km south of Majdanpek in the air route. It territorially belongs to the municipality of Majdanpek.

The site "Čoka Marin" can be reached via the inter - municipal road Majdanpek - Leskovo - Jasikovo - Vlaole - Gornjane - Bor and the railroad Belgrade - Majdanpek - Bor - Zaječar. The nearest railway station, Jasikovo, is about 1 km. By the railroad from Bor to the station Vlaole is 26 km, from Bor to Leskovo 36 km and 46 km to Majdanpek.

Along the ridge towards the villages of Leskovo, Vlaole and Jasikovo, the village and forest roads run that are passable mainly in dry periods.

The ore deposit "Čoka Marin" is located in the eastern part of the Timok Magmatic Complex (TMC), i.e. the Bor Metallogenic Zone (BMZ).

Besides the ore body "Čoka Marin - 1", two ore bodies "Čoka Marin - 2" and "Čoka Marin - 3", were discovered at distance of 1.5 km and 2.2 km (Fig. 2).

The narrow area of the ore body "Čoka Marin" was mainly built of hydrothermally altered volcanic rocks and series of pelytes (marls, tuffs and tuffites), volcanic breccias, quartz diorite - porphyryites, secondary quartzites and quaternary formations.

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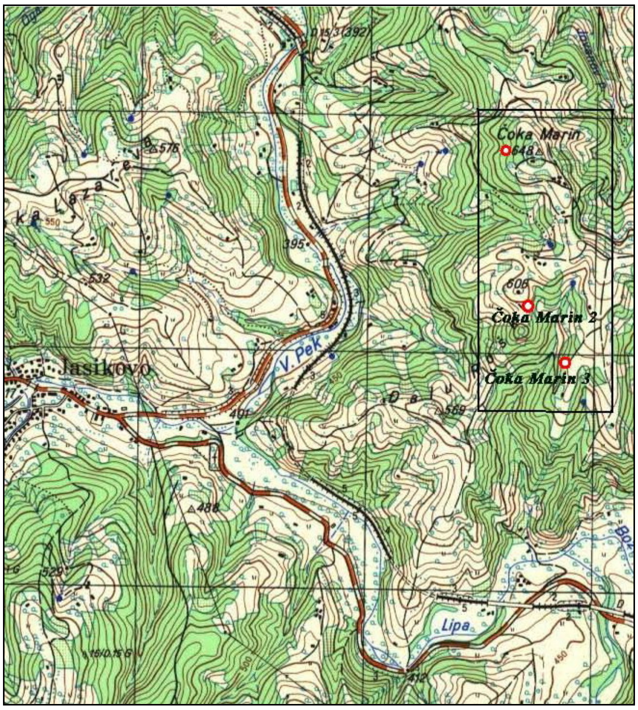

Figure 1 *Geographical position of the deposit "Čoka Marin"*

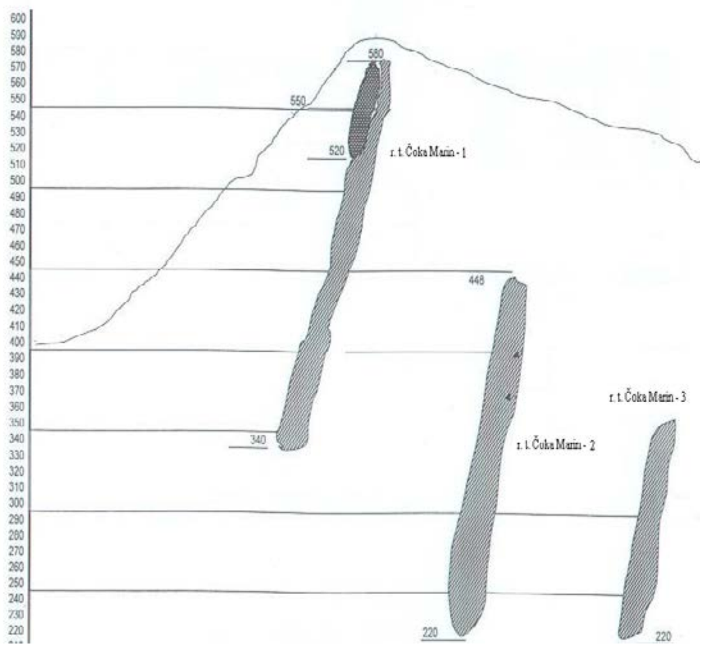

Figure 2 *Schematic view of the ore bodies in the deposit "Čoka Marin"*

There are also smaller breakthroughs of diorite and quartz diorite and veins of quartzdioriteporphyrite and dioriteporphyrite. A widely distributed hydro quartzite (with increase concentra-tions of gold) was obssrved directly above the ore bodies.

The ore body “Čoka Marin 1” has a tubular shape, with the expansion in the central part from the level +550 to +530 m, so that in takes in the horizontal sections a shape of lens, direction of NE-SW, with a very steep slope towards SE. The floor of the ore body is made of volcanogenic-sedimentary series of pelytes with the interstratified tuffs and volcanic breccias. The ore body “Čoka Marin - 1” is built of polymetallic (with Au, Cu, Zn, Pb and Ag), massive-sulphide (with Au, Cu and Ag) and stock work - impregnation mineralization (with Au and Ag). The ore body “Čoka Marin – 1” (according to the Rule Book) has been included in the first group, the first subgroup of gold ore bodies.

EXPERIMENTAL PART

The experimental part is reflected in a detailed geological exploration, sampling and analysis of samples obtained from exploration adits and drillholes.

Three types of mineralization are quantitatively and qualitatively separated in a contour of cut-off grade of 0.40% for copper and sulfur, in a contour of cut-off grade of zinc content of 0.50% for Zn and Pb, and in a contour of cut-off grade of gold of 0.5 g/t for Au and Ag:

1. Polymetallic mineralization is represented by gold, silver, copper, sulfur, zinc and lead. This mineralization is 29% of total balance reserves of ore
2. Massive - sulphide mineralization with gold, silver, copper and sulfur makes 47.4% of total balance reserves of ore.
3. Stock work-impregnation mineralization contains gold and silver. The amount of balance ore is 23.6%. This mineralization extends deeper (to K + 340 m), is made elaborate the categorization of balance reserves was carried out to K + 440 m by the Project Study.

The data shows that economically most interesting is the polymetallic mineralization with 29% of balance ore reserves, which includes 71% of gold, 82% of silver and 59.4% of copper, 40.5% of sulfur and 100% of lead and zinc.

A contour of the ore body was obtained within these cut-off grades, which extends by the height from the K + 440 m to K + 580 m, and which was the base for development the Project Study on mineral reserves from 2004.

For calculation the balance reserves in the ore body “Čoka Marin - 1”, it was started from the amount that is 337,017.45 t. When this value is reduced by the moisture content of 3.5%, the amount of dry ore is obtained of 325,221.84 t, which are the balance reserves.

The ore body "Čoka Marin - 1", as already explained, has a different content of useful components in all three mineralizations, or has very little some precious metals in some mineralizations, and the total is received as:

- In 325,221.81 t of dry ore with cut-off grade of copper of 0.40% and the mean content of 1.61%, 5,233.02 t of copper is obtained, after metallurgical treatment, and sulfur, with the mean content of 16.86%, has 54,851.84 t.
- In 262,292.95 t, with the mean content of 5.76 g/t gold, there is 1,510.72 kg, and silver with the mean content of 45.64 g/t, after metallurgical treatment, there is 11,971.71 kg,
- In 64,667.84 t dry ore with the mean content of lead of 1.99%, there is 1,284.85 t and zinc with the mean content of 4.86%, there is 3,142.20 t.

The content of mercury and arsenic is calculated based on sampling from both exploration horizons by the sampling procedure of gold, silver, copper, lead and zinc. It was calculated that in 325.221.81 t balance reserves of ore, there is the total of about 1,500 kg of mercury and 1,000 t of arsenic.

OPENING OF THE ORE BODY "ČOKA MARIN - 1"

The adit 534 (length 230 m) and adot 553 (length 200 m), used to the open ore body, were made at the stage of underground geological explorations the ore body "Čoka Marin - 1". They will be used in a function of future mining the ore body "Čoka Marin - 1" for ventilation of the mine and haulage of ore. For the purpose of ventilation during excavations, two ventilation shafts were made, respetively PVO 1 (565/534 m) and PVO 2 (557/537 m).

MINING OF THE ORE BODY "ČOKA MARIN - 1"

The sublevel caving method was adopted in the Main Mining Design for mining the ore body "Čoka Marin - 1", which in this case could provide the optimal results.

The ore mining by this method is carried out in the excavation blocks perpendiculary oriente on extenstion of the ore body. The base of caving blocks is of a rectangular shape, sizes 10 x Loh, m, and a block height is 10 m.

Excavation begins from roofing to the footwall of the ore body, with the general direction of excavation from top to the bottom by the height of the ore body.

According to the concept of mining method by the height of the ore body, a sublevel drift (SD) is made at every level by extension of the ore body.

The excavation drifts (ED) are made from sublevel drifts (SD) perpendiculary to the ore body in the middle of caving blocks at distance of 10 m.

Sublevels are linked to one side for the pass ventilation shafts, and the other side for the service rises or edits for communication with the outer surface of terrain.

Mining of the ore body wil be carried out at four sublevels (levels) as well as:

- I sublevel at K 565 (from K 565 to K 575)
- II sublevel at K555 (from K 555 to K 565)
- III sublevel at K545 (from K 545 to K 555)
- IV sublevel at K535 (from K 535 to K 545)

Thew entries, size 4 x 3 m, are developed on sublevels from sublevel drifts at the level of ore excavation and they are used for drilling, blasting and loading of ore.

Loading and transport of blasted material from the face of preparation drift will be done using the loading-transport-unloading machine (LTU) diesel - powered. Transport of ore by this machine will be done to the exit of adit (adit 534 or adit 553) where the ore will be reloaded into transport trucks.

OPENING OF THE ORE BODY "ČOKA MARIN - 1" BELOW K+535m

The need to open the lower parts of the ore body was caused by a number of reasons. One of the reasons is the high price of precious and non-ferrous metals on the stock market, which is far higher than the one used in calculation the technical-economic assessment in the project study on mineral reserves from 2004. Prices which have been used in calculation on 31/12.2003 are: 2,800 USD $ per ton of copper, 12,400 per kilogram of gold and 156 USD$ per kilogram of silver on the world market.

Current prices (June 2007) of these metals on the world market are as follows: 7,625.50 USD$ per ton of copper, 21,145.53 USD$ per kilogram of gold and 428.89 USD$ per kilogram of silver.

Another reason for opening the lower parts of the ore body would be the remaining part of the balance reserves verified by the project study on ore reserves, not included in the main mining design on mining the ore body "Čoka Marin – 1".

Another reason this paper is transfer from truck transport (transport of ore from the mine to the Flotation Plant in Majdanpek) to the railway transport.

Opening the lower parts of the ore body would be done by adit, spiral rise and pass ventilation shafts which would be done by deepening the already existing ones (Fig. 3).

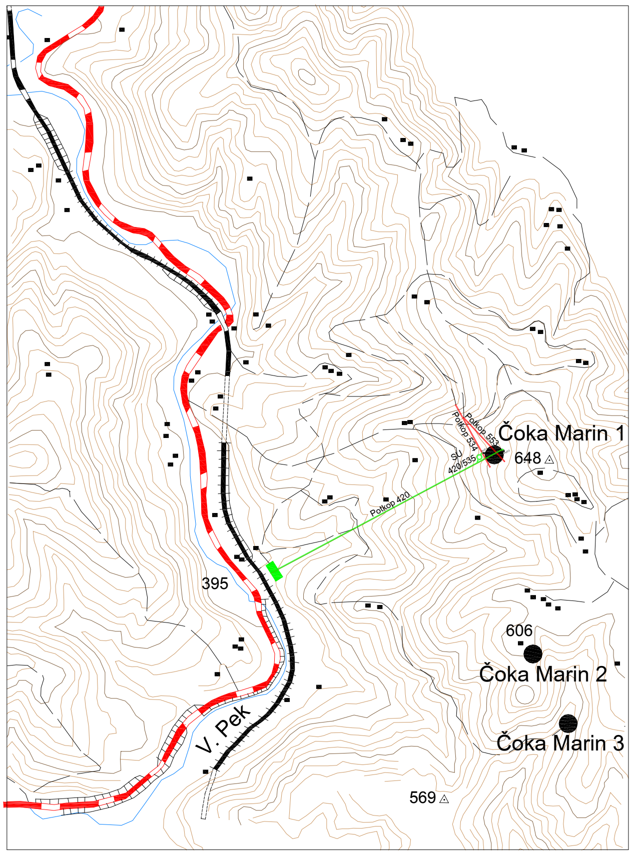

Figure 3 *Location of opening room of the ore body "Čoka Marin - 1"*

Adit 420 would be made from the field surface at K+420 m in the northeast direction of cross section 4x3 m, rise of 3 ‰, with length of 850 m, to the connection with PVO 2 at K +422.5 m (Fig. 3). Adit 420 would also have purpose of transport adit, because a belt conveyor will be located on a part of its length.

PVO 2, by deepening from K + 537 to K + 425 m and connection with adit 420, would have purpose to ventilate the future excavation levels.

Deepened PVO 1 from K + 534 to K + 425 m would have a multiple purpose, that is, it would be a mining shaft, where the crusher would be located at K + 430 m, and therefore to become also an accumulation shaft.

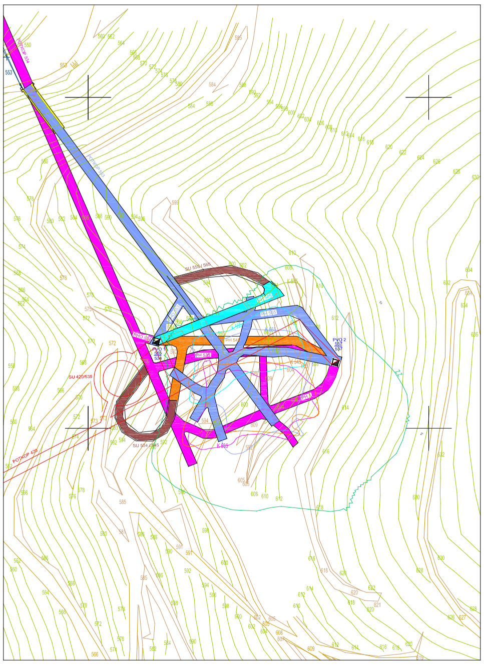

Figure 4 *Opening and development rooms*

Spiral rise (422/535), with a grade of 15%, and length of 750 m, would serve for development the other mining levels or sublevels (Fig. 4).

Connecting drift would be developed over a length of 20 m and connect the adit 420 with PVO 1. The beginning of belt conveyor would be located in this drift, which would be connected over unloading point (at the connection 420 and connecting drift) to the belt in the adit 420.

Total length of the belt conveyor would be 780 + 20 = 800 m.

At the exit of adit, at K + 420 m, a plateau would be made to accommodate the ore, size 10x10 m (Fig. 3). The ore loading would be done from this plateau into wagons in two ways: directly from belt or by loader.

THE REMAINING MINEABLE RESERVES

The amount of geological reserves, verified by the Project Study on the ore serves of 2004, amounts to 337,017.45 t. The Main Mining Design on ore mining in the ore body "Čoka Marin - 1" will mine to 179,866 t of mineable reserves.

Coefficients of utilization and depletion, calculated in the said MMD, will be used for calculation the mineable reserves at the lower parts of the ore body. The coefficients depend on the mining method. The sublevel caving method would be also used for excavation the lower parts of the ore body, because they are of small thickness and incline that their exploitation do not jeopardize the structures on the surface.

Total mineable reserves are calculated by the formula:

$$Qe = \frac{Qg \cdot Kir}{1 - Kor} = \frac{337{,}017.45 \cdot 0.85}{1 - 0.1} =$$

$$= 318{,}294.26\ t$$

where:

- Kir- coefficient of ore utilization
- Kor- coefficient of ore depletion

The remaining mineable reserves are:

$$Qe_2 = Qe - Qe_1 =$$

$$= 318{,}294.26 - 179{,}866 = 138{,}428.26\ t$$

Exploitation life:

$$T = \frac{Qe_2}{20000\, t / year} = 6.9\ year \approx 7\, year$$

The amount of run-of-mine ore is obtained by the formula:

$$Qr = \frac{Kir \cdot Qe_2\,(m - mj)}{mr - mj} =$$

$$= \frac{0.85 \cdot 138{,}428.26(2.16 - 0.3)}{1.97 - 0.3} =$$

$$= 131{,}050.95$$

$$Qr = 131{,}050.95\, t$$

where:

- mr – metal content in run-of-mine ore,
- mj – metal content in waste rock,
- m – metal content in ore reserves.

INVESTMENTS

Investments include the construction of all the above mentioned facilities to start the exploitation. Values of costs, which will be used in calculation, are taken from the Technical Design of ore mining in the ore body "Čoka Marin - 1".

Table 1 *Development costs of the mining rooms*

Order No.	**Room name**	**Type of development**	**Room length, (m)**	**Unit price, (USD$/m')**	**Total (USD$)**
A	B	C	D	E	F
1	Drift 420	Development and supporting	850	700	595,000
2	PVO 1	Development and supporting	109	500	54,500
3	PVO 2	Development and supporting	112	500	56,000
4	Spiral rise	Development and supporting	750	797	597,750
5	Connecting drift	Development and supporting	20	700	14,000
				Total	**1,317,250**

Labor costs are reflected in the time needed for construction the mining facilities and installation the additional equipment. By the beginning of exploitation, it is necessary that 12 workers work in two shifts 250 working days. If the price of gross wage is 25 USD$, the value of 150,000 USD$ is obtained.

Table 2 *Other costs*

Order No.	Name	Investments	Total (USD$)
A	B	C	D
1	Loader	Purchase	200,000
2	Crusher	Purchase and installation	300,000
3	Belt conveyor	Purchase and installation	400,000
4	Plateau at the entrance of adit	Purchase of land and preparation of plateau	30,000
5	Room for crusher	Preparation and supporting	20,000
6	Designing	Project development	50,000
		Total (USD$)	**1,000,000**

Total costs in opening the lower parts of the ore body "Čoka Marin - 1" are the sum of these costs:

$$Tuk = Tir + Trs + Tot$$

and the costs per ton of ore:

$$Tr = Tuk / Qr =$$

$$= 2{,}467{,}250 / 131{,}050.95 = 18.83\ USD\$/t$$

$$Tuk = 1{,}317{,}250 + 150{,}000 + 1{,}000{,}000$$

$$Tuk = 2{,}467{,}250\ USD\$$$

CONCLUSION

The task of this study was to show a possible way of opening the lower parts of the ore body "Čoka Marin - 1".

