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Georgi Dachev[*], *Kiril Kutsarov*[*]

METHODOLOGY FOR ASSESSMENT AND ANALYSIS THE GEOMECHANICAL STATE OF THE OPENCAST MINING OPERATIONS BUILT UP IN THE ROCK MASSES

Abstract

Ensuring the stability of constructive elements (rock flanks or benches) in the opencast pits and quarries is carried out in a different way, and this is often the reason of considering only separate parameters to be taken. Such assessments are often made using the different hypotheses and formulae such as those of Tsimbarevich, Fellenius, Maslov, Fisenko, etc. The key factors, influencing such assessments together and separately, are numerous and in most cases it is difficult to gather them together with one summarized formula. This paper presents a structured uniform methodology in order to provide an approach for assessment targeting the geomechanical state of the opencast mining operations, situated in the homogeneous rock masses.

Keywords: *methodology for assessing the stability, rock masses, geomechanical state parameters*

INTRODUCTION

The technological and operation processes of the excavation - loading mechanization and working mining specialists in the opencast pits and quarries are related to ensuring the stability of structural elements (flanks and benches). The pursuit of mining engineers to achieve higher heights and widths of the benches very often results in deformations and subsequent slides (collapses) along these structural elements, stopping or discontinuing the work processes or blocking the entire parts of the mining site.

To determine the geomechanical condition of the structural elements under consideration, terms as stable/unstable are used, whereas the boundary between the two is not fully quantified. There is also no uniform methodology in applying the computational procedures, and in most cases, only one formula or one model is used, which often is not even calibrated.

The well-known formulae and methods for assessment the stability of flanks, slopes and benches are those of Tsimbarevich, Fellenius, Maslov, Fisenko, Terzagi, Froelich and many others. All formulae and methods only give separate components of the state and properties of the rock mass, rather than assessing them as a whole. When assessment the geomechanical state of a rock slope, no account is taken on orientation, joint length, distance and type of filling substance of the joints. For example, in assessment the stability of a slope made up of marl, the mass strength - "in situ", its natural humidity, stratified structure, etc. are not taken into account.

Bulgaria has introduced the requirement that the mining and primary processing pro-

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jects for the underground natural resources should include sections on geomechanics and rock pressure management with Ordinance [11] in force since 2016. These sections should demonstrate the stability of design and existing opencast mining works and measures to prevent the negative geodynamic processes.

Ensuring the stability of mining works has always been and should be a leading condition when choosing the parameters for the method of mining, but in recent years there has been a disparaging attitude to this important issue. The relevant sections in the work projects are also developed mainly by the non-specialists in the field of geomechanics and are only intended to meet the mandatory provisions of the above-mentioned ordinance, instead of providing the real data on the rock mass state and choosing the adequate parameters for the method of mining, respectively.

Because of all these issues, a uniform solution, grounded on the real state parameters in order to identify separate and mutually influencing factors, should be found.

FACTOR OF STABILITY (SAFETY)

Defining the factor of safety (FS) for the rock mass state is a multi-complex approach that has to follow certain criteria. A number of mining specialists and scientists define in different ranges the factor of safety the slopes and benches of the opencast pits and quarries. Some of them (Fisenko, Arseniyev, Maslov) consider the FS of a bench or slope to be when the rock mass counteracts the external forces; the rock mass maintains its integrity and state for an extended period of time. Others believe that the FS is the state when the ratio of sliding forces to the retaining forces is more than one. Because of these and other factors, it is necessary to define when a structural element is stable and will break its integrity. This is possible thanks to the assessment methodology that systematizes in a single assessment all the factors influencing the stability and answers the question what is stable and what is unstable. In Bulgaria, according to the Ordinance No. 12/03.07.2001 and Euro Code 7, under the basic combination of load, the minimum factor of stability (also known as the factor of safety) must satisfy the condition: $FS \geq 1.25$.

ASSESSMENT METHODOLOGY

It is well known that each individual case for assessing the state of structural elements (slopes and benches) requires an individual approach that meets the specifics of the mining site. This is necessitated by the rock mass lithology, its momentary state and/or its structural disturbance. For this purpose, we have proposed a uniform methodology presented in Figure 1.