There are advantages of a new way of opening, reflected through:

1. The possibility of mining 138,428.26 t of mineable reserves, not affected by the MMD on mining from 2007.
2. The possibility to change the external transport of the ore body "Čoka Marin - 1", as well as savings on transportation costs:
   - By transfer from truck transport to the railway transport, the transport route is shorten to up to 10 km in one direction, and at the same time the transport costs are reduced, as the costs of railway transport are much lower than the cost of truck transport.
   - Shortening of internal transport by loaders is obtained, an average of 200 m in one direction, because their transport roure will be to PVO 1, a does not come from the adit.
3. The price of excavation per ton of ore would be reduced.
4. Development the adit 420 comes up to level at which there are peaks of the ore bodies "Čoka Marin 2 and 3," what would facilitate their ope-ning and exploitation in the future period.
5. Increase the prices of precious and non-ferrous metals on the market, allows excavation the ore body "Čoka Marin - 1" in the other boun-daries with much lower content of useful components, and the opening of the lower parts of the ore body is necessary.

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[2] Project Study on Mineral Reserves of Cu, Au, Ag, Pb, and Zn of the Deposit "Čoka Marin - 1", Copper Institute, Bor 2004 (in Serbian)

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SELECTION THE OPTIMAL PARAMETERS OF DRILLING AND BLASTING OPERATIONS AT THE OPEN PIT OF STONE COAL "PROGORELICA" - BALJEVAC

Abstract

Blasting is an integral part of excavation in the field "Progorelica". The quality of blasted material depends on proper selection of drilling and blasting operations, why the arrangement of boreholes and quantity of explosives need to be determined so that the effect of explosion is in the range r/W <0.75, i.e. without creating a large explosion funnel, but rather weakening it.

Keywords: *blasting, borehole, explosive, explosion funnel*

1 INTRODUCTION

Blasting is a part of overburden excavation technology in the field "Progorelica" in the areas where it is needed, i.e. in the working environments with physical and mechanical properties such as that the digging resistance is greater than the cutting force of Dragline M-7200 excavator. The purpose of mining the overburden is not as with the loading by hydraulic excavator complete separation of the block for loading from the whole, but only the distortion of cohesion between the particles in order to reduce the resistance during the excavation of waste rock. If during blasting the line of least resistance would be less than the radius of the base of explosion funnel (w <r), or if it would be equal to it (w=r) the material of blasted block would separate from the rock mass and found beyond the reach of the excavator M-7200. This effect of explosion is undesirable, there at in the arrangement of blasting holes and determination of the amount of explosive in them it needs to be strictly kept in mind that these are so determined that the effect of explosion re mains within the limits r/W <0.75 i.e. that the visible explosion funnel does not form, but rather weakened. It should be noted that the needs for blasting increase with increasing hardness of overlying sediments, because the excavator M-7200 could successfully excavate the overburden in the filed "Progorelica" even without the use of explosives, if the hardness of the material would be such that the resulting digging resistance is lower than the size of excavator cutting forces and if one would not pursue the minimum level of inclination of 60°. However, as it can be seen from the results of testing hardness of overlying sediments and interlayer waste that variable is the same and ranges from 1.37-1.88 for the soft sandstone and from 5.57-6.87 for moderately hard marl or marly limestone, so that excavation of harder lots without use of explosives would be impossible and also without disrupting the cohesion between the particles, especially in the foot wall section and in cutting the block. Applying the table of Novo-zhylova calculating the specific

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consumption of explosives in such a mode, the value obtained exceeds several times the values of experiential results, so that it is not practically applicable. Therefore, it is most secure that in determining the amount of explosive and arrangement of blasting holes to comply with the parameters that in the field Tadenje have already shown the results of mining and a trial mining is performed in the field "Progorelica" [1].

2 DRILLING AND BLASTING OPERATIONS

For performing drilling and blasting operations and for the purpose of destruction or shaking the working environment, the mine disposes with a self-propelled drill rig SVG-730 with a rotary hammer for mining and construction equipment in manufacturing RK-26MI.

Drilling carriage SHG-730 with deep hammer RK-26MI is intended for drilling diameters of 80 – 105 mm. Drilling rate ranges from 4-12 m/h, depending on the material, other mountaingeological conditions, proper maintenance and on several factors of technical and organizational character. The soft material can also be drilled (rotary drilling), such as for example, clay, earth and taking the core.

Drilling possibility

1. Horizontally up to a height	from 250 - 1800 mm
2. Vertically	up to + cca 27^0
3. Laterally	to 72^0

Determination of drilling parameters

The basic available information and of influence on the adoption of parameters of drilling - blasting works are:

Height level	H = 10m
Angle of inclinable level	$\alpha = 60^o$
Volumetric mass	$\gamma = 2230$ kg/m^3
Maximum diameter of blasted piece	$l_d = 700$ mm

Height of blasted level

By vertical division of deposits the height of level is determined where dragline excavator will operate and it is up to 10m with an inclination of operation slopes of α = 60°. At opening the first level, the height will change until it reaches 10m and, in that case, different depths of boreholes will be in blasting. During opening the I level, there will not be two free surfaces and thus the arrangement of blast boreholes and quantity of explosives in them will be different than in a regular technology. Figure 1 shows the arrangement of blast boreholes in cramped conditions (straitened minefield) needed for faster bringing into regular blasting technology.

As it can be seen from Figure 1, the block which will be opened needs to be drilled chequerwise in 5 rows across the width of block (labeled 1 through 5) and 6 per depth of block (labeled from a to f).

The arrangement of boreholes is provided on the spot as well as a way of charging them by person responsible for carrying out drilling and blasting operation depending on the material and the relief of terrain where they are performed. Distance between the boreholes is equal to

5 m, but the depth of boreholes and the amount of explosives in them is not the same (Figure 2). Depth of boreholes can be seen in profile A-A per depth of the block.

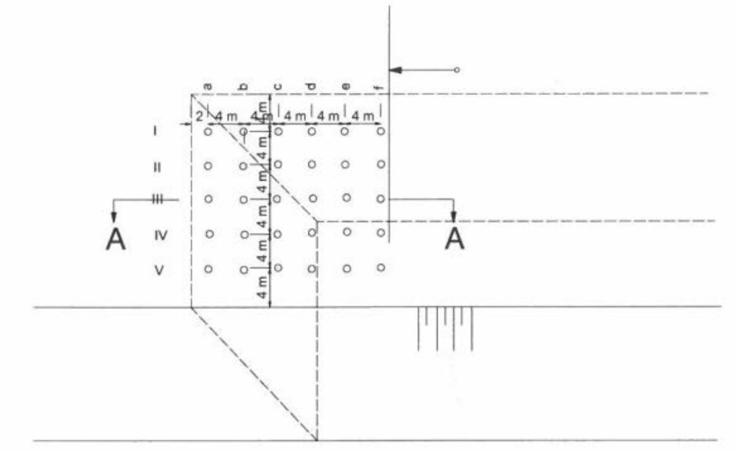

Figure 1 *Arrangement of blast boreholes in cramped conditions (straitened minefield)*

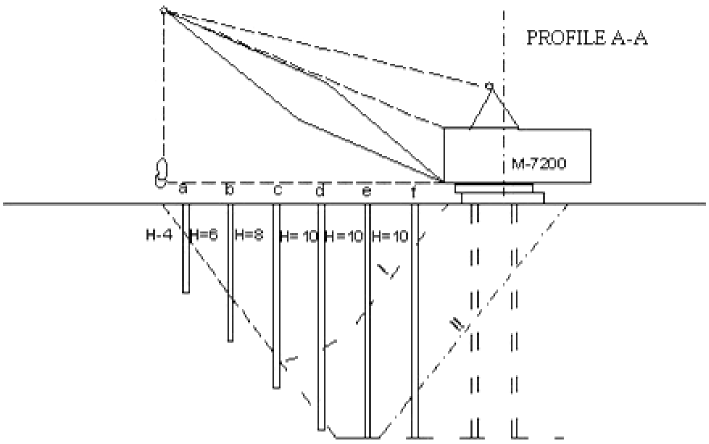

Figure 2 *Height of borehole in opening cutting*

The basic rule is that the blockage at the top of borehole needs to be at least:

- For boreholes up to 5 m depths - at least one half of the borehole depth
- For boreholes up to 6 to 10 m - at least one third of the borehole depth

Detailed instructions are provided by the technical manager through safety service at work.

Inclination angle of borehole

In calculating the inclination of operation slopes, the inclination angle of $\alpha = 60^o$ is adopted. In order to ensure the required security and stability of levels, the adopted boreholes inclination is the same as in operation inclination: $\alpha = 60°$. The same boreholes inclination is also adopted in the variant of opening the level.

Borehole depth

Total length of the borehole depends on:
- Level height (H)
- Borehole inclination (α)
- Pitting size (l_{pr})

The general formula for calculation the blasting hole depth has the form:

$L_b = H/\sin\alpha + l_{pr}$;

where:

L_b - total length of blasting borehole
H - level height (10 m)
l_{pr} - pitting below the floor level
α - inclination angle of borehole (60°)

$l_{pr} = (0.15 – 0.30)$ w

$l_{pr} = 0.2 \cdot 4.0$

$l_{pr} = 0.8$ m

$L_b = 10/\sin60^o + 0.8$

$L_b = 12.4$ m

3 DRILLING DIAMETER

Drilling diameter is directly linked with the choice of excavator or excavator bucket capacity. Starting from the overall dimensions (>$0.75\sqrt[3]{qk}$) through the formula:

$$d = \frac{70}{\sqrt{P_{ex}}} \cdot q_k^{\ 0,165} \cdot \sqrt{\eta_1 k_1 \cdot q^{0,1}}$$

where:

q_k - excavator bucket capacity 5,.

$\eta_1 = \frac{W}{H}$ - ratio of the line of least resistance and height levels

k_1 - coefficient of proportionality

q - specific consumption of explosive kg/m^3

P_{ex} - power coefficient of explosive

adopted as: d = 0,088 m

4 THE LEAST RESISTANCE LINE

By definition, the least resistance line is the shortest distance from the center of placement of explosive charge in the borehole to free surface. With inclined boreholes, it is equal to length of the entire borehole. The value of this parameter depends on: physical- mechanical and structural characteristics of the working environment, power and quantity of explosive charge and distribution of boreholes. There are several formulae for determining the least resistance line, and in principle formulae should be used that contain a larger number of dependent values.

The least resistance line is usually calculated according to the formula:

$$w = 53 \cdot kr \cdot d \cdot \sqrt{\frac{\gamma_e}{\gamma}}$$

where:

w - line of least resistance
kr - fissure coefficient 1.25
d - borehole diameter 88 mm
γ_e - volumetric mass of explosive 1.05 g/cm^3
γ - volumetric mass of the area being shaken 2.23 g/cm^3

$$w = 53 \cdot 1.25 \cdot 0.88 \cdot \sqrt{\frac{1.05}{2.23}}$$

adopted as w = 4.0 m

After determining the optimal length of the least resistance line w, it is preceded to the experimental blasting with varying distances between the boreholes to determine the coefficient of overlapping (density).

5 DISTANCE BETWEEN THE BOREHOLES IN A ROW

This parameter of drilling and blasting operation is determined by the size of the least resistance line:

$a = m \cdot w \cdot (m)$

where:

m - coefficient of rapprochement of boreholes in a row a - distance between the boreholes in a row (m)

$a = 1.1 \cdot 4\ m = 4.4\ m$

adopted as: a = 5 m

6 DISTANCE BETWEEN THE ROWS OF BOREHOLES

The effect of blasting at the open pits largely depends on the arrangement of boreholes. The holes in rows are distributed to form a square, rectangular or triangular arrangement. In cases where the blast holes are parallel to the slope of level (inclined), the distance between the rows of holes (b) is usually equal to the size of the line of least resistance:

$b = w$

where:

b - distance between the rows of boreholes (m)

w - line of least resistance (m adopted as: b = 4.0 m

The arrangement of boreholes is shown in the following Figure:

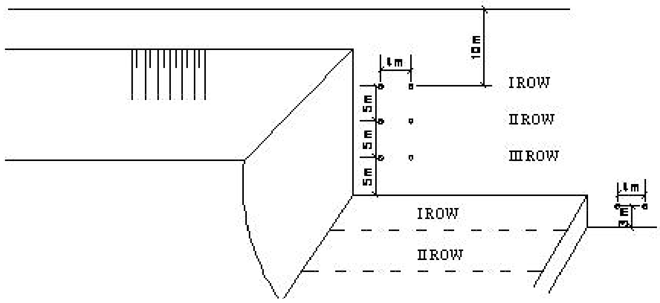

Figure 3 *The arrangement of blast boreholes*

As shown in Figure 3, row III of boreholes falls on the foot of the level slope, and that is why although there are two free surfaces, explosive is placed in it, because the excavator in cutting the floors has the worst conditions (bucket freefall) precisely at the profile line coinciding with the third row of blast boreholes. Slope of the level is already shot off in the earlier mining of the previous block (I and II row of boreholes is shown with dotted lines in Figure 3).

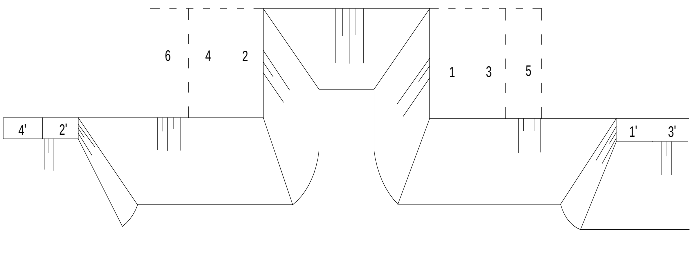

Figure 4 *The order of blasting the floor with excavation from the middle to the wings of floor*

The auxiliary block should ensure the coal production in one shift where blasting takes place in the main block. It is blasted by the use of one auxiliary row of blast boreholes drilled along the front floor at a distance of 3 m from the edge of the floor. As the blasting of a block requires about 8 h, and the work on blasting is allowed by regulations only under daylight, therefore the blasting of auxiliary block has to be per formed in the II shift. The boreholes of the auxiliary block are drilled in the II shift in a great number along the front floor and protect by stoppers on material filling, and the blasting is performed after the completion of blasting on the main block and the return of excavator to work on it. Figure 4 presents the order of blasting the floor with excavation from the middle to the wings of floor.

7 SELECTION OF EXPLOSIVE TYPE

Determination the corresponding type of explosive for the given work environment is done through acoustic impedance, which means that the physical properties of the working environment and explosives by which the environment is to be blasted in the blasting process have to be brought into relationship, and this relationship is:

$D_e * \gamma_e = K_o (V_o * \gamma)$

where:

D_e - detonation velocity of explosive (m/s)

γ_e - the explosive density (kg/dm^3)

K_o - reflection coefficient

V_o - propagation speed of longitudinal waves through the working environment (m/s)

γ - volumetric mass of working environment being destroyed (for roof sediments 2,23 gr/cm^3).

In blasting, a particular attention should be paid to the seismic waves speed. Between the seismic wave speed Ct and the coefficient by Protodjakonov there is a certain dependence taking also into account the coefficient of fissure of the rock Kr as follows:

$$C_t = 1540\sqrt{\frac{f_r}{K_r}}$$

for sandstone

$$C_t = 1540\sqrt{\frac{1,88}{1,25}} = 1888,6\ m/s$$

Size of seismic wave speed indicates the application of possible obtaining technology (digging, tearing of soil or mining).
for marly limestone

$$C_t = 1540\sqrt{\frac{6,87}{1,25}} = 3610,3\ m/s$$

The reflection coefficient can be determined based on diagram (Figure 5). Since it is known that the works are carried out in soft and medium-hard rocks, in which the speed of propagation of longitudinal waves is up to 3600 m/s. Energy utilization of explosives in similar conditions is around 80%, and the rest is lost in the cracks and spent on seismic effect in mining. The reflection coefficient in this case according to Figure 5 has the value K_o= 0.5. Certainly, the values V_o and K_o can be exclusively determined experimentally measuring only at the first test blasting.

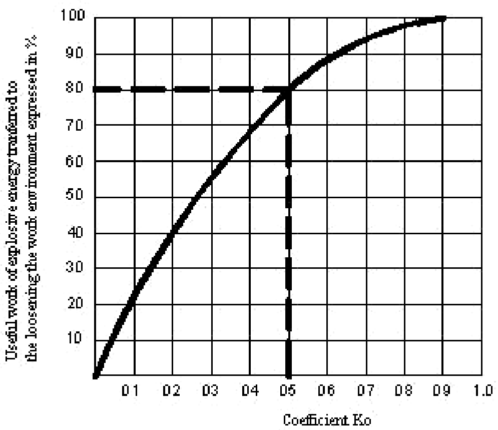

Figure 5 *Diagram for determining the value of K_o*

Based on the value of V_o and K_o, the appropriate type of explosive can be determined, as follows:

$D_e * \gamma_e = 0{,}5(3600 * 2{,}23)$

$D_e * \gamma_e = 4025$

"AMMONAL" explosive corresponds to this value of product density and detonation velocity of explosive. It can be concluded that this explosive is fully suitable for blasting at the open pit "Progorelica". The all other explosives of appropriate characteristics can be used for blasting, i.e. detonation velocity and density approximately equal to 4000.

8 SPECIFIC CONSUMPTION OF EXPLOSIVE

The possibility of obtaining rocks by blasting is characterized by a specific consumption of explosives, and it can be determined approximately according to the classification by Protodjakon:

$$q = 0{,}27\sqrt[3]{f}\ kg/m^3$$

for sandstone

$$q = 0{,}27\sqrt[3]{1{,}88} = 0{,}333\ kg/m^3$$

for limestone marl

$$q = 0{,}27\sqrt[3]{6{,}87} = 0{,}513\ kg/m^3$$

The ratio of blasting funnel radius (r) and the least resistance line (w) is called the indicator of explosion (blasting) effect.

$$n_g = \frac{r}{W}$$

For $n_g = \frac{r}{w} = 1$ funnel normal blasting is formed (swooping)

$n_g > 1$ - funnel of increased exploding is formed

$n_g < 0{,}75$ - no rebuff (swooping) but only the rock is loosened without formation of the funnel.

9 QUANTITY OF EXPLOSIVE PER METER OF THE BOREHOLE

The amount of explosive per meter of borehole and density depends on diameter of the borehole mine of explosive charge and is calculated using the formula:

$$q_b = \frac{\Pi \cdot D^2}{4} \cdot \rho \cdot p,\ \text{(kg/m)};$$

where:

q_b - quantity of explosive per linear meter of borehole (kg/m'),

D –borehole diameter (m),

ρ - density of explosive (kg/m^3),

p- coefficient of borehole filling,

$$p = \frac{d_1^2}{D^2}$$

d_1 –cartridge diameter

For available explosives, the quantity of explosives per meter of the borehole will be:

- For ammonal

p = (3.14 · (0.088^2)/4) · 1.05 · 0.63·10$^{\wedge 3}$ = 4.02 kg/m'

Based on empirical data, knowing the amount of the proposed explosives, the cartridge diameter θ diameter 70 mm, which can fit in 1 m' of charging, it can be concluded that the real amount of explosive per meter of the borehole is:

p = 4.5 kg/m'

10 PLUG LENGTH OF THE BLAST BOREHOLE

The plug length of blast borehole influences the effects of blasting by increasing duration of explosive pulse, providing a complete detonation of explosive charge and prevents the uncontrolled spreading of rock mass. Experimental studies have shown that the length of mine plug largely depends on diameter of blast borehole and resistance in the floor of level. Length of the mine plug can be calculated depending on the length of the least resistance line: [2]

l_p = (0.75 ÷ 1.0) * w, (m)

l_p = (0.75 ÷ 1.0) * 4 = (3 ÷ 4) m

the adopted length of plug is: l_p = 4.0 m

The inter-plugging will be performed only in the boreholes length L = 15 m and in the boreholes length of over 15 m.