The methodology for assessing the stability of opencast mining workings localized in homogeneous rock masses uses the so-called state parameters (databases) that can be determined (laboratory and/or "in situ"). In this sequence, both general slopes and individual benches can be dimensioned. The lack of a database for the composition and the structural characteristics of the rock mass has led to a number of laboratory tests following the ISRM [5] recommendations that have been used over the past thirty years.

The presented methodology can be implemented taking into consideration the influence of density and strength - deformation parameters, structural characteristics and their interaction, which can ensure the stability and corresponding effectiveness and safety during mining. This database requires a preliminary assessment related to the review of available information, hydrogeological conditions, geology, composition, etc. for the production level or section where the dimensioning or assessment the slope/bench will be carried out. In order to accomplish and acquire the necessary database, it is necessary to get acquainted in advance "ïnsitu" with the location and orientation the various lithological varieties of rocks. It is also necessary to provide the information on structural disturbance both in terms of surface area and height. It is necessary to know that the "ïn-situ" research studies also be in line with the recommendations of the ISRM [5].

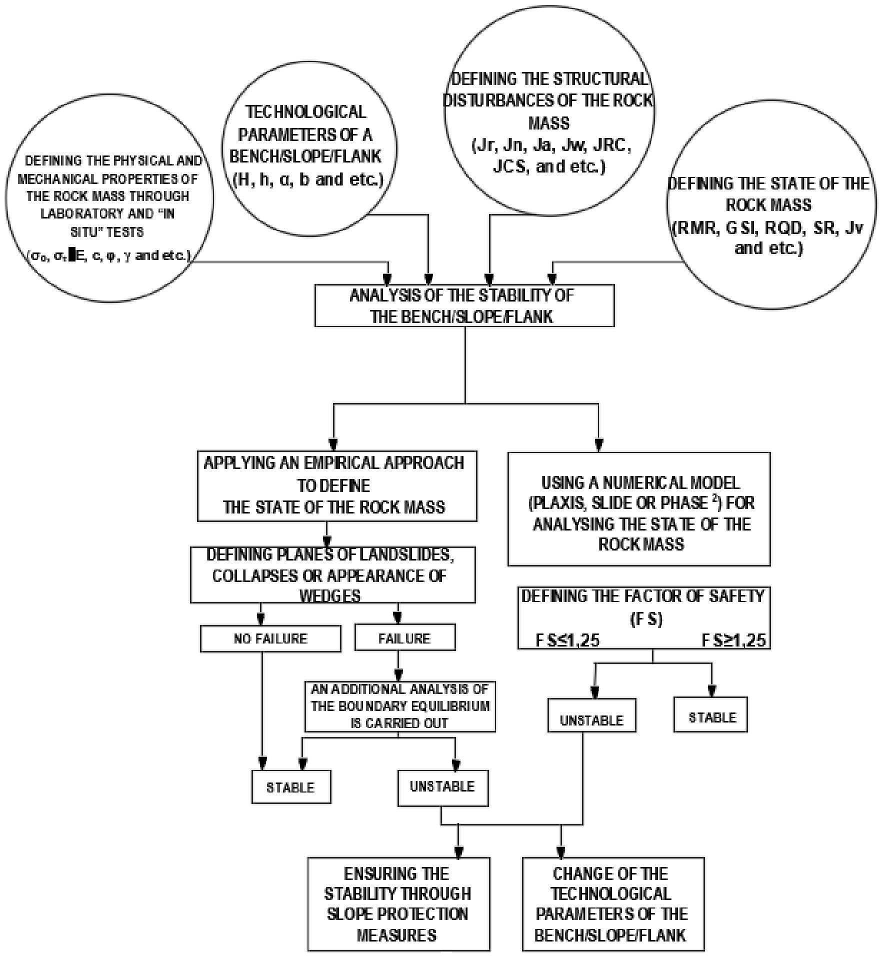


Figure 1 *Methodology for geomechanical assessment*

The next step of methodology reflects the dimensioning by means of empirical or numerical methods. When choosing a modeling method, it is necessary first to formulate a model reflecting the geomechanical and structural characteristics. The widely used models on the basis of the methods of finite, boundary elements or currently, hybrid methods for solving such tasks are also widely used.