11 CONNECTING AND ACTIVATION OF THE MINEFIELD

Connecting and activating the minefield will be carried out using:

- detonating cord,
- detonator no. 8,
- slowburning fuse,
- millisecond decelerators.

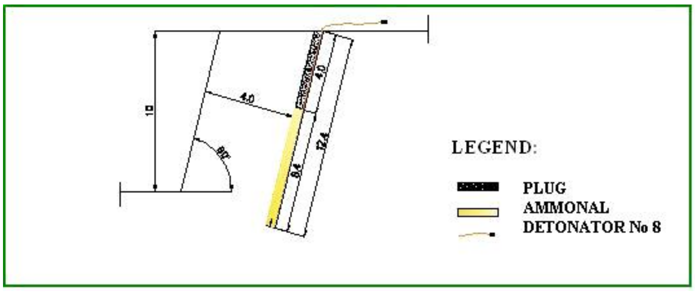

Figure 6 *Scheme of initiating explosive charges*

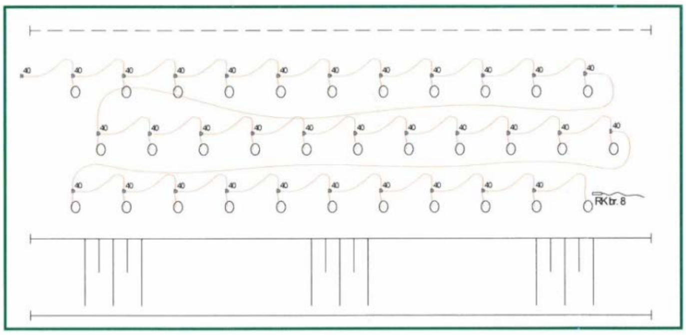

Figure 7 *Scheme of connection and activation the minefield*

CONCLUSION

In exploitation of mineral resources, it is necessary to fully comply with the parameters (quantity of explosive, deceleration intervals, minefield schemes, etc.) given in the design solution. Also, if for any reason there is a change of explosives or some other parameter of blasting, they should be thoroughly checked and subsequently analyzed.

During exploitation it is necessary to carry out continuous monitoring the results of blasting (quality of grinding, impact of blasting on the surrounding objects, etc.) for feedback analysis and possible correction of parameters that were unknown or taken into account during designing.

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DIMENSIONING OF AIR PIPELINE FOR THE SECONDARY CRUSHER DEDUSTING IN THE FLOTATION PLANT BOR

Abstract

This work gives the calculation methodology of air pipeline for dusty air removal on the example of air pipeline for the HP 200 secondary crusher dedusting, designed for the needs of reconstruction the Flotation Plant Bor. The analysis was done by calculation and includes checking the loss of pressure in the pipeline, taking into account the presence of dust. Graphical representation of the pipeline is also given, as well as its characteristic elements.

Keywords*: air pipeline for dusty air removal, calculation, pressure loss in the pipeline*

1 INTRODUCTION

Project of reconstruction the Flotation Plant Bor [1] has also included the Old Flotation Crushing Plant in terms of assembly the new equipment for crushing, screening and transport of slag from the New Smelter in Bor. In order to keep working environment conditions within the norms prescribed by the by standard SRPS Z.B0.001 [2], a dedusting system was designed [3]. The dedusting system provides that the dust emission to the atmosphere after purification to be below the limit value of emission the noxious and dangerous matters into the air at the place of pollution source determined by corresponding regulations [4]. The dedusting system was designed as an installation for dry dust extraction with forced air circulation where dusty air is removed from the place of pollution sources (ten suction places), purified in a bag house pulse jet filter (label FKK-750.s, manufacturer Termometal Belgrade) and discharged into atmosphere as purified air. Forced air circulation is provided by a centrifugal medium pressure fan (label R5A.100.10, manufacturer Termometal Belgrade) placed downstream of the bag house pulse jet filter.

2 TECHNICAL DESCRIPTION

In order to prevent dust emission from the HP 200 secondary crusher, it is covered from the top by a hood with aperture for material loading into the crusher and aperture for air pipeline connection for dusty air removal from this suction place. Dusty air is transported from the secondary crusher by the air pipeline Ø315 to the collecting air pipeline Ø1000 in front of the bag house pulse jet filter.

Air pipeline for the secondary crusher dedusting consists of straight segments and fittings with outer diameter of D=315 mm. Elements of the pipeline are made by welding from sheet steel S235JRG2 (Č.0361) with thickness of 3 mm. The pipeline segments are mutually joined by flanges with thickness of 5 mm, whereby a simple

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assembly and disassembly of pipeline elements is enabled. The pipeline is connected to the suction hood through an elastic element preventing the vibrations of the secondary crusher to expand to the pipeline. A manually actuated round control damper is placed above this connection point for pipe network balancing. The pipeline bends are made as segmented bends with radius of *r* =.,5D reinforc ed on the outer side of the curve. The branch at the connection point of this pipeline to the collecting air pipeline Ø1000 has connection angle of 30° in relation to the axis of the collecting air pipeline. The pipeline runs along the existing steel structure in the hall of the Old Flotation Crushing Plant being suitably supported on it, on the outer side, the pipeline goes along the wall of the building and then is connected to the collecting air pipeline. The pipeline is primed protected and coated by final paint.

Pipeline view in the cross section of the hall is given in Figure 1.

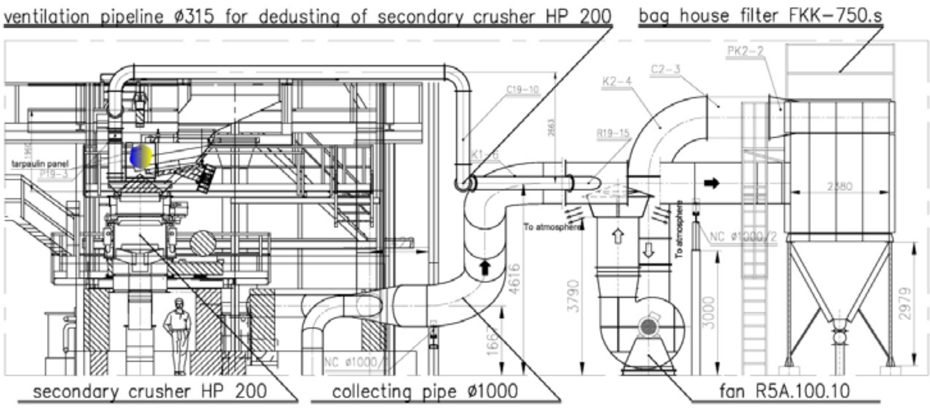

Figure 1 *Pipeline for the HP 200 secondary crusher dedusting in the cross section of the hall of the Old Flotation Crushing Plant*

The pipeline view for the HP 200 secondary crusher dedusting and part of the collecting air pipeline between the building and wall in front of the bag filter is given in Figure 2 in isometric view.

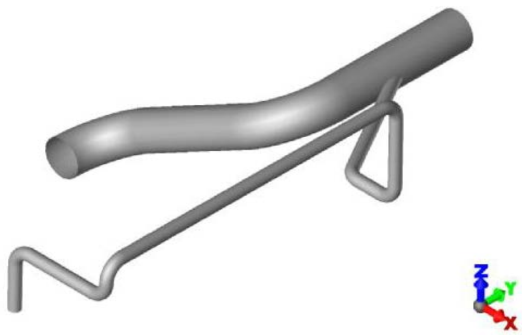

Figure 2 *Isometric view of pipeline for the secondary crusher dedusting ∅315 and segment of the collecting pipeline ∅1000*

Fittings of the pipeline are segmented bends of 90° and 60°, as well as the branch at the connection point of pipeline Ø315 to the collecting pipeline Ø1000. These fittings are shown in Figure 3, as well as a typical support and round control damper.

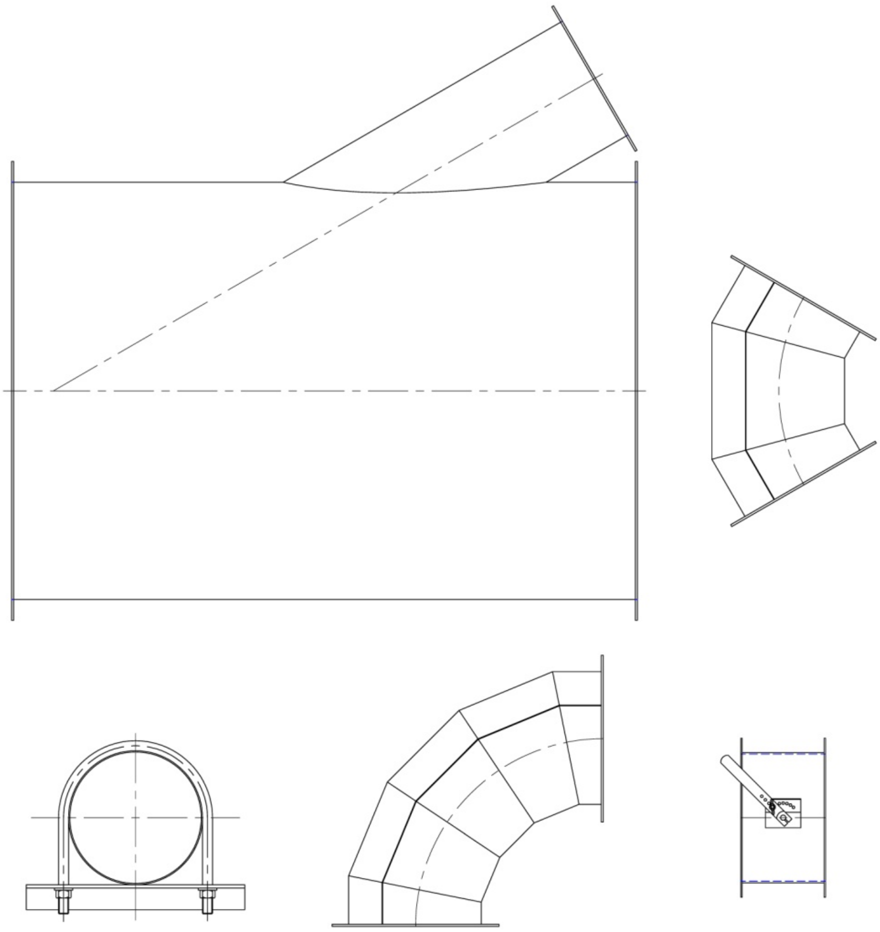

Figure 3 *Elements of the pipeline for the secondary crusher dedusting*

3 CALCULATION

Calculation is aimed to determination of pressure drop at dusty air flow through the pipeline section for secondary crusher dedusting and it is given according to [5]. Based on the calculation results, the pipeline is dimensioned and the pipe network is balanced.

1. Calculation the inner diameter of the pipeline is determined by the following formula:

$$d_r = \sqrt{\frac{4 \cdot Q}{3600 \cdot \pi \cdot v_r}} = 0.326[m]$$

Where:

$Q = 6000 \left[\frac{m^3}{h}\right]$ - volumetric air flow

$v_r = 20 \left[\frac{m}{s}\right]$ - calculating air velocity

The standard outer pipeline diameter is adopted for ventilation piping installation $d_{sp} = 0.315[m]$ which corresponds to the inner diameter of the pipeline of

$d = 0.309\ [m]$

(for pipe wall thickness $\delta = 3\ [mm]$), and the actual air velocity is calculated:

$$v = \frac{4 \cdot Q}{3600 \cdot \pi \cdot d^2} = 22.23 \left[\frac{m}{s}\right]$$

2. Friction loss coefficient is determined by the following formula:

$$\lambda = 0.013 + \frac{0.001}{d} = 0.016$$

3. The sum of point loss coefficients of the pipeline is determined according to [6] as follows:

Conical convergent opening with wall at the end θ=0º	0.50
Damper, control, round θ=0º D/Do=1	0.19
Bend, 5 segments, round θ=90º r/D=1.5 pieces: 5	1.20
Bend, 3 segments, round θ=60º r/D=1.5	0.27
Branch convergent V type, 30º, round, A_2=A_1, connection A_3/A_1=0,1; Q_3/Q_1=0,1	0.24
Σς =	2.40

4. Critical velocity is checked using the following formula:

$$v_{kr} = 0.3 \cdot \sqrt{c \cdot g \cdot d \cdot \frac{\rho_č}{\rho_v}} =$$

$$= 1.67 \left[\frac{m}{s}\right] < 22.23 \left[\frac{m}{s}\right]$$

Where:

$c = 0.00333 \left[\frac{kg_č}{kg_v}\right]$ - solid particles concentration in the air

$\rho_č = 3700 \left[\frac{kg}{m^3}\right]$ - solid particles density

$\rho_v = 1.2 \left[\frac{kg}{m^3}\right]$ - air density

$g = 9.81 \left[\frac{m}{s^2}\right]$-gravitational acceleration

5. Pressure drop for clean air flow is determined by the following formula:

$$\Delta p_v = \left(l \cdot \frac{\lambda}{d} + \Sigma\varsigma\right) \cdot \frac{\rho_v \cdot v^2}{2} =$$

$$= 1040.3[Pa]$$

Where:

$l = 21.1[m]$ - pipeline length

6. Pressure increase factor is:

$$\Omega = 0.02 \cdot \frac{v^2}{g \cdot \frac{d}{2} \cdot cos\beta} = 6.52$$

Where:

$\beta = 90[°]$ - pipeline inclination angle

7. Pressure drop for dusty air flow is:

$$\Delta p_č = \Delta p_v \cdot (1 + k \cdot c) = 1045.1[Pa]$$

Where:

$k = 1.4$ za $\Omega > 1$ - pressure increase coefficient

4 DISCUSSION OF CALCULATION

As it can be seen, the calculation diameter of the pipeline is determined on the basis of the recommended air velocity for this type of installation, which amounts $v_r = 20 \left[\frac{m}{s}\right]$.

The standard value of the pipeline diameter for ventilation piping installation is adopted and on its basis the actual velocity is calculated which to a lesser extent deviates from the calculation velocity. Then the pressure drop is calculated in the pipeline due to the friction losses and point losses under assumption that the air is clean. The effect of dust presence on pressure drop at dusty air flow is taken into account through the pressure increase factor Ω and the pressure increase coefficient k. The results obtained by calculation show that for selected operating parameters the effect of dust presence on pressure drop is negligible in relation to the pressure drop at clean air flow what may not always be the case.

In case of flow the heterogeneous mixture of fluid and solid particles such as dusty air flow, it is checked that the value of air velocity in the pipeline is above the critical rate at which deposition of dust particles in the pipeline takes place. As it can be seen from calculation, this requirement is met here.

The pipeline for secondary crusher dedusting represents only one branch of the installation for dust extraction from Old Flotation Crushing Facility which contains, as it was mentioned before, the total of ten suction places and the same number of flow circuits. Total pressure drop in flow circuit for the secondary crusher dedusting is compared to the pressure drop in the most unfavourable flow circuit and the remainder between these two values is determined.

This remainder is the value of pressure which has to be choked at round control damper and i amounts here $\Delta p = 262.6\ [Pa]$. By choking in such way at the all rest of the flow circuits (except the most unfavourable flow circuit, i.e. flow circuit with the highest pressure drop which represents the reference pressure loss), the aero dynamic balancing of the pipe network is done.

5 CONCLUSION

Dimensioning pipeline on the basis of the recommended speed is relatively simple method for design the pipeline installation. Certainly, it should be taken into account the all specifics of dusty air installation. Calculation of pressure drop in the dusty air flow deviates very little from calculation the pressure drop in the clean air flow, i.e. the effect of dust presence of dust is included by the appropriate corrective coefficient that depends on the air velocity, dust concentration and geometric parameters of pipeline.

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TECHNOLOGICAL PROCEDURE FOR PROCESSING THE QUARTZ RESOURCES IN ORDER TO OBTAIN THE ASSORTMENT FOR WATER GLASS**

Abstract

Tests on quartz raw material from the deposit "Bijela Stijena - Skočić" have included: grading, washing, grinding and magnetic separation. Test results have shown that the assortment of required sand quality can be obtained for water glass. The required quality condition for assortment of water glass, set by the company "Alumina" Zvornik, is that Fe_2O_3 content does not exceed 0.04% and the grit of -0.4 + 0.05 mm. The results obtained after washing and grading starting sample used in these tests to a class of -0.4 + 0.05 mm showed that content of Fe_2O_3 from 0.131% was reduced to 0.075%, and after treatment at high gradient electromagnetic separator at 0.038%. Microscopic analysis showed that the initial sample has: quartz, chalcedony, feldspar, mica, cherts, magnetite, limonite-goethite, shells, fossil remains, and that after the magnetic separation of magnetite sample was removed and most of the other carriers magnetic fraction. Based on this, a flow diagram is defined for procedure of obtaining the quartz sand for water glass on the basis of quartz raw materials from the deposit "Bijela Stijena - Skočić".

***Keywords**: quartz raw materials, the range of water glass, grinding, high gradient magnetic separator*

INTRODUCTION

Quartz is, by the chemical composition, silicon dioxide SiO_2 and it is one of the most common minerals in nature. It is on the seventh place on the Mos scale of hardness. Quartz crystallizes hexagonally, can be colorless or colored differently depending on the impurities. Quartz is used very widely in the production of modern high technology products. Quartz raw material is used in the production of water glass. Water-glass is solution of sodium silicate salt in water. By the chemical composition is sodium metasilicate, and appears in the following forms: Na_2SiO_3 and $Na_2SiO_3 \bullet 9H_2O$. There are other forms (e.g., Na_4SiO_4 orthosilicate), and their common characteristic is solubility in water with formation of vitreous emulsions. Water glass is widely used in manufacture of synthetic zeolite, silica gel and silica-sol as well as in production of detergent. It is added to the concrete mix in order to reduce permeability of water in concrete. It is also used as a binder for preparing a mold and coating procedure code of casting in order to allow

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easier separation of the castings. Also, water glass is widely used in the textile and paper industry as a bleaching agent [1-4]. Data about the deposit of quartz raw material “Bijela Stijena - Skočić” are given in the study of Geology and Mining of Project of exploitation [5]. The company “Kesogradnja” from Kozluk has the right to exploit quartz sand from this deposit. “Birač” Zvornik or “Alumina” Zvornik, as manufacturer of water glass needs to around 30 000 tons/year assortment of quartz sand of certain quality. Previous tests on raw material from said deposit has indicated that the range of -0.4 + 0.05 mm can be obtained by methods of preparation the mineral raw materials [6-8]. As the raw material in deposit is not loose, ant the required range of products is represented by a class of -0.4 + 0.05 mm, it is necessary to comminute large classes that are separated in the process of separation, and classification. This paper presents the results of tests and technological scheme for obtaining the products for water glass -0.4 + 0.05 mm [8].