The third important stage of methodology is the determination of load (sliding forces) (σ) and retaining forces (S) after specifying the geometric parameters of the bench. Based on these two factors, the safety factor (FS or FOS) is assessed. The method preferred most for the geomechanical assessment is the "Boundary Element Method".

The boundary states are grouped into the sets, symbolically shown in Figure 2.

The most appropriate method is found to be the GEO:

- GEO states – strength failure (including as a result of inadmissible deformations) of the ground, related to the disturbance of relative and overall stability (bearing capacity) of the rock mass under foundations (flat, pilot, well or mixed type foundations); strength failure in the rock masses resulting from the sliding of parts of it, etc. or generally, failures in the ground base under loads or when its stressed state is changed.

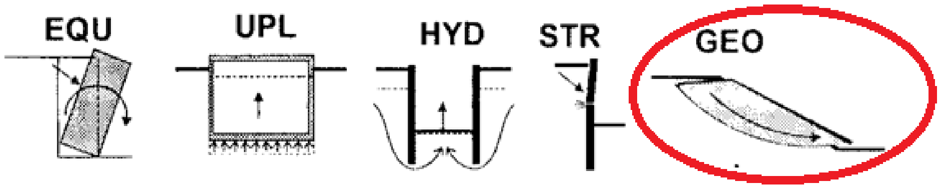


Figure 2 *Sets of boundary states*

- In the GEO equilibrium state, the following condition has to be observed: Ed ≤ Rd.

Ed - active force resulting from external and internal loads (impacts), called the computational value of impact. Rd – maximum resistance force, strength, called the computational value of strength or bearing capacity.

To determine Rd, the combined methods are used applying the different combinations of impacts, and computational geotechnical properties of the varieties are only determined by the laboratory tests.

Most importantly, the proposed assessment methodology can also be used in assessment the state of underground mining portals such as tunnels and entrances of adits and inclined shafts built into rock masses as it includes a wide range of data characterizing the state of such important facilities.

APPLICATION OF METHODOLOGY

The methodology has been verified and applied to assess the geomechanical state of slopes and benches in the limestone quarries. The research has been carried out for a quarry that produces limestone as a major lithological variety of rocks. It should be noted that this was done following the proposed sequence of operations presented in Fig. 1 such as: the studies started with the structural disturbance of rock mass both in terms of surface area and height, then the strength-deformation properties of rock mass samples were determined and, as a final result, the structural state and quality of studied section were reported.

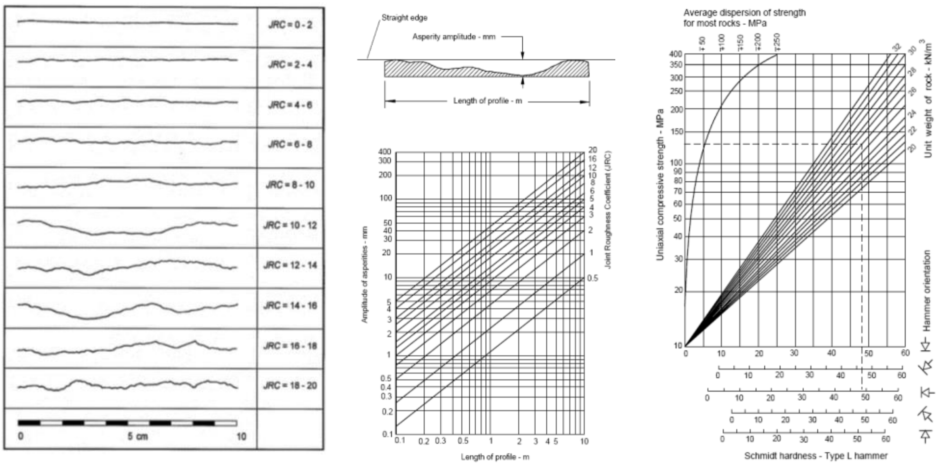
The studies started with in situ and laboratory methods to determine the physical and mechanical properties of the bedding rock mass. These studies include determining the strength (c, φ, σ_c, σ_t, $\tau_{cp,}$ etc.), density (γ, ρ, w_i, etc.) and deformation (($E_{el.}$, $E_{def.}$, ν, etc.) parameters. The tests were performed according to the established ISRM procedures [5]. It should be also noted that the RocData program [10] was used to obtain the values of individual parameters presented in Table 1, which characterize the strength-deformation properties of the rock mass.