EXPERIMENTAL PART

Material and Methods

The initial sample for tests presented in this paper is the raw quartz sand from the deposit “Bijela Stijena –Skočić”.

Chemical composition: The initial sample of quartz sand CaO content is determined by the volumetric method, while the content of SiO_2 and loss on ignition (900°C) were determined by gravimetric method (JUS B.B8. 070). For determining of Al_2O_3, Fe_2O_3, Cr_2O_3, TiO_2, MgO, Na_2O and K_2O, an atomic absorption spectrophotometer, type "Perkin Elmer 703 Analyst 300", was used.

Magnetic concentration: It was carried out on high gradient magnetic separator, type “SALA-HGMS”, which works with the possibility of discontinuous change in magnetic field strength, speed washing water content of the solid phase and retention time of material in the matrix. Terms of device during testing which are presented in this paper are: solids content of 10%, magnetic induction 1T, speed washing water 0.1 m/s and the residence time of material in matrix 15s.

Determination the Bond's index: Determination of the work index grindability was performed in the Bond's ball mill “Bico Braun International” by dry milling process.

Determination the bulk density: The method involves determining the mass of buried free sample without compression, in the dish of known volume and weight according to the formula:

$$\Delta = \frac{m_1 - m}{V}, \qquad \left[\frac{t}{m^3}\right]$$

where:

Δ - bulk density of sample;
m_1 - mass of sample and dish;
m - mass of dish;
V - volume of dish.

RESULTS AND DISCUSSION

Characterization of Starting Sample

At the initial sample was determined by grain size and chemical composition, moisture, bulk density and Bond Index. Results of determination of particle size distribution are shown in Table 1 and graphically in Figure 1.

On the basis of particle size distribution, it can be seen that the average grain diameter of sample is d_{50} = 2,08 mm, the upper limit grit ugsl = 16.81 mm.

Table 1 *Particle size distribution of raw quartz sand*

Size class, mm	M, %	Reflection %	Sieving material, %
+15.00	7.20	7.20	100.00
-15.00+4.00	35.34	42.54	92.80
-4.00+2.00	6.62	49.16	57.46
-2.00+0.60	12.89	62.05	50.84
-0.60+0.30	15.33	77.38	37.95
-0.30+0.10	15.74	93.12	22.62
-0.10+0.05	1.88	95.00	6.88
-0.05+0.00	5.00	100.00	5.00

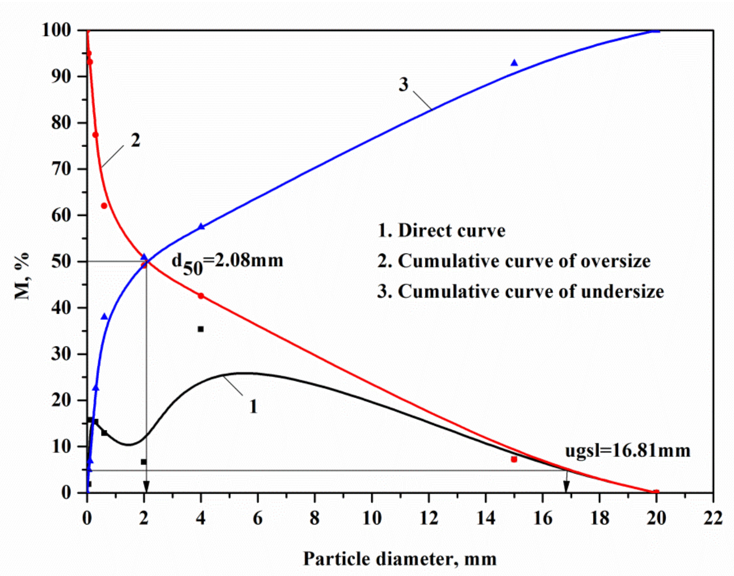

Figure 1 *Particle size distribution of raw quartz sand*

Chemical analysis was performed on a sample of raw quartz sand, then on the class of -0.4 + 0.05 mm which represents the required granularity for use in the production of water glass and after washing and electromagnet. The obtained results are shown in Table 2.

Table 2 *Chemical composition of raw quartz sand and classes -0.4 + 0.05 mm after washing and electromagnet*

Sample	Content, %									
	SiO_2	Al_2O_3	Fe_2O_3	Cr_2O_3	TiO_2	CaO	MgO	Na_2O	K_2O	L.I.
Row sand	97.82	1.24	**0.131**	0.0012	0.068	0.04	0.02	0.007	0.086	0.51
-0.4+0.05 mm after washing	99.15	0.29	**0.075**	0.0003	0.007	0.04	0.008	0.003	0.0032	0.09
-0.4+0.05 mm after the electromagnet	99.49	0.174	**0.0301**	0.0002	0.039	0.028	0.007	0.0014	0.022	0.09

From the presented chemical composition, it can be seen that the raw sample contains 0.131% Fe_2O_3. It also shows that content of Fe_2O_3 in class -0.4 +0.05 mm after washing 0.075%, which is above the prescribed values for use in the production of water glass, which is 0.04% max. That is why the magnetic concentration was done on class -0.4 +0.05 mm with high gradient magnetic separator in order to remove Fe_2O_3. After magnetic separation, Fe_2O_3 content is reduced to 0.0301%, what meets the required quality required by the user.

It was determined on initial sample that the moisture is 5.0%, while the apparent density is 1.852 t/m^3 and Bond Index is 14.0 kWh/t. It was also determined the apparent density of the class -0.4 +0.05 mm, which represents the required granularity for use in the production of water glass and it is 1.42 t/m^3.

Determination the Particle Size Distribution of Quartz Sand, Obtained in Separation

Having in mind the fact that the required grit silica sand for use in the production of water glass is a class of -0.4 to +0.05 mm, it was necessary to determine the grain size distribution of quartz sand, obtained in separation. Connecting ways of classes that go on re-grinding to obtain the required granularity are shown in Table 3.

Table 3 *Particle size distribution of silica sand with classes that will be obtained by separation*

Size class, mm	M, %	Oversize, %	Undersize, %	Class name (mm) and content (%)	
+15.00	7.20	7.20	100.00	+15.00	7.20
-15.00+4.00	37.80	45.00	92.80	**-15.00+0.40 class for re-grinding**	**63.46**
- 4.00+2.00	4.16	49.16	55.00		
- 2.00+0.60	12.89	62.05	50.84		
- 0.60+0.40	8.61	70.66	37.95		
- 0.40+0.05	24.34	95.00	29.34	**0.40+0.05 final product**	**24.34**
- 0.05+0.00	5.00	100.00	5.00	-0.05+0.00	5.00
raw material	100.00	-	-		100.00

It can be seen from Table 3 that it is ne-cessary to connect all classes between -15.00 + 4.00 + -0.60 mm and 0.40 mm into class -15.00 + 0.40 mm that will go to re-grinding. Class -0.40 + 0.05% is the final product to the proportion of total sample mass of 24.34%, and that can go into direct use.

After re-grinding the coarse classes of quartz sand in a ball mill, the grain size distribution was determined, and the results are shown in Table 4 and graphically in Figure 2.

Table 4 *Particle size distribution of quartz sand after grinding of large classes*

Size class, mm	M,%	Oversize, %	Undersize, %
+0.60	4.35	4.35	100.00
- 0.60+0.40	7.75	12.1	95.65
- 0.40+0.05	81.51	93.61	87.9
- 0.05+0.00	6.39	100.00	6.39
Total output from mill	100.00	-	-

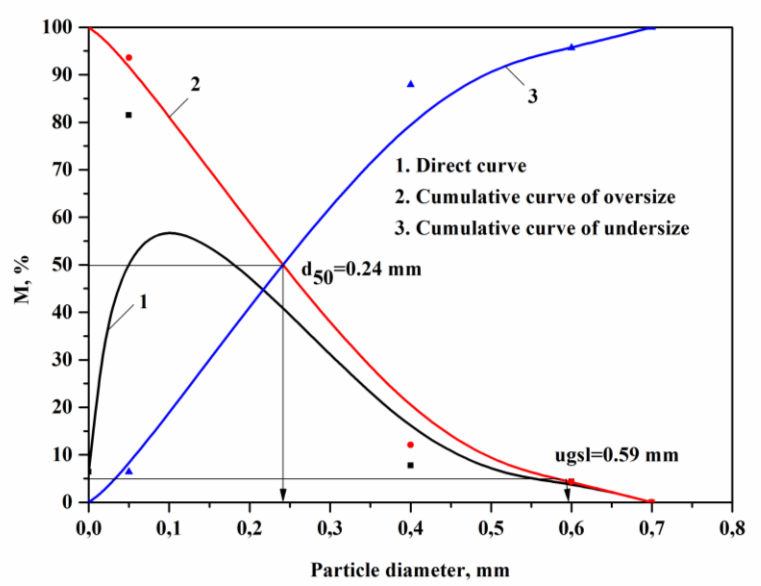

Figure 2 *Particle size distribution of quartz sand after grinding of large classes*

Based on the results obtained by determination the particle size distribution, it can be seen that by grinding of class -15.00 + 0.40 mm, the average diameter decreased from 2.08 mm as it was in the run-of-mine sample at 0.24 mm, what it is after re-grinding. Also, upper grain size limit decreased from 16.81 mm to 0.59 mm.

Technological Procedure of Processing the Quartz Raw Material

On the basis of tests, it came down to the technological scheme for valorization of this raw material. This scheme is given in Figure 3.

Description the Technological Process of Separation

Quartz sand from the deposit "Bijela Stijena - Skočić" is transported by truck to the landfill and from there loaded into the receiving hopper (pos. 1.). Then dosed the vibrating feeder (pos. 2) on the conveyor belt (pos. 3) carrying the raw material in the drum slurry (pos. 4). Water is added into drum for washing to achieve proper density pulp. The resultant pulp comes on the grate opening of 15 mm, which is the output part of drum. Here, the isolated class + 15 mm, falls on conveyor belt (pos. 5) which goes to the landfill near the building of separation. Class -15 +0 mm comes into chute and from there to the vibration sieve (pos. 6). Vibro sieve is supplied with water from the pump position 29. In the vibrating sieve, which has two floors allocated ranges -15 +4 mm and -4 + 2 mm (pos. 7 and pos. 8) that are transported by conveyor belts to the anticipated concrete boxes. These assortments are ground to obtain the class -0.4 + 0.05 mm. Class -2 + 0 mm goes by gravitation from vibrating sieve into the rotation sieve (pos. 9) where stands out the product -2 + 0.6 mm which falls on the conveyor belt (pos. 10), and after that carries it into concrete box. This product can be commercial or ground with the other classes of size -15 + 0.4 mm. Sieving material from rota-ting sieve -0.6 + 0 mm, by gravity, goes to the recycle pump (pos. 11). The pump transports this class to hydrocyclone (pos. 12). Hydrocyclone overflow (pos. 12) goes by gravity into a common collector pipe that takes it into lagoon about 150 meters from the plant. Sand hydrocyclone, pos. 12, goes to scrubbing in attrition machine (pos. 13).

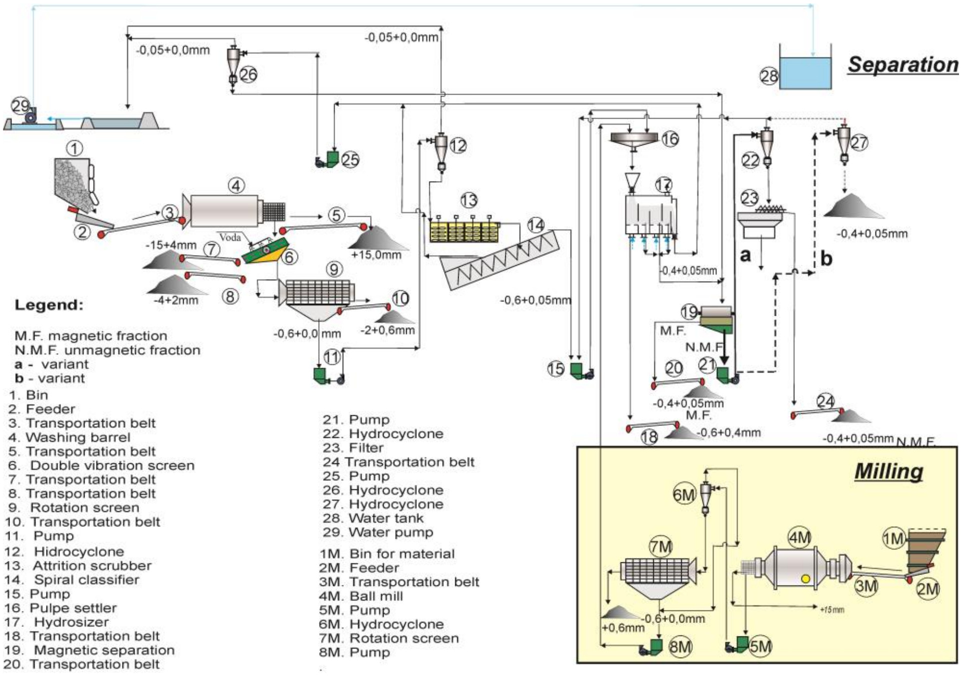

Figure 3 *Figure of quartz sand separation and milling - Kozluk*

After attrition and scrubbing, material goes into gravitational classifier with spiral (pos. 14) in which the required amount of water is added. Overflow of classifier -0.05 + 0 mm, goes by gravity into the pump basket, pos. 25. Pump transports overflow to the hydrocyclone thickeners, pos. 26. Sand of this cyclone goes to high gradient magnetic separator, pos. 19, and overflow in lagoon together with hydro-cyclone overflow, pos. 12. The sand of classifier, class -0.6 + 0.05 mm, goes by gravity to the basket of centrifugal pumps (pos. 15). Pump is conveyed the material in the "silencer" (pos. 16), which is the point of joining material from separation and material from grinding, which is delivered by pump (pos. 8M). From there, the material goes by gravity in hydrosizer (pos. 17). Hydrosizer role is to classify the material into classes of 0.6 mm + 0.4 mm; -0.5 + 0.05 mm and -0.05 mm + 0 with the aid of water under constant hydrostatic pressure that comes from the reservoir supplying the whole process by water (pos. 28). In the first chamber of hydrosizer, the separated class -0.6 + 0.4, mm which falls by gravity onto conveyor belt (pos.16), continues into its concrete boxing. Class -0.05 +0 mm from hydrosizer goes into t collector and after that into pump, pos. 25. Class -0.4 + 0.05 mm from hydrosizer comes by gravity into electromagnetic separator (pos. 17). Here, magnetic fraction is obtained, which falls by gravity onto conveyor belt (pos. 18) which brings this material on concrete dump. Non-magnetic fraction goes into the basket pump (pos. 21) which has two outputs with valves:

A variant: Allows the material to be sent to the hydrocyclone pos. 22. Dressing of hydrocyclone, pos. 22, goes by gravity to the basket pump, pos. 15. Sand of hydrocyclone, pos. 22, goes to the plan filter (pos. 23). The role of plan filter is that the material is so concentrated that the product has a moisture around 6%. Filtered quartz sand filter with a plan comes flowing by gravity onto conveyor belt (pos. 24) which does the storage of filtered quartz sand into position. This is the final product (-0.4 ± 0.05 mm) which is used for water glass.

B variant: Makes possible that material by pump pos. 21 is sent to the hydrocyclone pos. 27 which is located on an open landfill on the tower height of about 10 meters. Hydrocyclone has four output cones and comes to form the four cone landfills of final product - sand of hydrocyclone - class -0.4 + 0.05 mm. The moisture of such disposed products after natural squeezing is about 12%. Overflow of this hydrocyclone goes into collector pipe and into recycle pump, pos. 15. Thus, leaving hydrocyclone overflow, pos. 12, and hydrocyclone overflow, pos. 26, in the lagoon. Two pipelines, connected merge into one, and finally sets a flexible hose that allows maneuvering in filling the lagoon with this material. The overflow water from lagoon moves in the water catchment from which pump, pos. 29, supplies water to the entire process. Pump, pos. 29, puts water in water tank, pos. 28. Tank (pos. 28) is at the required height that allows the constant pressure required to operate hydrosizer. Sprayers of the sieve, pos. 5, pos. 9 and pos. 7M, are supplied with water from the pipe pumps 29. Water pump equipment for sealing the pumps is supplied with water from the reservoir 28. For thickening material that enters the lagoon from time to time and, if necessary, the flocculent A1 is used. This flocculent is in the powder state and for preparation and mixing with water is performed in special stirrers, located at the required height in order to be performed in the same dosage at the exit piping that goes to the lagoon. From the process of quartz sand separation, most of the range larger than 0.6 mm goes to grinding to obtain class 0 + -0.6 mm, which returns to the process of separation in order to increase the content of class -0.4 + 0.05 mm.

Description of Grinding Scheme

The classes -15 + 4 mm, -4 + 2 mm, -2 + 0.6 mm and 0.6 + 0.4 mm are separated from separation process and go on grinding. It is also expected that after the control sieving in the rotary sieve (pos. 7M), the oversize -2 + 0.6 mm goes on grinding. After working a few hours of separation and creation of an initial stock of materials that are intended for grinding, the process of grinding is carried out. These assortments are dosed in a loader carrying a metal basket (pos. 1 M) which is located on the line for grinding. Below trash feeder (pos. 2M), t this material is metered onto a conveyor belt (pos. 3M), which carries the same into the mill with metal balls and rubber linings (pos. 4M). Selection of this mill was carried out to achieve the required amount of class -0.4 + 0.05 mm, which will then be treated to a high-intensity electromagnetic separator by wet procedure. Fresh water from the reservoir (pos. 28) is added into the mill relationships to achieve solid-liquid T: T = 1: 1. The ground material comes into the basket of pump (pos. 5M), which sends it to the hydrocyclone (pos. 6M). Sand of hydrocyclone goes by gravity in the rotary sieve, diameter 0.6 mm (pos. 7M). Dressing of this hydrocyclone (water) goes to the basket pump (pos. 8M). On a rotary sieve, a control sieving of material is carried out in order to obtain the upper limit of size of the final grinding product of 0.6 mm. Therefore, the adequate net is put on mesh that makes access to some class -0.6 mm. At the rotary sieve, the fresh water is fed from the , pos. 28 Sieving material goes by gravity to the basket pump (pos. 8M), which is transported the same into silencer located in the separation, pos. 16. It is the connection point of material from grinding and separation.

CONCLUSION

Tests have shown that from the raw material of quartz from deposit “Bijela Stijena - Skočić”, the grain size can be obtained for water glass, i.e. fraction -0.4 mm + 0.05. The content of this class in the initial sample was 24.34%. It is necessary to comminute larger classes in the ball mill to this fineness. The necessary quality requirements for the range of water glass are that the content of Fe_2O_3 does not exceed 0.04%. Chemical analyses of the starting sample, used in these tests, have showed Fe_2O_3 content of 0.131%. Product -0.4 + 0.1 mm, obtained after washing and grading, has content of 0.075% Fe_2O_3. However, after magnetic concentration of this product, Fe_2O_3 content is reduced to 0.038%, which meets the conditions required by the manufacturer of water glass. Based on these results, the scheme of valorisation the quartz raw materials from deposits “Bijela Stijena - Skočić” is designed, which is given in the paper.

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ECOLOGICAL AND TECHNICAL - TECHNOLOGICAL RECONSTRUCTIONS AND THEIR EFFECT ON THE EFFICIENCY OF ENTERPRISE

Abstract

Under the influence of technical progress, the radical changes are brought in the technical-technological and socio-economic systems. Technical progress, which has a universal characteristic of diffusion, does not any of areas of economic and social activities. This dual effect of technical progress manifests itself in affirmation the new products, new technologies, new knowledge and simultaneous devaluation the existing products, technology, skills. The task of dynamically sustainable development is, actually, to reconcile what is irreconcilable. In this affirmation and devaluation under the influence of technical progress, the advent of ecological principles receives a special importance. Simply put, with every technical and technological change, it is easier and more effective to incorporate the environmental requirements in it which means that the efficiency of output and its quality will be dominant in relation to the previous level of output regardless the quantity and value of resources consumed and engaged workforce.

Keywords: *technology process, environmental technologies, profitability, relative efficiency*

1 INTRODUCTION

Since the end of the eighteenth century to the second half of the twentieth century there was no comprehensive theoretical concept which specifically dealt with the environmental problems and consequences of economic and overall social development and a need for this was necessarily imposed together with the processes of industrial growth and its impact on the balance in nature. The second half of the twentieth century is characterized by the problem of pollution, but also the problem of environmental protection. Technological innovations in the field of traffic, chemical industry, energy, raw material processing, etc., became evident through the advent of the economic theory of mass production. Access to this theory led to the above average use and exploitation of natural resources and to the increased environmental degradation.

In different countries, the challenges for violation of environment are mostly economic in nature, which means that the need to address them is in accordance with the logic that the goal of human community is organization and economic formulation the desired output, because the economic development is based on growth and its maintenance. It is necessary to change the human morality within the community structure and to give absolute

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political support to the environmental movement. The moral way of thinking at the moment is opposite to the profitable way, but political decisions and institutions are obliged to reconcile and harmonize these two irreconcilable approaches. The way out is seen in affirmation a higher degree of knowledge and in recognition the new dominant technologies.

In this paper, the assumption was that the permanently sustainable development means a transition from classical market economy to the environmental economy because market economy encourages the irrational use of resources, considering natural resources unlimited and free. The concept of continuous, dynamic - sustainable development will be considered as a continuous use of limited energy sources, resources, and limited space for development the economic goods production.

2 VERIFICATION OF THEORETICAL VIEWS ON THE EFFECTIVENESS OF ENVIRONMENTAL TECHNOLOGIES AND TECHNICAL RECONSTRUCTION ON AN PRACTICAL EXAMPLE OF THE "X" COMPANY

In particular a company that exists with specific technological setting and specific product range has noticed that its competitive position is becoming weak, and that the geographic spatial horizons are narrowing. Empirical data show that the implementation of the plan as the only mechanism for resource allocation is practically impossible at the current level of scientific and technological development from the postion of realistically foreseeable future, and nor will it be possible even in the near future. [1]

There is a twofold approach to the resource exploitation. On one side is globalization, which is realized through the process of approaching the centers of origin of raw materials and centers of energy sources, and on the other side, those that proclaim this kind of globalization imlement the process of storing and saving of resources in their own geographical spatial environment. [4]

To that end, the company management was in a dilemma whether to undertake the completely new investment activities through purchase of new technological equipment and the shift in product mix, to perform certain rationalization in terms of maintaining operational readiness of business and technological equipment, or to perform a reconstruction of the existing capacity in terms of their narrowing or extension, etc. It means that a number of alternative solutions were available to the management of the company. From the position of the ethical approach, the changes in terms of pollution the natural environment emerged as an extremely complex task, which may not be obvious at first glance. [5]

Control as an instrument that should ensure compliance with standards and regulations, receives a significant role in relation to companies that are emitters of pollution. [2]

Bearing in mind the possibility of reaction and the freedom of choice, the company decided to replace certain product lines in the following way: in a certain number of production lines the existing equipment would be kept but fully amortized, while a part of the equipment in the existing production lines would be replaced with new highly productive and ecological standard quality lines.

3 ECONOMIC EVALUATION THE INVESTMENTS INTO EQUIPMENT OF ENVIRONMENTAL TYPE

In order to analyze the efficiency assessment of investments into environmental equipment, it is primarily necessary to make an information base of investment through creation the review of financial flows of the investment project in the period of the so-called economic life of the investment project. [3]

The average life of amortization of fixed assets after completion of the investment for purchase the technological equipment of ecological type is 8.26 years, or, rounded, 8 years, which represents an average economic life of the investment project.

a. Calculation the Rest of the Investment Project of Reconstruction

Table 1 *Calculation the rest of the investment project*

Ser. no.	Description	Basis for calculation	Average annual rate	Annual depreciation	Life-time	Total	Residual value
1.	Technol. equipment for production	1,544,455	1.,5	193,057	8	1,544,455	0
2.	Supporting technol. equipment	296,235	10	29,623	8	236,984	59,251
	Total:	1,840,690	xx	222,680	xx	1,781,439	59,251
3.	Permanent current assets	-	-	-	-	-	100,000
	Total:	xx	xx	xx	xx	xx	159,251

The accounts of liquidity of the investment project show whether the effects of the envisaged investments will be sufficient to cover all expenditures which will be included in the investment project in its economic lifetime, where the liquidity criterion requires that the so-called "net proceeds" should be greater than zero or, at worst, equal to zero in order to measure whether the economic assessment of the investment is positive.

In order to determine in this particular case whether the project is liquid in certain years of its economic life, the calculation of "Financial Progress of the Project" is given hereinafter.

b. Assessment the Profitability of the Investment Project of Reconstruction

One of the most important sources of information about the possibility of evaluation the profitability of the investment project is called "Economic Progress of the Project."

For assessing profitability of the investment project in this programme, the dynamic analysis was used with the following methods:

1. method of investment payback period,
2. method of the net present value of the investment project ,
3. the methods of internal of internal profitability rate of the investment project.

Table 2. *Economic progress of the project*

CALCULATION OF ECONOMIC PROGRESS OF THE PROJECT (in RSD 000)									
STRUCTURE	DURATION OF THE PROJECT EXPRESSED IN YEARS								
	2003	2004	2005	2006	2007	2008	2009	2010	2011
I. GAINS – TOTAL INCOME	-	5,003,657	5,003,657	5,003,657	5,003,657	5,003,657	5,003,657	5,003,657	5,003,657
RESIDUAL VALUE OF THE PROJECT	-	-	-	-	-	-	-	-	159,251
-TOTAL GAINS	-	5,003,657	5,003,657	5,003,657	5,003,657	5,003,657	5,003,657	5,003,657	5,162,908
II. EXPENSES - INVESTM. IN FIX. ASSETS	1.840.690	-	-	-	-	-	-	-	-
INVESTMENTS IN TOS	100.000	-	-	-	-	-	-	-	-
CONTRIBUTION TO ENERGETICS	110.442	-	-	-	-	-	-	-	-
MATERIAL COSTS	-	2,973,510	2,973,510	2,973,510	2,973,510	2,973,510	2,973,510	2,973,510	2,973,510
LIABILITY FROM INCOME	-	222,779	222,779	222,779	222,779	222,779	222,779	222,779	222,779
GROSS INCOME	-	1,303,712	1,303,712	1,303,712	1,303,712	1,303,712	1,303,712	1,303,712	1,303,712
SHARED SPENDING	-	41,585	41,585	41,585	41,585	41,585	41,585	41,585	41,585
RESERVES	-	72,299	72,299	72,299	72,299	72,299	72,299	72,299	72,299
LIABILITIES FROM BUSI-NESS FUND	-	28,412	33,410	38,412	43,420	47,752	52,748	57,570	62,223
TOTAL COSTS:	2.051.132	4,642,297	4,647,295	4,622,297	4,657,305	4,661,637	4,666,633	4,671,455	4,676,108
III. NET GAINS	-2.051.132	+361,360	356,362	+351,330	+346,352	+342,020	+337,024	+332,202	+486,800

c. Calculation the Investment Payback Period

For calculation the investment payback period serves the following formula:

i = OTI i = i = O NP i

$$\sum_{i=0}^{n} TI_i = \sum_{i=0}^{tp} NT_i$$

wherefrom it follows that:

TI = investments in the first year

NT_i = net income in the first year of the project operation

n = number of years in the project life

tp = payback period of the investment

tm = duration of the project

Table 3 *Payback period of investments*

Year in the project life	Investment		Net gains		Uncovered part of investment
	Annual amount	Cumulative	Annual amount	Cumulative	
0	-2,051,132	-2,051,132	+	-	2-051,132
1		-2,051,132	+ 361,360	+ 361,360	- 1,689,772
2		-2,051,132	+ 356,362	+ 717,722	-1,333,410
3		-2,051,132	+ 251,360	+ 1069,082	- 982,050
4		-2,051,132	+ 346,352	+ 1415,434	- 635,698
5		-2,051,132	+ 342,020	+ 1757,454	-293,678
6		-2,051,132	+ 337,024	+ 2094,478	+ 43,346

Payback period (tp) is rounded to 6 years and several months. Project duration (tm) is rounded to 8 years.

tp <tm = which means that return of the investments requires less time than the maximum set time limit (average economic life), and thus, the investment project is acceptable for the investors.

d. Calculation the Present Value of the Investment in the Process of Reconstruction

The following formula serves for calculation the present value of the investment project:

$$So = \sum_{i=0}^{n} \frac{NPi}{(1+\frac{P}{100})^{i}}$$

wherefrom it follows that:

So - present value of the investment project,

NP_i - net gains during the eonomic life of the project in the first year, when I = 0 ... n

P - individual discount rate that reflects time preferences of the company

4 DETERMINING THE DISCOUNT RATE

Following the usual practice, the average discount rate, derived from the different or same interest rates on loans (real interest rates), is taken for determining a discount rate when calculating the present value of an investment project. [3] Since the sources of financing the investment provides for the use of financial loans (domestic sources) with different interest rates, it is necessary to find the average interest rate (real) which will be equal to the discount rate, according to the following formula.

$$P = \frac{\sum_{m=A}^{K} Kmxkm}{\sum_{m=A}^{K} km}$$

Table 4 *Parameters of discouont rate*

in RSD 000.

Loan label	Loan amount	Real interest rate	Loan amount multiplied with interest rate (Km · km)
A	250,000	0	
B	250,000	12%	3,000,000
Total	500,000	-	3,000,000

$$P = \frac{3{,}000{,}000}{500{,}000} = 6\%$$

Therefore, the average real interest rate in this case amounts to 6%, which will represent the discount rate as well.

However, as stated, the average real interest rate is lower than the predicted minimum prescribed discount rate of 8%, but in terms of a common methodology for assessing the social and economic feasibility of investments and investment efficiency, the discount rate will be 8%.

4.1 Determining the Present Value of Anticipated Reconstruction

Table 5 *Results of the present value*

In 000 din.

Year in a life of the project	Net gains NP*i*	Discount factor with discount rate 8%	NP*i* x 8%.
0	-2,051,132	1.0000	-2,051,132
1	+361,360	0.9259	+334,583
2	+356,362	0.8573	+305,509
3	+351,360	0.7938	+278,910
4	+346,352	0.7350	+254,569
5	+342,020	0.6806	+232,779
6	+337,024	0.6302	+212,393
7	+332,202	0.5835	+193,840
8	+486,800[x)]	0.5403	263,018
Total:	xx	xx	+24,469

The stated amount of 486,800/millions include the amortized cost of an investment project of RSD 159,251/million dinar.

So = Therefore, the present value of the investment project amounts to 24.469 million dinar, which means that, with the aforementioned increase, this project will contribute to the increase in the amount of material base of the investor during its economic life, and given that the present value of the project is larger than 0, this project is acceptable for the investors.

4.2 Calculation the Internal Profitability Rate of Anticipated Reconstruction

For calculation the internal profitability rate of the investment project the following formula was used:

$$0 = \sum_{i=0}^{v} \frac{NPi}{(1+\frac{:P}{100})^1}$$

wherefrom it follows that:

NPI = net gains in the first year of the economic life when I=0 ... n

P = individual discount rate, which reduces the present project value to 0. It represents an internal profitability rate

n = years of the project life, a n = 0 ... t.

Table 6 *Confidence intervals in terms of net present value*

Finding intervals for (±)

Years	Net gains	Discount factor with 8%	Discount factor with 8.50%	Present value 8%	Present value 8.50%
0	-2,051,132	1.0000	1.0000	-2,051,132	-1,051,132
1	+361,360	0.9259	0.9216	+334,583	+333,029
2	+356,362	0.8573	0.8494	+305,509	+302,694
3	+351,360	0.7938	0.7829	+278,910	+275,080
4	+346,352	0.7350	0.7216	+254,569	+249,928
5	+342,020	0.6806	0.6650	+232,779	+227,443
6	+337,024	0.6302	0.5129	+212,393	+206,562
7	+332,202	0.5835	0.5649	+193,840	+187,661
8	+486,800	0.5403	0.5206	+263,018	+253,428
Total	xx	xx	xx	+24,469	-15,307

Thus, it follows from the abovestated that

1. present value with the discount rate of 8% is +24,469
2. latest present value with a positive balance and with a discount rate of 8% is +24,469
3. first present value with a negative balance and discount rate of 8, 5% is -15.307

In order to determine the exact internal profitability rate of this investment project, in continuation of this programme is the calculation of these rates through interpolation and using the following formula:

$$p^r = P_p + \frac{Sop(Pn - Pp)}{So^p - So^n}$$

p^r = internal profitability rate

P_p = discount rate with which the present value is positive for the last time

Pn = discount rate with which the present value of the project is negative for the first time

So^P = present value of the project with the discount rate Po

So^n = present value of the project with the discount rate Pn

Calculation:

$$p^r = 8\% \frac{24{,}469(8.5-8)}{24{,}469(-15{,}307)} =$$

$$= \frac{12{,}234{,}500}{39{,}776} = 0.31 = 8 + 0.31 = 8.31\%$$

Therefore, the internal profitability rate of this project is 8.31%

4.3 Indicators of Relative Efficiency

4.3.1 Calculation the Present Value of the Investment Project Costs

Table 7 *Present value as an idicator of relative efficiency*

Year in a project life	Net expenditures	Discount factor with discount rate of 8%	NP*i* x 8%.
0	2,051,132	1.0000	2,051,132
1	4,642,297	0.9259	4,298,303
2	4,647,285	0.8573	3,984,126
3	4,652,297	0.7938	3,692,993
4	4,657,305	0.7350	3,423,119
5	4,661,637	0.6806	3,172,710
6	4,666,633	0.6302	2,940,912
7	4,671,455	0.5835	2,725,794
8	4,676,108	0.5403	2,526,501
Total:	xx	xx	28,815,590

4.3.2 *Calculation the Relative Efficiency*

Table 8 *Relative efficiency of the investment project*

Item	Item size
Present value of the project (So)	24,469
Present value of the investments (Ui)	2,051,132
Present value of expenditures (I)	28,815,590
Number of workers (N)	-

a. Indicator the relative efficiency of the project in relation to the total investment

$$e^n = \frac{So}{Ui} = \frac{24{,}469}{2{,}051{,}132} = 0.01$$

b. Indicator the relative efficiency of the project in relation to the expenditures during its life

$$e^i = \frac{So}{} = \frac{24{,}469}{28{,}815{,}590} = 0.0008$$

c. Indicator the relative efficiency of the project in relation to the number of workers

Procurement of highly productive technological equipment for the same or increased level of production, reduces the number of workers by eight.

5 SUMMARY

On the basis of the calculation of the payback period, the current values of the investment project, internal rates of profitabiliy as well as the indicators of relative efficiency, the following conclusions can be drawn:

The payback period of the investment in the project is 6 years, which is shorter than the maximum time limit (economic life of the project) of 8 years.

The present value of positive net income is greater than the negative expenditures by 24.469 dinar. Therefore, the project is acceptable, given that the present value is greater than 0.

The discount rate is 8%.

5.1 Additional Criteria for Evaluating the Social Contribution

a. Effect on Employment

In the previous chapters it was pointed out that the purchase of a highly productive technological equipment, which will largely replace the completely obsolete and dilapidated equipment, carries a message of the increased volume of production with fewer workers.

After completion of the investments and putting the new machines and equipment into regular operation from 1 January 2003, 8 skilled workers will be removed from the production process, and deployed to other manufacturing jobs within the enterprise.

In addition to savings in energy, achieving increased production with fewer workers will also have the economic effects on total accumulation after the investment.

b. Impact on Balance of Payment

Out of the total projected amount of income for the increased volume of production, it can be seen that the investors anticipate export of their products to the convertible markets, and in this respect they anticipate a significant foreign exchange effect.

Accordingly, this investment project has a very positive impact on the balance of payments, since in the course of its economic life of 8 years, it will receive DM 20,921,056 from the convertible market, and $ 4,656,000 from the other markets.

c. Impact on Technical-Technological Level of Society

According to the technological project, which is an integral part of the programme, there is a plan for procurement the modern equipment, with strong ecological characteristics and quality standards. It has a major impact on improving the organization of work and acquiring even better work habits of the employees.

Such impacts of the project have a positive influence on the level of the overall technical and technological modernity of wider community.

In the executed calculations, it was determined that if the environmental technologies meet the prerequisites and laws of the market from the perspctive of economics, despite the fact that they initially require the increased resources of investment, they can show their dominance over at first sight cheaper technology and less investment. It will be shown that, in essence, the environmental requirements are economic assumptions, which can realize their very successful evaluation in the market through the so-called value chain.

6 CONCLUSION

The usability of economic instruments to protect the natural environment is fairly limited due to an extremely large number of different factors. These factors are not only and exclusievely found in the rigidity of behavior the state bureaucracy accustomed to managing through mandatory regulations, or in the fact that most members of the government authorities responsible for the implementation of environmental protection are non-economists who, the advocates of economic and market instruments prefer to identify as the main reasons for their previous poor implementation, but also, and foremost, they are found in the objective existence of a series of problems of an economic, technical and environmental nature that occur when it is tried to implement in practice the economic instruments for protection the natural environment.

The main economic technical problem occurs in identification of contaminants. Who has to pay a penalty or tax for an in creased concentration of harmful substances in the air or in a local river, for instance, in circumstances where there are multiple potential causes? This is a question that is still impossible to answer precisely. Due to this fact, the problem of ecology is, the first of all, a global problem, and then individual. Individual problems can be easily observed, troubleshot, affected and their behavior can be controlled. The global problems, the problems in the environment, always come after the facts and are manifested in the longer time perspective. Individual ecological performances are environmentally ex ante moves or a reaction before a fact. The author of this study proved this with the project that he implemented.