Table 1 *Laboratory results for the physical and mechanical properties of the bedding rock mass*

Parameter / Lithology	In situ density γ, [MN/m^3]	Uniaxial compressive strength, σ ucs [MPa] min/max	Tensile strength, σt [MPa] min/max	Cohesion C cp. [MPa]	Internal friction angle φ cp.,[°]	Elasticity modulus, E [MPa] min /max	Poisson's ratio ν average.
Limestone	0.0267	45.8/ 68.5	12.2/16.7	6.1	38.4	39 650/ 58 370	0.22

In details, for assessment the rock mass state, which builds a slope in the end contour, the "in situ" methods were used and the following parameters were defined: distance between the disturbances Rdj, joint length of disturbances L, type of the joint (x, r or d), orientation of the joint Roj, roughness of the joint Jr (rough, smooth, wind-polished, etc.), degree of joint weathering (fresh, slightly weathered, moderately weathered, high weathering, etc.), determining the joint wall compressive strength (JCS), determining the joint opening (open, moderate, wide, etc.), disturbance saturation Jw (dry, moist, wet, etc.).

For the analysis of results, the Barton standardized rocks [5] were used to determine the joint roughness (JRC) and wall strength (JCS), presented in Figure 3.



A) B) C)

Figure 3 *Additional Barton's graphs for defining the assessments JRC (A and B) and JCS (C)*

For the analysis of geomechanical state of the rock mass using the obtained results in the analyzed profile, the geomechanical classification RMR (Rock Mass Rating, according to Bieniawski [6], was applied. The results from the qualification assessment are presented in Table 2.

Table 2 *Results from the qualification assessment RMR (Bieniawski 1989).*

Qualification assessment / Parameter	Rock Mass Rating (RMR)
Rβs	7
R_{RQD}	13
Rdj	20
Rci	20
Rwi	15
Roj	-5
RMR	**70**

The obtained results show that the rock mass falls into the second class according to the Benyanski classification, i.e. it is of good quality. The RMR assessment gives a possibility to determine the geological strength index GSI: GSI= RMR_{89}-5 → GSI=65.

The results providing a relationship between the structural disturbances and state of the rock mass [1] are presented in Table 3.

Table 3 *Results providing the relationship between the structural disturbances and rock mass state with the help of the GSI (Hoek and Brown 1998)*