The problem becomes particularly acute when there is a small number of major pollutants and when the use of economic instruments of protection may appear as completely counterproductive. Then the application of environmental taxes can lead not to a decrease but to an increase in pollution, while the introduction of tradable permits may appear as negative from the standpoint of development a competition in the market, due to the fact that then appears the phenomenon of discriminatory nature for all potential new entrants in a given production process who initially do not have the already distributed emission quotas of permitted pollution.

It follows that permitted pollution arises as the main problem, since the environmental duties and understandable rights, as two basic types of economic and market instruments of protection, may be used only in cases of permitted pollution tolerance. Apart from this standpoint that the certain environmental requirements should be respected, there are also problems related to the existence of spatial and temporal imbalances in emitting pollution. The problem of introduction the economic instruments of protection occurs in all cases where pollution is territorially limited, and when it is concentrated at the certain peak hours. In the first case, the use of these instruments is practically impossible due to too narrow market of potential pollutants, and in the second, due to the lack of any possibility that their use will prevent exceeding the permitted quoata of pollution in a specific environment at certain parts of day or year. Are the earth, water and air public goods? Issuers of pollution are exactly oriented towards this holy trinity of environmental protection. If this trinity would were threatened, it would not be written about these problems.

Modern demands for a greater market measure of the environment protection, which are generally accompanied by controversy at the expense of large inefficiencies of previous reliance of the state on imperative regulation measures in the form of prohibitions, regulations, technical standards and norms, appear as misplaced. This, however, does not mean that the measures and instruments of economy should not be nurtured where possible. The same is applied for government regulations, processes and procedures that are aimed to the environment preservation.

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ADVANTAGES OF IMPLEMENTATION THE PROCESS MODEL FOR SUSTAINABLE BUSINESS OPERATIONS OF MINING COMPANIES[***]

Abstract

Process approach is the basic element for integration the all similar requirements of the integrated management system (ISM) standard and stakeholders.

Previous studies have shown that the process model of the ISM is the most represented in the Serbian companies. Implementation of the process model in mining company improves the company performances.

This work analyzes the most important advantages achieved in implementation the process model and the appropriate criteria are defined for their evaluation. The AHP method was used to evaluate the advantages of process model. The results differentiate the most important advantages of the process model achieved by sustainable business operations of mining companies on the basis of competitiveness based on eco-innovations.

***Keywords**: process model, sustainable business operation, AHP method*

INTRODUCTION

According to definition of the standard ISO 9000, the process is a set of interrelated or interacting activities that transform inputs into outputs (SRPS ISO 9000:2008). Each interrelated mining activity in a sustainable business operation that transforms inputs into outputs is seen as a process with the aim of creating the value for customer. It is common in the mining processes that the output elements from one process (excavation) present the input elements (drilling) of the following processes. The process approach is when these actions and the related necessary resources are managed as a process. As the mining company would be able to satisfy the customer demands, they should be analyzed and to recognize and establish each process. Management of the mining company is aimed to operate responsibly so that the processes should have the "owners" of process or persons who are responsible for these processes.

Process approach is the basis of implementation the integrated management system or management standards. The need for more efficient management by simplifying the job (quality control) and development of information technologies have shaped the

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process approach. The essence of the process model is to improve the way of sustainable business, to make more efficient and effective the overall business. To introduce a business that suits satisfying the requirements of stakeholders, a business that corresponds to the modern trends, the modern management business.

Modern management is a quality management, identification and understanding the process. Therefore, the mining companies need to establish a catalog of the process where the reciprocal links of each process are established with related resources and other processes. Management of mining company has to make the Matrix of responsibilities of each organizational unit for given processes where the owners of these processes are pre-determined.

The purpose of process approach is improvement and optimization of sustainable business in order to obtain the best possible result with minimum investment of resources

The process model is the basic element of integration the all requirements of IMS and all interested parties (stakeholders). The process approach represents an important new management approach due to the integration of identical and specific requirements of standard and interested parties. The similarity in context of the standards ISO 9001, ISO 14001, OHSAS 18001 and ISO 2200 indicate the integration of standards in the aim of customer satisfaction, what is the essence of the process model.

ISO 9001 Quality Management System (QMS) is the "core of integration." QMS does not include the specific requirements of the other standards but already has the ability to connect with its quality system the requirements with the other systems that are similar. Quality management system focuses on providing the quality results to satisfy the needs of interested parties which have similarities with the other integrated standards.

As it is shown in Figure 1, the inpu elements arise from the user requirements. During realization of the product, the permanent measurements, analyses and improvement of the product quality are made with the management of resources. For continuous improvements of the quality management system, a responsible person is the leader of management according to the new standard ISO 9001:2015 as to improve the user requirements.

Trends of modern management follow the PDCA (Plan, Do, Check, Act, Approach) cycle:

Plan: establish the objectives and processes necessary to deliver the results in accordance with the customer requirements, purpose and established strategy of organization.

Do: apply the processes related to the customer requirements.

Check: Supervise, measure the processes and products according to demand and objectives of the company, a permanent presentation of the results

Work (improve): follow the actions for continuous process improvement.

The existence of a clear and precise process model is a prerequisite for effective implementation of requirements of the new organizational - management standards and establishment of an integrated management system [2]. Implementation of the process model identifies: constant improvement of processes based on objective measurement, measurement the process performances, needs of process consideration with added value and increase the satisfaction of stakeholders [3]. Principles for access to the process model are explained in the work paper "Process Model for Sustainable Business of Mining Companies" [4].

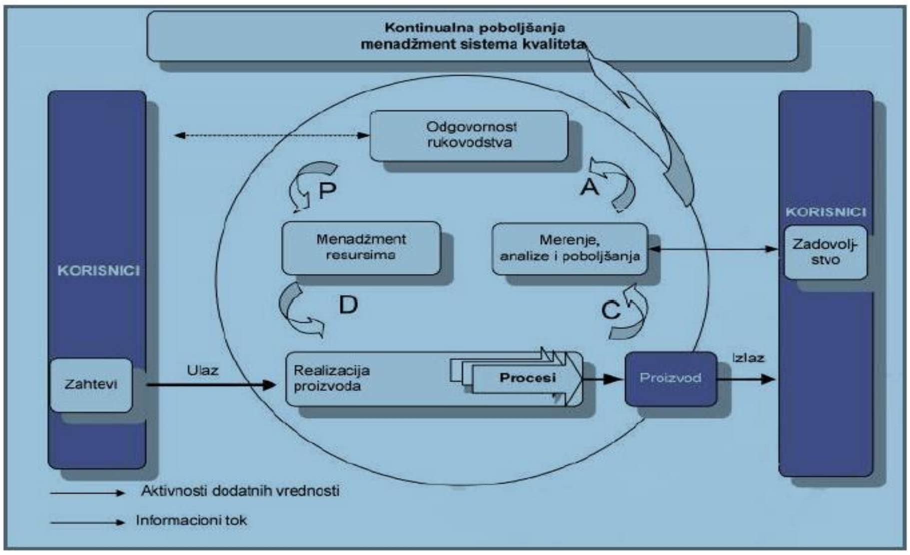

Figure 1 *Model of quality management system based on processes [1]*

The aim of work is to differentiate the most important benefits by implementation the process models, to evaluate in relation to the defined criteria using the AHP (Analytical Hierarchy Process) method. Assessment the benefits by the multi-criteria analysis for sustainable operations of mining companies shows where the company will be positioned for several years, the performances, profit, cost, maximizing the product quality, and the most important - the customer satisfaction.

BENEFITS OF IMPLEMENTATION THE PROCESS MODEL

Studies show that the representation of the process model is 96.23% in our companies. ISO 9001:2015, which should be valid from 15th September 2018, represents highlighting of the process model.

The process model has its own characteristics which are reflected through application the process approach. It integrates N system and QMS, EMS System (environment protection system), OHSAS (health and safety system) and HACCP (food safety system). The essence of these standards is in management of processes.

The most important advantages of the process model in sustainable business operation of mining companies are:

- **Effective external and internal communication (Alternative 1)** - Process model enables to the mining companies to effectively communicate with customers and in terms of:
  - Information on services and product,
  - Contract and order replacements,
  - Feedback on services and product including complaints and appeals.

Managers and leaders of the mining companies are required to establish an appropriate communication process within the business at the level of effectiveness the quality management system.

- **Providing the resources (Alternative 2)** - Process approach allows the company to provide the necessary resources that are required: for continuous improvement, implementation, es tablishment and maintenance the management system.

- **Improvement of performances in the planning and management processes (Alternative 3)** - Process model enables the company to plan and manage the processes in relation to determination the requirements of products and services. The focus is on increasing the customer satisfaction and improvement the performances of the company in order to support sustainable business operations of mining companies.
- **Effective implementation the changes and additions to ISM (Alternative 4)** -Process approach enables the mining companies, due to their specific activities and improvement the green economy and clean production processes, to efficiently and, as required by the interested parties, to make changes and additions of ISM.
- **Lower costs (Alternative 5)** – By implementation the process model, the mining companies plan the processes, apply processes as to respond to the user requirements, check the processes and constantly present the results and improve processes by reducing the costs of products and services.
- **Monitoring and process measurement (Alternative 6)** - Process approach allows continuous monitoring and process measurement, and this is the primary for the mining company. Accordingly, the specific requirements of standard are confirmed as well as the specific user requirements. The process assessment by this alternative runs the company to the sustainable development.
- **Monitoring the overall business (Alternative 7)** - Process model of the mining companies enables monitoring the overall business, what gives the guidance to the company. With this approach, monitoring the overall business as an integrated system of the process in which all segments of the organization process (development, procurement, production preparation, production, sales, marketing) function as a whole (integrated) system. So, to yield the efficient and effective organization that functions as a mechanism.

DEFINING THE CRITERIA FOR EVALUATION THE BENEFITS

The alternatives are evaluated by the criteria and they are the most important in the process of multi-criteria decision-making.

Positioning (Criterion C1). This criterion plays an important role in evaluation of the process model implementation (PM). By implementation, PM comes to better positioning of the mining company.

Profit (Criterion C2) - Process model ISM is in the focus of satisfaction the customer, stakeholders and for profit, so that this criterion has great influence on the process model advantages. Profit or gain for all stakeholders is the highest priority. Realizing the profit, all users and stakeholders become satisfied and mining organizations are sustainable.

User satisfaction (Criterion C3): Every organization depends on satisfaction of its users. Therefore, the organization is forced to have perception for their current and future needs. Constant monitoring of customer requirements, overcoming the expectations of users and improving the business practices is the easiest way to the sustainability of the mining company.

Maximizing the quality of products and services (Criterion C4): This criterion brings maximizing the quality of products and services what increase the customer satisfaction.

The involvement of employees (Criterion C5): The organization must include the employees for effective implementation the quality management system, implementation the operational activity of the process and determining the compliance of products and services. The employees are part of an organization where they meet and integrate with organization. It is important to develop a working environment and evaluate the knowledge, behavior and skills.

Cost reduction (Criterion C6): Cost reduction as a criterion is very important for the company survival, its growth, development and improvement of the quality management system.

Risk Reduction (Criterion C7): Risk reduction criterion is of particular importance for sustainable operations of the mining companies. By risk reduction, the negative effects are prevented, the results of business are improved and the effectiveness of the quality management system increases.

Applicability of the process model (Criterion C8): ISO Standard 9001:2015 supports the process model. Mining companies have complex processes so that the process model is the optimal model [5].

RESULT OF SELECTION THE PM ADVANTAGES

Over time, the multi-criteria decision-making methods MCDM were applied to solve a lot of problems [6]. They have this ability to rank the alternatives based on a predefined set of specific criteria that are conflict [7]. For ranking of alternatives, the AHP method is applied whose creator Thomas Saaty, which "represents a powerful tool of leaders (decision makers) where more alternative solutions" are offered [8], and the software Criterium Decision Plus was used for calculation.

Later works with the applied AHP method are: Selection of an optimal model of ISM of the mining companies [5], ranking the indicators of sustainability for decision making in the mining companies [9], evaluation and selection of personnel using the MCDM method [10], management model of investment projects for opening the coal open pits [11] and others.

In this method, the first step is to define the multi-dimensional hierarchical structure of objectives, criteria and alternatives in Figure 1.

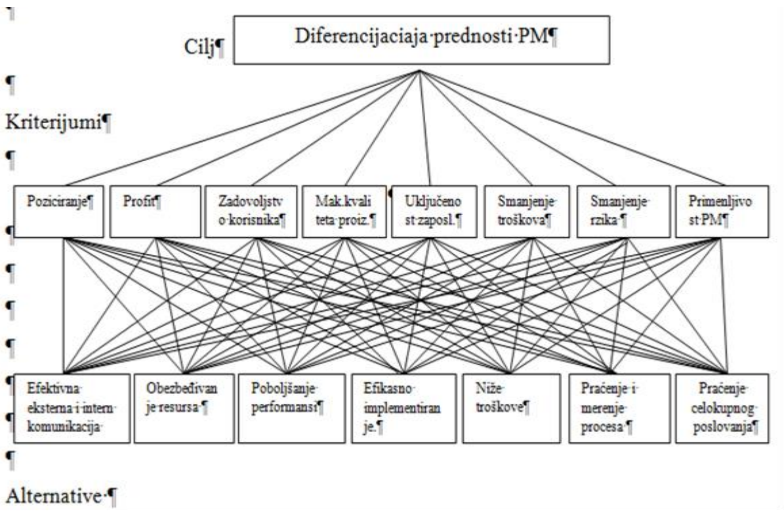

Figure 2 *Structuring an advantage differentiation of the Process Model*

To determine the weighting coefficient of criteria with the help of comparison scale, given in Table 1. Tables 2 and 3 show the comparison results.

Table 1 *Comparing scale of decision elements*

Dominance	
Description	**Rating**
Equally	1
Poor domination	3
Strong domination	5
Very strong domination	7
Absolute domination	9
2, 4, 6, 8 are intermediate value	

Table 2 *Defining of weighting coefficient criteria*

Criteria	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**
C1	1	1/2	3	2	4	1/3	1/2	4
C2		1	2	3	5	1/2	1/2	4
C3			1	2	1/3	1/7	1/7	1/3
C4				1	3	1/2	1/3	1/3
C5					1	1/7	1/7	1/3
C6						1	1	3
C7							1	3
C8								1

Table 3 *Results of weighting coefficient criteria*

Criteria	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**
Weighting coefficients	**0.130**	**0.164**	**0.045**	**0.061**	**0.040**	**0.241**	**0.234**	**0.084**
Consistency degree	0.097							

Further step of the AHP method is to compare the advantages (alternatives) relative to all eight criteria defined in Tables 5-12.

Table 4 *Comparison of alternatives in relation to criterion C1*

Alternatives	A1	A2	A3	A4	A5	A6	A7
A1	1	1	1/3	5	1/2	1/2	4
A2		1	1/3	7	1	2	6
A3			1	8	1	2	5
A4				1	1/7	1/5	1/5
A5					1	2	1
A6						1	1
A7							1
Consistency degree		0.091					

Table 5 *Comparison of alternatives in relation to criterion C2*

Alternatives	A1	A2	A3	A4	A5	A6	A7
A1	1	2	1/3	3	1/3	1/5	1/2
A2		1	1	3	1/3	1/3	1/2
A3			1	5	1	2	1/4
A4				1	1/5	1/7	1/9
A5					1	1/2	1/3
A6						1	1/2
A7							1
Consistency degree			0.091				

Table 6 *Comparison of alternatives in relation to criterion C3*

Alternatives	A1	A2	A3	A4	A5	A6	A7
A1	1	1	2	2	2	2	1/2
A2		1	1/2	1	1/2	2	1/2
A3			1	3	1/2	1	2
A4				1	1/3	1/3	1/3
A5					1	3	1
A6						1	1
A7							1
Consistency degree			0.093				

Table 7 *Comparison of alternatives in relation to criterion C4*

Alternatives	A1	A2	A3	A4	A5	A6	A7
A1	1	1	1	1/2	2	1	1
A2		1	4	2	3	1/2	1/3
A3			1	1/3	1	1	1/5
A4				1	1	1/3	1/3
A5					1	1/2	1/3
A6						1	1/2
A7							1
Consistency degree			0.095				

Table 8 *Comparison of alternatives in relation to criterion C5*

Alternatives	A1	A2	A3	A4	A5	A6	A7
A1	1	3	2	1/3	3	1	1
A2		1	1/2	1	1/2	1/3	1/3
A3			1	1	1	1/2	1
A4				1	1/2	1	1/2
A5					1	1/2	1/3
A6						1	1
A7							1
Consistency degree			0.095				

Table 9 *Comparison of alternatives in relation to criterion C6*

Alternatives	A1	A2	A3	A4	A5	A6	A7
A1	1	1	1/3	1/2	1/5	1	2
A2		1	1/5	1/4	1/9	1/3	1/3
A3			1	2	1/3	1	1/2
A4				1	1/5	1	1/3
A5					1	5	3
A6						1	1/2
A7							1
Consistency degree		0.091					

Table 10 *Comparison of alternatives in relation to criterion C7*

Alternatives	A1	A2	A3	A4	A5	A6	A7
A1	1	2	1/2	1	1/7	1	1/5
A2		1	1/2	2	1/7	1/5	1/7
A3			1	3	1/5	1/3	1/5
A4				1	1/5	1/3	1/7
A5					1	7	5
A6						1	1/3
A7							1
Consistency degree		0.094					

Table 11 *Comparison of alternatives in relation to criterion C8*

Alternatives	A1	A2	A3	A4	A5	A6	A7
A1	1	1	1	1/2	1/3	1/3	1
A2		1	1	1	1	1	1/4
A3			1	1/3	1	1	1/3
A4				1	1/3	1	1/3
A5					1	3	1/2
A6						1	1/2
A7							1
Consistency degree		0.097					

The obtained results of ranking after calculation are shown in Table 12. The results show that the most important advantages of the procedural model implementation are in the following order: lower costs alternative A5, monitoring the overall business A7, improvement the performances in the planning and management processes alternative A3, monitoring and measuring the process alternatives A6, effective external and internal communication alternative A1, supplying the resources alternatives A2, and in the end the effective implementation of changes and additions of ISM alternative A4.

Table 12 *Final ranking*

Ord. No.	PM advantages per importance	Result
1.	A5 (lower costs)	0.282
2.	A7 (monitoring the overall business)	0.207
3.	A3 (improvement the performances in the planning and management processes)	0.139
4.	A6 (monitoring and measuring the process)	0.127
5.	A1 (effective external and internal communication)	0.097
6.	A2 (supplying the resources)	0.082
7.	A4 (effective implementation of changes and additions of ISM)	0.065

Figure 2 shows the structure of benefit differentiation the implementation of process model with the weighting coefficients obtained in calculation by hierarchy of decision making.