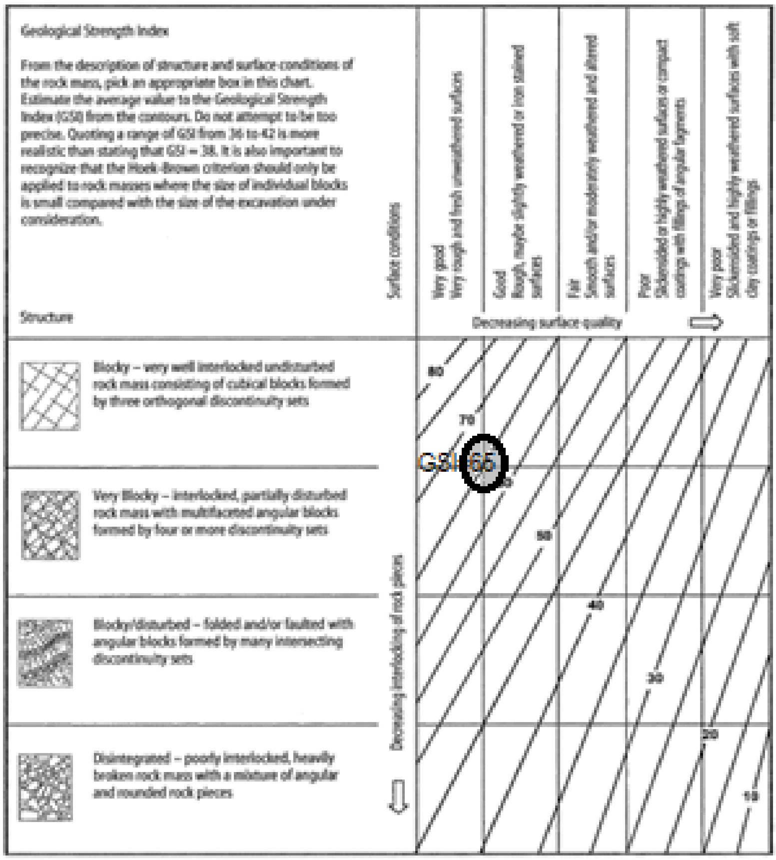
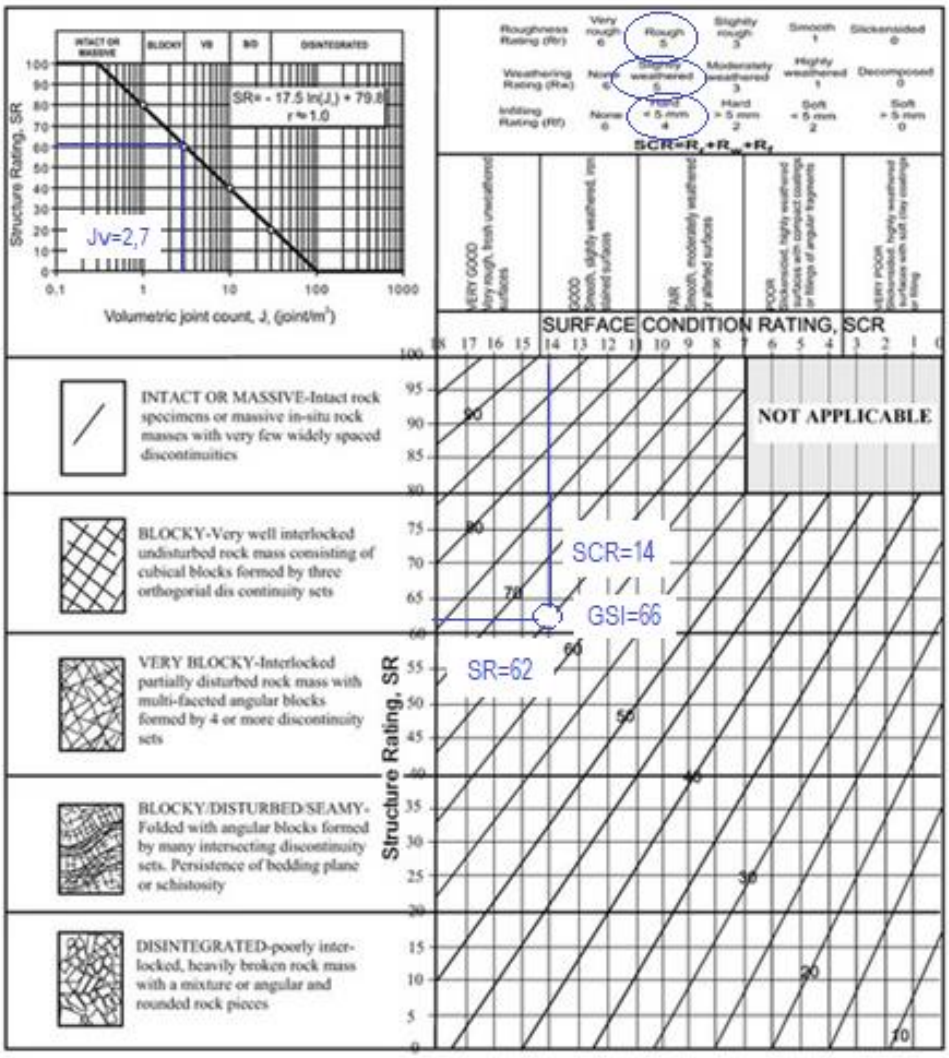


Table 4 presents the results for the GSI defined by the Sonmez and Ulusay [4] graph, they allow verification of the results determined using the RMR classification rating.

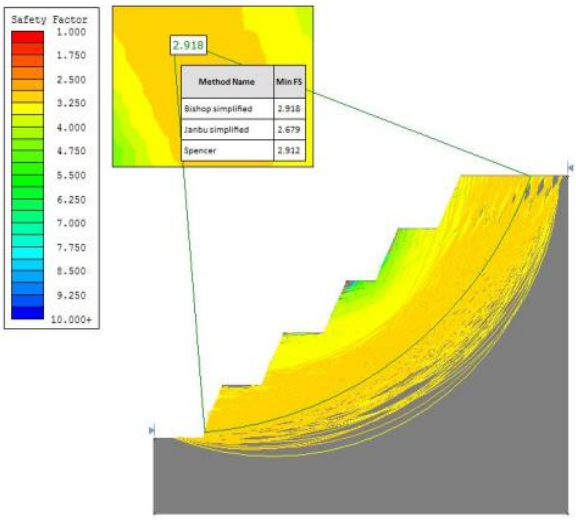
Table 4 *Defining the GSI values using the Sonmez and Ulusay graph*



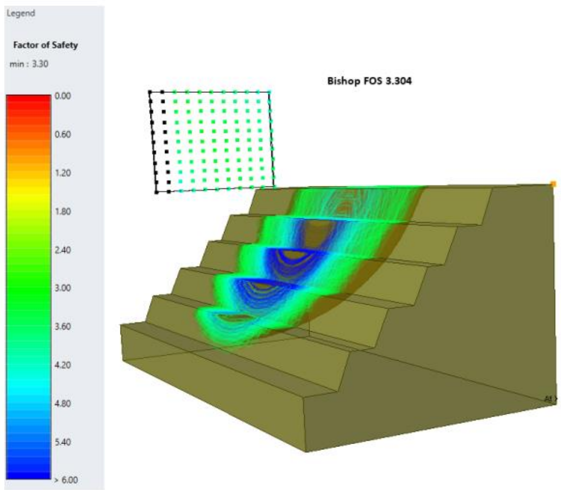
The results obtained in Table 4 make it possible to link the in-situ index of fissuration, geological strength index and surface state of the disturbances by their assessment. The obtained results in Table 4 also allow verification of the GSI results, obtained by the classical method, in orde to adequately set it as an input parameter in the numerical model.

The final step for obtaining the input information involves accurate measuring the geometric parameters of analyzed profile (heights, widths, angle of inclination, etc.) using the geodetic methods. This measurement includes a detailed determination the height of analyzed profile of a flank (H), general angle of a slope (b), flank profile type, inclination angle of a bench (a), bench height (h), bench width (b), etc.

Following the proposed methodology (Figure 1), the existing database is used to develop an adequate model and its accompanying stability analysis using the numerical software [8, 9] presented in Figure 4. The model in Figure 4 includes a high wall composed of five benches in the eastern section of the limestone quarry, covering the five levels in height – from the level 185 to the level 260.



A)



B)

Figure 4 *Stability calculations for a high wall built in a rock mass using a two-dimensional model Slide 7.0 - A; using a three-dimensional model Slide 3 2017 - B*

The software products of the Canadian company Rocscience [8, 9] allow the boundary state calculation by several methods. The methods of Bishop, Janbu and Spencer were used for the stability calculation of a flank. The software allows many of in-situ and laboratory evaluations, defined as the database, to be set as the input parameters. In addition, they allow the identification of landslide surface or local losses of stability.

For the example under consideration, no dangerous sliding surfaces have been reported under the three methods of analysis. Similarly, in the three methods, the safety factor is significantly higher than the normative minimum; the results for both numerical models are almost the same, which means that the model works adequately. The analysis shows that no sliding surfaces that disrupt the local stability have been identified in any of the five benches building up a flank, as well as no wedges have been formed which can lead to sliding.

For a more complete and accurate verification of the obtained results, it is advisable to use the left-hand branch of methodology applying the empirical methods of analysis. This allows the final design solution to be justified by the two independent methods using the same input parameters.

CONCLUSION

The need for adequate stability analyses requires the development of a new methodology for complex parametric, geomechanical assessment and logistics. The purpose of methodology is to serve in the assessment of stability and preliminary dimensioning of flanks, slopes and benches at the opencast mining sites. Following the proposed methodology, it allows the accurate engineering solutions to determine the state and stabilityof structural elements at the open pit mines and quarries.