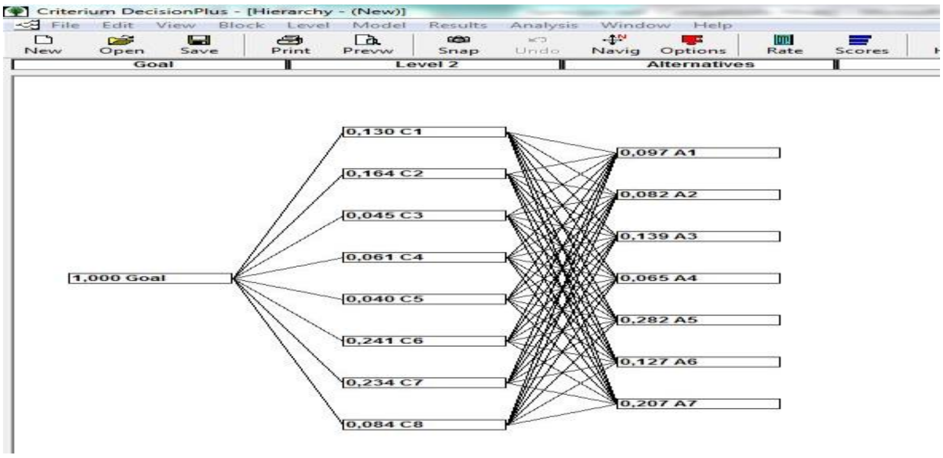

Figure 2 *Results of PM implementation advantages by hierarchy of decision making*

ANALYSIS OF THE OBTAINED RESULTS

Analysis of the results includes eight criteria and their impact on ranking the advantage of implementation the process model, and the advantage (alternative) by importance.

In criteria analyzing, the most important are the weighting coefficients of criteria because it is their measure that affects the results of ranking the alternatives, or advantages of implementation the process model.

Table 3 shows that criteria could be divided into three groups:

- The first group includes the criteria C6 - cost reduction, which has the greatest impact on the results of ranking because its weighting coefficient is 0.241, and criterion C7 - risk reduction with a coefficient of 0.234. Cost reduction affects from 24.1% to the ranking of implementation benefits the process model in relation to the other criteria. While, the criterion of risk reduction affects 23.4%, so that these two criteria have the greatest impact on ranking the PM implementation benefits PM to determine their importance. This analysis shows that ranking the benefits of PM implementation of the mining company is the most important cost reduction and risk reduction what is improved by the company growth and development, reducing the negative effects and improving the effectiveness of the quality management system.

- The second group is generated by two criteria: criterion C1-profit with weighting coefficient of 0.164 which, 16.4% affects the obtained result and criterion C2-positioning, which carries the weighting coefficient of 0.130, so that the result is affected by 13%. The results of ranking the benefits of PM implementation show how important are the criteria profit and positioning for the mining company. Well positioned mining company brings higher profit and vice versa higher profit enables better positioning to the company. So that the PM imple-mentation of the mining company enables improvement the satisfaction of the end user and leads the company to the sustainable business.
- The third group includes: criteria C8 - applicability of the process model with coefficient of 0.084 which affects the result by 8.4%; Criterion C4 - maximization the quality of products and services with the weighting coefficient of 0.061 in affecting the obtained result 6.1%; Criterion C3 - user satisfaction with the weighting coefficient of 0.045 to the obtained result affects 4.5% and criterion C4 - involvement of employees with the weighting coefficient of 0.040, which means that it affects with 4.0% to the ranking of results. This analysis shows that the applicability of the process model for the complex process of mining company with maximizing the quality of products and services in involvement of employees comes to improvement the satisfaction of the end user and all stakeholders.

Analyzing the most important alternative implementation to the process model, it starts from the most important alternative. This is the alternative A5 (lower costs) with the highest value of results 0.282. This alternative is focused on cost reduction of the company. Applying the PDCA cycle: process planning; realization of products; verification and presentation of results and action (improvement) is followed by reduction of total costs.

The second most important is the alternative A7 (monitoring the entire business) which carries the value of results 0.207. By this approach, the managers of the mining company have the ability to monitor the entire business from procurement to sales and marketing as one mechanism that operates efficiently and effectively.

On the third place is the alternative A3 (performance improvement in the planning and management processes) with a degree of consistency 0.139. This alternative refers to the established requirements of products and services and in the focus of increasing the end user satisfaction.

On the fourth place is the alternative A6 (monitoring and measurement of processes) with a degree of consistency 0.127. Monitoring and measurement of processes in the mining company confirms the specific requirements of standard and established requirements of the users.

On the fifth place of the most important advantages of PM is the alternative A1 (effective external and internal communication) which the value of results 0.097.

The alternative 1 enables to the managers of the mining company:

- effective communication with internal and external users about the product and services,
- agreement on contracts and change of order,
- feedback on services and products including the complaints and appeals
- establish the communication within the business at the level of effectiveness the quality management system.

The sixth place is occupied by the alternative A2 (supplying the resources) with a degree of consistency of 0.082. This alternative is aimed, unlike the others, to provide the necessary resources for process development for company to be kept up.

On the seventh place of importance is the alternative A4 (effective implementation of change and addition the ISM-a), which has the value of results of 0.065. The alternative A4, due to the specific activities, green economy, clean production and satisfying the user requirements, enables to the mining company fast and efficient addition and change the ISM.

CONCLUSION

In this work, one of the multicriteria method AHP was applied to rank the benefits of PM by importance with the aim of helping the managers for selecting the optimal model ISM. The process model is supported by the ISO standard 9001:2015, which prompted the authors to analyze its advantages by importance.

Based on calculation by the AHP, the ranked benefits by importance were obtained. Analyzing the benefits resulted into the final ranking: lower costs (Alternative 5) took the first place, the second place was taken by the alternative of monitoring the overall business (Alternative A7), the third place is improvement in the planning and management processes (Alternativa 3), the fourth place is the alternative A6 – monitoring and measuring of processes, and on the fifth place is the Alternative A1 - effective external and internal communication, and on the sixth place is the Alternative A2 – supplying the resources, while the last place is the effective implementation of addition and change the ISM (Alternative A4). It can be concluded from rom this analysis that lower costs and monitoring the overall business are the most important advantages of PM, where the mining companies are run to a competitive advantage. Analyzing the alternatives leads to an interesting conclusion and that all are related and integrated work.

The most influential criteria for complete rankings the PM advantages are: cost reduction (criterion 6) and criterion C7-risk reduction. By identification of these two criteria: cost reduction and risk reduction are crucial in managing the mining companies. These two criteria can help to reduce risk and better strategic development of the company. A well-chosen strategy of the mining companies is the key to the success of the company.

Such made analysis of the implementtation benefits of the process model serve to the managers as an aid to select the optimal form of ISM, to lead the mining company to the increased profit, good ranking, competitive advantage based on eco-innovation, green economy and that all integrated represents an improvement of satisfaction the all stakeholders.

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ECOLOGY, ECONOMY AND TECHNOLOGICAL CHALLENGES OF THE FUTURE

Abstract

Economic development depends on the used technology. Using the new technology should be to create the conditions on possibilities for improvement the working conditions in order to reduce the environmental pollution; the all in order to increase the labor productivity. Dynamic sustainable development implies harmonization of the environmental development with the principles of social justice atin the global international level.

Keywords: *ecology, globalization, knowledge, technology*

INTRODUCTION

Development of science and technical-technological achievements, complexity of work and life processes, demographic growth, increase of uncertainty and risks, as well as tendency to safeguard and increase the achieved, have impacted the man to tend to foresee and master the facts of the future. Different approaches to the future in different time periods refer to different contexts when the thinkers and philosophers lived and worked. Such thinking about the future refers to certain values and there is no such a way of thinking which might be called highly normative exercise.[3]

Only relative ambiguity allows for freedom of choice. There is no freedom of choice under circumstances of absolute organization. Freedom of a being is a knowledge about freedom. To be means to know. Is the level of freedom increased as the cage gets bigger!? Yes and no, but only in sense of space. You are still inside the cage. There is no movement, no communication, no freedom. Openness is a path towards freedom and it does not matter whether it is a door or a window. The most important is that there is a way out! There is always a way out, but it has to be found and it is there that we face the man's greatness of ability to get free from destiny. While running away from destiny, we are actually facing it. While going towards it, we control it, solving and making it desired. Here is substantial difference between organized and unorganized man. Some tend towards the order, whereas the others tend towards the chaos. Only chaos is absolute.

We live in a cyber space. The decisive factor for development the activities leading to creation of cyber concept was a war.[8] One reacts faster under circumstances of war danger. Entropy of human psychology does not tolerate emptiness.

Changing a pattern of values, we are actually attempting to change a system of va-

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lues. By devaluing the old, we are affirming the new. Preconditions for affirmation of progressive achievements are created.

System becomes flexible, since it simply responds to changes and challenges in its environment.

Intellectual climate was conducive the emergence of the economy based on knowledge. Was the knowledge of economy conducive for development of economy based on knowledge?

Let's get back to the main point. There was a directing through sharp semantic barriers between disciplines to build a more efficient interdisciplinary scientific method of managing complex, stochastic systems and development the general theory of management and communication.

1 INFORMATION SOCIETY AND GLOBALIZATION

In relation to the challenges of the future, the cosmological aspect withdraws in front of the anthropological, the man is put in the center of attention, which leads to a shift towards specifically human, psychological and ethical-anthropological issue.

And only when the developed sense of commitment to the future - prognostic-futurological, is caught in the jaws of life with the cosmological approach, reconstructive need will be opened as a necessity, just as the innovative cognitive aspects for defining grandiose visionary as we have felt sometimes in the past and feel now.[5]

It is a process of reshaping the scientific thoughts. The message is to unite knowledge and actions in order to reach the desired future. Even the ancient Greeks were aware of the need for effective strategic management and dealt with anticipation, even through prophecy, with the desire to create a projection about the future of the environment. [3]

Forecasters and futurologists agree that the 21st century will be marked the achieved level and pace of information technology development with the characteristics of universal diffusion, which will inevitably lead to the emergence of a new social structure - the global information society.

The idea of globalization is not verified by any significant and proven experimental conception of historical development. Globalization is the result of forces - powers, which will over time become impotent. There will be a formidable defensive processes.

There will be a reversibility, when we will get things, phenomena and processes back to their original state. Globalization discards uniqueness of civilization development paths, the uniqueness of its experiential, cultural and historical heritage of the total historical heritage.

In their turn, the uniqueness of each civilization development is associated with the peculiarities of formation the leaders and characteristics of educational process, with a help of leaders who bring their ideas to every man.

It seems hardly possible that these characteristics might be globalized now or anytime possible. It is certain that there will be a differentiation of the view on the world, culture, development ... Need to forecast the role of information in development of a society is necessary, both as a factor stimulating development and as a mobilizing force. It is critical that information exchange for the optimal development of the society shall be subjected to management and control. In the basis of the management processes in contemporary circumstances, there is a dominant need to have a new strong educational system, able to absorb, process and distribute the huge volume of information and effectively directs and brings it to the trainee and users in general. In case of absence or unpopularity of some material operation methods in a society, as well as short-term effects of wide range violent methods, information is becoming the dominant means of social influence.

Contrary to the idea of social globalization, the idea of information society does not contradict anything. The concept of globalization is applicable to social processes in general and the information society, in details, as already addressed, is very conditional. However, it does not mean that Information Society is also conditional.[5]

In general, the information society is one of the variants of the society with service technologies, where the gradual transition towards it is one of the characteristics of modern historical epoch.

The question is not in fact, is there a principle possibility of the information society existence? The issue is something else. Does such a society already exist or is it just a feud of future? Information society cannot be founded in rapid information technology development. It would not correspond to the historical development of human society and civilization. Simple exponential growth and development are not possible in social systems. The gradual approach is inevitable. There are no experiments there.

The establishment of a society or changes within it are historical processes came under the influence of numerous factors. The result of these processes is a complex component of certain economic, political and social relations between people. Information technology itself cannot ensure the emergence of such a complex component. It can only create a part of the infrastructure for the information society, an information environment for its formation, development and existence. However, it is too early to speak what it shall mean for a society some time soon. It is only possible with certain scientific accuracy to predict some characteristics of an information society. At the same time, it turns out that the existing information forces analysts to think not only about the benefits of the information society, but also about its shortcomings. The digital Darwinism is about to start.[6]

2 MODERN TECHNOLOGIES FOR ENVIRONMENTAL PROTECTION

Use of modern technology is a crucial prerequisite for addressing the current problems of environmental protection. The main objective is to initially an integrate environmental protection in all stages of the production cycle - from production to waste disposal. This includes, for instance, reduction of hazardous waste already in the production process, increase of the functioning level of invested energy, economized investment of resources, the development of alternative and reserve funds that are environment friendly.

Achieving all this is primarily the task of scientists and engineers in science, in business and in government. They can make their own effect on the environment contribute to this, that the technical and scientific progress is again perceived as something more than just something positive. There is a great opportunity for economy in incoming periods of technical development for environmental protection: creativity, innovation on the edge of new challenges create the new economic and social perspectives.

Progressive world tries to define principles of behavior towards the nature. Although most developed countries are in favor (!?), the United Nations Convention on protection the environment has not been signed yet. There have been directives these days obliging the United Kingdom to reduce the level of pollution by 48%, Luxembourg and Belgium by 42%, Italy 36%, Germany, which leads the world in terms of technique and technology, for equipment production and technology, as well as with regards the efforts in legislation, by 28% and so on. China and America continue to support the environmental protection, but still remain the world's greatest polluters.

Germany has a dominant position in the world for export of technologies for environmental protection. Out of total internationally recognized environmental protection patents, 23% originate from Germany, followed by the US with 15%, and Japan with 10%. Here are some examples where it is possible to effectively implement the achievements of innovative technologies for environmental protection.[4]

Coal gas for heating, obtained by drilling deep coal deposits, independently from mining works for excavation of stone coal. Drill holes up to 1900 m lead into a layer of stone coal, which contains a large amount of coal gas.

The wind generated energy is produced by the wind turbine generators made by "Sever" from Subotica, with 20 years warranty (!) and whose production in Subotica is being supported by “Siemens” after the disputable privatization process. With the advancement of technology in this field, there will be improvement of performance and an increase in installed power.

Production of electricity from coal in combined power plants with integrated gasification of coal in the world of science is viewed as a technical alternative to conventional gas production of electricity, but with little impact on the environment. The expected increase in the level of action against the new conventional coal plants means carbon dioxide reduction for at least 12%.

Gas and steam turbine power plants with integrated coal gasification has a corresponding lower level of activity in the production of gas by the nature of the losses in the conversion process. Yet it reaches between 45 and 50% of the efficacy, which is far more than what can be achieved in conventional coal-fired power plants. By coal gasification, any coal can be converted into a fuel gas friendly for the environment. While the coal with high melting points is prioritized in conventional power plants, for reasons of environmental protection, any type of coal may be used in gas and steam turbine power plants with integrated coal gasification. Thus, the range of coals suitable for the production of electricity is significantly extended.

The heat of the Earth appears as a natural technical storage for solar energy. However, such accumulated heat cannot be directly used, because it is at too low temperature level to be able to heat the room. **'Heat pump',** which works inversely to the principle of refrigerator, takes away the underground heat and rises a level of water temperature to a maximum of 50 degrees. These pumps, although they have to be turned on with the help of other types of energy, provide more than three times as much useful energy.

Solar thermal energy is not accumulated the best in large power plants, but directly at the consumers, because it is easier to cover as much surface as needed for amount of energy demand, for instance by installation on rooftops and facades. Use of technologies and systems for solar energy is expected to expand and we have witnessed a dramatic decline in the price of these systems, as well as increase of their technological efficiency. The absorption plants, which show good levels of operation especially at relatively low operating temperatures, are particularly suitable for heating outdoor pools. Depending on the installation and operation mode of an outdoor swimming pool, it is possible to replace 25 - 100% of outdated energy for heating.

Solar power and solar thermal power plant work on the system of the thermal battery to be able to cover the maximum energy consummation in the evening hours. Energy costs are about 10% higher in the conventional energy production, however saving of the outdated energy sources is on the other side of the cost surplus.

Solar plants as a type of power are far above all other technologies and they works on the principle of flat discs, where plastic cell systems and sensors are placed so that the sun rays are always focused on solar elements regardless of the height of the sun. Daily orientation towards the sun is very simple and is done by simple rotation of one plate on its axis, which lies on a hollow ring to its outer edge and which is located in an annular channel. Completely flat power plant is cheaper, almost with no need for maintenance and does not provide any resistance to the wind and with its distance, it takes up the smallest surface of all known plants.*

Energy from deposited gas is produced from garbage dumps. Nowadays, Norway exports waste to Sweden, which produces electricity from it and then exports it to Norway in order to pay off for the imported garbage.

P**roduction process in a steel plant** makes it possible to produce carbon dioxide with more than 50% less hazardous materials per 1 ton than by the usual four-stage system of steel production. Proceeding to a steel plant, where steel scrap melts directly into pure liquid steel, can make a major contribution to environmental protection and maintenance of additional assets. Around the world, the steel scrap is put again into use, which is equivalent to processing of 50 car bodies in a second. Facilities of material combustion are capable to convert chemical energy (any reaction of oxygen with hydrogen or methanol from natural gas, oil or coal) into electricity. The principle approximately corresponds to the chemical electrolysis. For Europe in the 21st century, the scientists have forecast that the market of these facilities will produce 300-800 mW per year, and since 2010 from 400 to 1400 mW per year.

Holographic-optical light control with light electricity savings of more than 80% compared to conventional lighting system.

Technology of old building renovation has produced a combination of heat and radiation termination in flats with the recapture of heat, which consequently has enabled that the total energy consumption of an existing home with four members is reduced by about 60% and that for at least 8 liters of fuel oil2. This shows that even in old buildings concepts for home energy reduction can be completely implemented.

Constructed buildings with energy saving system have wood as **the best building material**. It is renewable and environment friendly resource. Small energy costs are presented, as opposed to production of other building materials. At the same time, it is an ideal thermo-insulator for appropriate manner of construction. Research in the field of "double house" made of wood, limestone, bricks and light concrete gave the following results: the wooden house made from prefab construction elements jumped by 46 kWh of energy for heating2 per year. On the other side, a German average for conventional building houses is 140 and 200 kWh. A new German legislation on heat protection permits maximum 85 kWh for new buildings, almost double value of the one achieved in a wooden house.

3 MANAGEMENT DIMENSION IN THE WORLD OF WORK

Presented results of scientific/technical/technological/biological and other processes of predictions suggest that the world of work has expanded from working on the land to work on oceans and in the cosmos, and that it is gradually transformed from a

**The authors of this study designed and implemented a project of solar power plant in Serbia in 2015, power of 1.54 MW, worth 820,000 EUR.*

manual, via capital, to intensive research work producing knowledge, experience and skills. In our case, these are the sizes for the growing level of operational readiness, reliability and functional benefits, meaning that our landmarks for the future are more effective technologies and machines.