The applicability of assessment and analysis methodology is indisputable due to the fact that it has been applied and verified in practical conditions in assessment the geomechanical status of a high wall in a rock mass made up of limestone. The results from these studies were subsequently introduced into the production process.

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POTENTIALITY OF THE RAW MATERIAL COAL BASE FROM THE GACKO DEPOSIT IN A FUNCTION OF PROVIDING THE ENERGY FUEL FOR STRATEGIC PLANNING OF THE TPP GACKO 2

Abstract

Coal resources, in addition to oil, gas and uranium as a non-renewable and hydropotential as a renewable energy source, represent the most significant part of energy potential and an energy source of strategic importance on the Republic of Srpska. The modern pace of technological and industrial development causes a permanent increase in coal exploitation and consumption. The use of this resource must be planned and extremely rational. Coal deposits in the Republc Srpska are differed in the structure and quantities of reserves, geological and technical-economic conditions of exploitation and quality. Geological reserves of the Gacko coal deposit amount to 330 Mt. According to the current geological documentation, the balance reserves are ≈182 Mt, with an energy potential of 545 TWh. According to the processed performance indicators, the balance and mineable reserves of coal enable a long-term supply of fuel for the current and future thermal power plant under the favorable economic conditions. In order to provide the required amount of energy for operation the existing and "new" thermal power plant in Gacko, it is necessary to carry out the geological explorations in order to reproduce the mineral and raw material base. The duty of every company engaged in exploitation the coal energy resources is a continuous performance of geological explorations in order to find the new ones or transfer the existing reserves into a higher category. The future development and level of coal production from the Gacko deposit will mostly depend on the electricity production in the Gacko Thermal Power Plant. It would certainly strive for fulfillment the basic conditions, i.e. the cost of coal heat utilization, as in many other countries, be at least approximately competitive with the cost of heat from the other primary energy sources (hydro sources, imported energy, etc.).In order that the Gacko non-renewable energy resource would survive and evolve in a particular environment, it must have a clearly defined purpose of existence. This purpose of existence is primarily reduced to a multiphase process of providing and using a non-renewable energy resource in accordance with the realistic natural, economic and ecological opportunities, in relation to which there are the expressed needs in a wider or narrower environment.

Keywords: *coal, Gacko deposit, open pit, energy fuel, thermal power plant*

1 INTRODUCTION

The Gacko field and carbonaceous Neogene sediments deposited in its former depression are located in the far southeast of the Republic of Srpska on the border with Montenegro. Three quarters of the fields are covered by the Quaternary sediments below which are the Neogene formations, covering an area of about 40 km^2. The Neogene sediments are distributed over an area of about 16.5 km long, from

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Nadanić in the northwest, to Gareva and Dobrelja in the southeast, with the maximum width of about 3 km [2].

The Gacko deposit contains lignite/brown-lignite coal type as an economic raw material type. It is used almost exclusively as a thermal energy fuel, for the needs of the Thermal Power Plant in Gacko and is one of the strategic raw materials of the Republic of Srpska. Coal from the Gacko deposit is a non-renewable energy mineral raw material of the primary economic importance for the Republic of Srpska.

The coal mines in the Republic of Srpska, during their production activities, encounter the specific problems, issues and challenges [10]. The same are related both to the quantity and quality of mineral raw materials, as well as to the organizational and production activity. They also share a need to improve and modernize the production and work organization technology. The latter is particularly pronounced in the case of the Gacko coal deposit, that is, the mine supplying the Gacko Thermal Power Plant with the raw material.

2 COAL RESOURCES FROM GACKO - ENERGY FUEL FOR THE CURRENT AND FUTURE THERMAL POWER PLANTS

Geological reserves of the Gacko coal deposit amount to 330 Mt [8]. According to the current geological documentation, the balance reserves are ≈182 Mt, with an energy potential of 545 TWh. Due to the total quantity of ore reserves and quality, the Gacko coal deposit is the most important source of this raw material for the needs of thermal power plants in the Republic of Srpska.