The world of technologies and machines is growing exponentially in constant development; the world of technologies - machine is following us since the birth of the first thoughts in a human being, through the current period, and further into the fu-ture [10].

Science grows by the law of exponential growth. Science grows similar to the population. Population grows proportionally to the last generation. Science grows proportionally to the mass of knowledge that we have been left by the previous generation. Today there are between 92 and 93% of all scientists who have ever been engaged in science. All the legacy of the past (although awareness of the late generations governs the heads of the living ones), all Tesla, Einstein, Pupin, ... make only 7 to 8%, but this is a grand legacy. However number of prominent scientists today is consistent percentage of the total number of people who do the science !?

The total number of scientists grow more or less in proportion to the square value of number of prominent scientists. If we want to increase a number of prominent scientists by 5, we have to increase a total number of scientists by 25.

On the other hand, the funds are increased for the fourth root of the number of famous scientists. If we increase the number of scientists for 3 times, the funds should be increased by 71 times.

There is no serial production in science. We have found that the number of researchers doubles every 12 years, meaning that in each such interval there will be as many researchers as there were in entire previous period. For the last 60 years, the number of researchers has been increased by 17 times, which corresponds to an exponential development with the doubling period of 12 years.

This exponential growth cannot go on forever because it would come to absurd proportions, since in the real world there would be no conditions for its existence. And system, even the scientific one, which suffers absurd proportions must fall apart. It is therefore essential, and it is imposed by itself, to establish adaptive braking system, because, if development continued at exponential characteristics we would have the situation that there would be 2 million scientists per a million inhabitants in the United States in 200 years, and it simply could not exist.

We have calculated that the braking period is about 30 years. This is essentially the time it takes to master the results of fundamental research, to apply strategic plans and achieve continuity in the developmental research. In the history of science, after a period of braking- "stagnation", the period of development always came, meaning that the period of revolutionary, i.e. exponential growth is coming. We are to prove that in science, there are cycles in terms of development, however, without recourse and stagnation, but the lower limit of the cyclic curve takes place in the level of scientific achievements and abilities of their materialization [5].

The economic system can be studied in the same way as the molecular structure. Interdependence of parts of the system creates a situation where changes in one direction may produce changes in the counterclockwise. This indicates that the equilibrium (balance of system) detects the cyclical development. This is contrary to the prevailing evolution of a certain time. We hereby verify that economy indicates that we are again and again on the verge of increasing demands in terms of radical efforts on securing the life, achieving solutions for unemployment processes, maintaining national aspirations in the survival, in the developed society and providing conditions for the development and maintenance of a high level of education of the population in all areas of economic and social activity.[1] As it may be concluded according to the above mentioned facts, that survival, development and duration of the enterprising processes in time and in given social conditions and changes may have a continuous development of all social activities and this presupposes the development of increasingly sophisticated, better quality, more reliable, more effective technology and machines. This world was and will remain the greatest man's ally. Production of the new values of the material and the spiritual character is, quite certainly, the main driving force of development of each serious society.

4 EVOLUTIONARY PERFORMANCE OF ECOLOGY AND TECHNOLOGY PROBLEMS

Researches show that almost every issue in economic development leads towards technology. H. J. Bruton compiled empirical evidence from numerous studies on the technology and concluded that the increased quantity of physical inputs (capital kvalitetra da) is rarely worth more than half of the increase in gross domestic production. Lester Thurow [7] has come to the same conclusion. Rest of increase is a result of increase in productivity based on increasing levels of technical modernity and quality management[†].

Never before has the environmental movement around the world been so well-established, but also has the environmental movement never been so obstructed by advocates of the ecological movement as it is a case now. This attitude comes from the fact that most developed countries outside Europe, opposite of the European developed countries, do not pay enough attention to environmental issues. Their "contribution" consists in the relocation of technologies that pollute the environment outside their space to areas that are geographically very distant from them (one of the characteristics of globalization).

Shortly before the industrial revolution the level of environmental pollution was insignificant. In the 19th century with the development of industry and international trade began formation of large working village near factories and mines with inadequate housing and the general hygienic conditions. Such a poor way of life imposed a need for ecological thinking about ways how to improve living conditions in order to reduce the social and class tensions, all in function of increasing the labor productivity. Bentham and Malthus' theory were among the first to have sought to link environmental issues with economic effects.

Jeremy Bentham advocated improvement of living conditions for workers in the settlements, characterized by a high density of habitation, poverty and poor hygienic conditions. He claimed that creation of the green parks, improvement of sanitation and more comfortable apartments, would trigger greater interest for work in factories and mines.

Thomas Robert Malthus, contrary of Bentamona, drew attention to the problems of human population growth. He claimed that population grows by geometrical progression whereas food production is arithmetically increased, which leads to deeper gap between number of population and available resources for life. Guided by this perception, he proposed imposing the

[†] *Unfortunately, some people, due to narrow scientific horizons, still discover that the sun rises in the east !? We point out to the models of Kalecki, then Pola Romer from Stanford, and Michael Davidson and their contribution to growth and development, through the implementation of technical progress by raising the level of technical modernity of assets.*

childbirth limitation in working families and other lower social strata.

Serious objections may be made to Malthus attitude for favoring the wealthy social classes at the expense of the poor. Despite theoretical and practical opposition to this theory by the Marxist way of thinking, ideas of Maltusas are actual even now for seeking solutions to the problems of growing population amongst the poor in the world.

In countries with a high standard, the current government are faced with a number of incentives in the form of subsidies and other material benefits aimed at increasing the birth rate. Population growth must be in line with available resources and other possibilities for its survival. The views of Malthus, were scientifically refuted by Karl Marx, the philosopher of the 19th century, through his research work and his simple view that the production of means of consumption practically is unlimited and is harmonized with the law on survival of the matter.

From the late 19th century until the second half of the twentieth century, there was no comprehensive theoretical concept which dealt specifically with environmental problems and consequences of economic and overall social development, even though the need for this was imposed precisely by the process of industrial growth and its impact on the balance in nature. The second half of the 20th century was characterized by the problem of pollution, but also the problem of environmental protection. The ecological - geographical determinism.[2] was created. Hypothesis provides a physical environment for a major determinant of the level of economic development of the country.

Technological innovations in the field of transport, chemical industry, energy, raw material processing, etc., came to the fore by the advent of the economic theory of mass production. Approach to this theory led to extensive use and exploitation of natural resources and to increased environmental degradation. Pesticides have become the first products that were in the dock. In 1952 Rahel Acason was the first one who pointed out to the dangers caused by excessive use of pesticides.

Researches made during the ‘70s of the last century by the Club of Rome resulted in appearance of 'global balance'. Reports on research results submitted in 1970 under the name “World dynamics and other reports”, and in 1972 called “The Limits to Growth” covered the most important elements of life on Earth, namely: population, industrial production, natural resources, raw materials, agricultural production and environmental pollution. The prevailing idea is that it is not possible to exercise unlimited economic growth on limited space and with limited resources.

Primary relations in economic terms can be represented as: the degree resource exploitation can only be less than or equal to the total available resources [4].

The Club of Rome has considered more opportunities for future development with the initial assumption that the economic system and social values will remain unchanged.

Stockholm Declaration from 1980, presented to worrisome state of environmental quality and appealed to all countries to work together to preserve the planet's capacity to produce and renew natural resources‡. The principles of conservation the natural resources of the earth and

‡ *Expansion of learning and commitment begins for the sake of sustainable development. According to civic learning it "means maximizing net benefits of the economic development that depends on maintaining the service and quality of natural resources over time. Economists who advocate environmental protection and presented this concept in the 1980s, meant the use of renewable natural resources at a pace that is slower than the pace of their recovery, and the use of non-renewable resources with optimum efficiency, taking into account the possibility of substitution the natural resources with technical progress.*

environmental protection were advocated, including care for the coming generations.

It is necessary to facilitate and accelerate transition from predominantly industrial production to the production of services relying mainly on resources of knowledge, ie. accelerated transition to post-industrial stage of development. World forecasts show that after 2020, 80% of people will be working in the tertiary services and information, and only 20% in primary and secondary services. This prognosis is given as a form of evidence of autonomy, as one of the characteristics of the environmental movement, because such a shift of employment, will necessarily result in a high degree of production system determination, which will be both technical and technological and ecological systems; Production systems will operate according to predefined software [6] and social reforms occur as a need that should allow smaller, local communities and individuals to care more about their environment and to contribute more to increasing global environmental awareness.

Bergen Declaration proclaimed in 1989 the concept of sustainable development. It was presented as a special concept at the United Nations conference in Rio de Janeiro in 1992. This concept basis its validity on the principle of intergenerational equity. Current generation has no right to leave in legacy a damage inflicted to the environment to the future generations, or to leave future generations without the resources that it exploited for itself. Future development, by the rule, will depend on adjustment with the possibilities of biosphere and its eco-systems, as well as the behavior of people in the areas of their performance.[4]

This dynamic or permanent sustainable development implies harmonization of economic development with the principles of social justice, not only at local and national level, but also on the global international milieu. Permanently sustainable development implies a transition from the classical market economy to ecological economy, as a market economy encourages the irrational use of resources, considering natural resources unlimited and free. The concept of continuous dynamic - sustainable development will be considered as continuous use of limited energy resources, resources, and limited space for development of economic goods production.

State of balance is an assumption for existence of this concept and it is only possible with adequate development of scientific and technological progress. Namely, non-accumulated resources (non-renewable), unlike the accumulated (renewable) resources can be renewable through the scientific and technical materialization and according to the law on the survival of matter.

For instance, waste is only now defined as substances that are found on the site unsuitable for them. Recycling and recovery are unconsciously attached to ecological progress and preservation of equilibrium of the environment. Waste in the production of steel, paper, glass participate, depending on the level of organization of their collection, selection and processing, from 35% to 65% in developing countries.

Radical changes in the technical-technological and socio-economic systems are created under the influence of technical progress. Technical progress, which has a universal characteristic of diffusion does not bypass any of the areas of economic and social activities. This dual effect of technical progress is manifested in the affirmation of new products, new technologies, new knowledge ... and simultaneous devaluation of existing products, technology, and knowledge. The task of dynamic-sustainable development is in fact to reconcile what is irreconcilable. In this affirmation and devaluation under the influence of technical progress, the advent of ecological principles receives special importance. Simply put, it is easier and more effective for every technical and technological change to incorporate and environmental requirements in it, so the efficiency of output and its quality will be dominant in relation to the previous level of output, regardless of the quantity and value of resources consumed and engaged workforce.

Human activities are most detrimental to the functioning of the natural balance in the environment. Those who care for the environment and human health deem that the most visible sources of pollution lie in the industry.

Today we need an active rather than a passive protection of the environment. Achievements of the scientific and technological development may significantly contribute to the application of active methods. Trends indicating absolutely closed systems, point out that the process of metamorphosis will take place according to a pre-defined software, including the selection of an organized waste collection to ensure their recycling and bringing in raw material. This process is a set of active methods aimed at protecting the environment. Intensive protection largely depends on the achieved level of technological development, institutionalized and implemented standards of environmental protection. The proper implementation of standards and scientific-technological achievements, the process itself eliminates the environmental problems and promotes a clean, healthy environment.

Application of modern techniques is a crucial prerequisite for resolving the current problems of environmental protection. The main aim to integrate environmental protection into all phases of the production cycle - from production to waste disposal. Upcoming trends emerge as a readiness of actors in the processes of reproduction to accept innovation. One type of preventive care may be the reconstructions or changing of polluting technologies for so-called clean technologies. Thus, the possibilities of environmental protection can be: a method of passive character that reduce harmful effects and methods of active operation through extensive and intensive access to radiation of harmful substances. As a rule, prevention is much more effective than the other methods. Conclusion is made according to the analogy with the health care of the population. If the ecology is in function of health and the health of nation is on the first place on a matrix of values in a society, it follows that all issues related to ecology cannot have a ban at their setting.

Today, there is no economy without the emission of waste, however, the process of "acceptance" of waste processing and its return to the reproduction process is taking place, which is one of the most important environmental and economic factors, as well as priorities in terms of the law of limitations in the availability of certain types of resources. It is exactly a new dominant technology, with high level of production and economic efficiency, that will act as a substituent for the quantity and quality of available resources. The first primary elaboration of the theory of limitation was given by Richard, which was then taken by Marks who included it into his scientific method, and then it later became generally accepted bourgeois way of thinking of modern economics when it comes to the theory of resources.

Preventive measures can be formulated in various ways depending on whether certain methods deal with harmful substances or energy. For practical reasons, this prevention in most cases leads to higher savings, which compensates for the increased cost of the any new investment, be in reconstruction or revitalization. As an evidence to the given claims, the program of preventive protection Minnesota Minningand Manufacturing (briefly three M) Pollution, Preventions, Pays, in short 3P 3P +) is given. In period between 1975 and 1992, three M eliminated more than 575 thousand tons of waste materials around the world in 3500 successful projects, whereas the application of the cumulative cost savings projects kept up to 573 million dollars in the first year.

The claim that environmental technologies compared to commercial ones do not need to lag behind in economic effects, on the contrary, be dominant, is proven by the experience of Harry Edwards, a professor at the University of Colorado, whose work in the field of reducing environmental pollution achieved the following results from 39 projects for minimization of waste: mean annual savings amounted to an average of 31,581 dollars. One-off costs of implementation amounted to 33.105 dollars which means that the profitability of the project is proved almost as early as the first year of activating investments.

One system is better than another for as much as to it manages to provide a greater degree of rationality in decision-making process.[8] Starting from this attitude, more economical and more efficient use of raw materials and energy will prove to be favorable for the environment, because it slows down the pace of extraction of natural resources, extending their lifespan exploitation, reducing the waste generated, wastes and emissions of harmful substances, just reduced environmental burden. Incorporation of prevention as a way of behavior in the production process, creates an objective protection that is integrated both into the tasks, but also in the minds of employees. Prevention is easier to work, enforcement and continuous improvement of attitude towards the environment.

Economy and ecology have a common interest. For instance, in countries where the cost of handling waste are high and raw materials are expensive, the consumers have raised awareness and laws on the protection are strict, so it is worth organizing cleaner production. Where these conditions are not present, it is typically better "to use the crowd," or insufficient normative regulations and patience of the population.

The cultural aspect is a predominant for ecological way of thinking, because if there are not strong oral arguments besides motivation for profit in decision-making process, then in a longer time projection lots of damage will be inflicted within society itself and in the natural environment. It turns out that emotions are not a good ally for the reason!? Complementary is missing? Capital has no soul! The question which then can be asked is the ratio of the economy and morality. The solution lies in the legal regulation and control. In order to avoid methodological disagreements, it is necessary to define objectives of economy in the case of organizations created for the realization of economic goals. By obtaining credibility, it can be affirm advantages of those companies that will leave traces in the protection of the environment.

If the existing industrial and other economic activities, which now exist under certain conditions, would be stopped, total chaos would be caused in the functioning of the organizational and general social systems existing in organized societies. If production of food, energy and other resources, be it a final or production consumption, was stopped, it would lead to endangering the existence of masses of people.

Therefore, the retention of the existing structure of production and services is subjected to specific selection, because the environmental pollution is considered lesser evil than "production shortages." The advent of new technologies is usually gradual and continuous, mainly also due to the fact that an sudden growth and development "hardendfastlines" are not possible. Continuity is ensured by the achievements of technical progress and the development of competition. Nano technology era is approaching. digital Darwinism is coming. Their main role is consisted of reducing resource consumption leading to their delimitation and the effects of Nano technology are becoming generally acceptable, because the quality of the output is gaining absolute environmental characteristics. Performance of nano technology will significantly increase productivity, and other principles of economy occur with the affirmation of the power of technical progress and competitiveness, which is primarily the economy. There are advantages in costs and the cost-effectiveness for reasons of reducing capital employed. Thus, it creates threefold objective: rational exploitation of natural resources, increase of economic effects and protection against environmental pollution. The degree of technological process determination and the organization of its functioning plays a dominant role.

Moral thinking of this moment is opposite to the profit, however, the political decisions and institutions are obliged to reconcile and harmonize these two irreconcilable approach. Solution is seen in the affirmation of a higher degree of knowledge and recognition a new dominant technology. It will be shown that the prevention of eco-system destruction is more profitable that pollution control; the waste reduction through recycling and reuse, which has already been proven, is more profitable than disposal of waste and controls on certain depots.

CONCLUSIONS

Nowadays, there is an uncritical approach to the importance of markets in the economic aspects of the overall economic trend functioning. The role of the market is too exaggerated. Neither privatization, nor the free market, will solve the accumulated problems of individual economies and the global economy. Technology will, rather than the market, considered by economists for many years as a residual factor, influence the direction and pace of economic development. The time for "creative destruction" is coming, which confirms the above given attitude on the dual effect of technical progress.

The action is an attempt to solve strategic forecasted phenomena for planning, flexibility, so that the uncertainty that has characterized the future may be limited.

The present superiority of the market as a mechanism of allocation should be seen only as a temporary nature despite the fact that many authors (Michaelis, Bratsch, Stavins, Grumbly, and others) insist on the need of such a conception of nature protection measures that would minimize their planned character !?

Along with the action, there is an incarnation, which represents a commitment, joint assume of the obligations, projects and common values on the path towards maximizing the objective function. The anticipation, action and incarnations are part of the same organism. Together they imply a synergistic effect, interconnection and interdependence; furthermore, they form a strategic culture, which as such is a key variable in determination of the performance of routing prognostic statements and development.

Platitudes about the free market should be quickly demystified, because the market and the media everywhere in the world are free only as long as they are allowed. The standards and absolute organization are imposed, meaning that there is no freedom of choice in such case.

Specification of market economic instruments for environmental protection is essentially a commitment to their greater affirmation that can be opportunistic from the position of desired effects: maximizing the overall social economic efficiency and maximizing performance to achieve environmental protection. The results achieved by applying these instruments may be used to support this claim. Through widespread use of reforming deposits in a series of modern developed economies there has been an improvement in environmental protection and the increase of economic savings. The quality of output is the result of technological performance.

Comparative use of economic and non-economic instruments appears as the basis of realization of the dynamic - sustainable development concept. This concept, as a rule, leads to the unification of economic and environmental objectives of social development that occurs as a necessary for two key reasons: application as a theoretical and methodological.

Economic or market-based instruments, can act as an adjustment through the price increase use of specific natural resources, work space or quality of the natural environment to be paid by a specific user and which, then through the market, influences the choice of methods of exploitation and the volume of pollution.

Penal policy or refundable deposits through certain licenses cannot be a substitute for the advent of modern technologies**.** Here there are opposing views of experts. Some advocate for individual property rights, others are in favor of legal judicial coercion, the third are for valorization the economic output, some are for environmental effects that would be higher than they are today, and so on. Wide variety of view, theoretical interpretations, as well as practical actions, which appear as partial performances, are canceled by complex technical and technological development, which is predominant in the selection of appropriate solutions. The question is whether more knowledge and technology or less knowledge and technology? The answer is: not less knowledge but more knowledge, not less technology, but more technology, because in this way, by facing problems directly and solving them, we are liberated from destiny.

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622

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