The average coal bearing content in the Gacko coal deposit, by the individual coal seams, only for the main seam is 9.36 t/m^2. For all three coal levels of the first coal seam, the average coal content is 13.73 t/m^2. The second coal seam is characterized by the uniform development throughout the deposit with average coal content of 13.46 t/m^2. The average coal bearing content in the contours of balance reserves of the roof seams of coal zone is 7.12 t/m^2.

There are 36.1 Mt of coal in the Gacko coal deposit, category C_2 mainly in the deepest parts of the Eastern Field. This practically means that there is a real potential for finding the new coal reserves in this area. If the new reserves would be found (for which there are favorable mineral genetic preconditions), the open pit life would be increased, so the coal mine in Gacko would be a long-term economic facility with a significant impact on development the other economies and social activities in the Municipality of Gacko. Within this, it is estimated that construction of the second and, in perspective the third phase of the Thermal Power Plant, has its full justification.

To evaluate the possibility of energy development on the basis of coal use from the deposit "Gacko", it is necessary to know the actual coal reserves, mining-geological conditions, hydrogeological conditions, geomechanical parameters of waste sediments (overburden), quality and usability of coal, possibility of development the cheaper surface exploitation, possibility of applications the modern mechanization at the open pit, i.e. mechanized high-performance complexes in surface exploitation. In principle, over a longer period of exploitation, it is realistic to expect a more pronounced impact of various risks, within which the geological, mining and economic risks are dominated.

3 TECHNOLOGICAL PROPERTIES OF THE RAW MATERIAL BASE OF COAL

Technological properties of the raw material base of coal are determined by its mineral and chemical composition, structural-textural characteristics, granulometric characteristics, amount of useful and harmful or undesirable components, as well as the characteristics of their location in the deposit. For evaluation the coal quality from the Gacko deposit, its thermal value is of the greatest importance.

The use of raw lignite in a batch form in a wider and general consumption and industry is justified only within the economic transport radius because its thermal value is low. This means that the sale of pre-sorted raw lignite as fuel in smaller urban settlements (closer to the mine) would have the positive economic effects. However, most of the raw lignite produced from the Gacko deposit, as well as in the Republic of Srpska, is used in the thermal power plants for electricity generation [7].

The qualitative characteristics of coal as an energy fuel from the Gacko deposit have been defined by the classical immediate analyzes. The results of such research often deviate from those tested in practice. The coal quality studies were carried out in a manner that is not adapted to the requirements of selective exploitation. However, no low thermal value interlayers, such as clay coal or coal clays, were precisely defined, which also reduce the thermal value of coal. All of this had a direct effect on poor separation of the waste interlayers from coal and decrease of its thermal value. Coal intended as a thermal energy fuel and coal intended for the general consumption are delivered to the final consumers without additional technological processes for coal refining and classification.

The basic aspects of utilization the existing coal reserves, in order to obtain the quality fuel for the thermal power plant, require a professional and modern approach in order to obtain the adequate, maximally rational technological effects in the processes of coal production and combustion. Considering that coal is a heterogeneous raw material, that its composition and properties can differ from the same seam, there is a need to obtain as uniform and high-quality characteristics as possible by the technological solutions and processes. For these reasons, all issues related to ensuring the guaranteed quality of coal as a fuel for the thermal power plant are directed to finding the technological solutions in order to improve and harmonize the quality of mined coal. Solving the problem of providing coal of uniform quality and composition can be realized through the technological process of refining (cleaning) the run-of-mine coal [5].

Previous solving the above problem in the mine has been in a direction of selection the optimum coal mining technology, which implied the application of selective exploitation. Coal in the deposit of the Gacko basin is of complex geological structure, layered with a large number of barren interlayers of low power and, therefore, very ungrateful for exploitation and preparation. Selective coal mining partially solves the problem, but due to the above characteristics of coal series, it encounters difficulties and does not produce the good enough results. It is obvious that the present exploitation results in a kind of dilution, i.e. a decrease in the quality of raw material, which is reflected in the lower thermal value of coal that is burned in comparison with the heat value, which, according to the research, was calculated for "clean" coal. As this problem has not been satisfactorily resolved previously, it should be considered as an important technical and exploitation factor and in future exploitation in the new Open Pit Gacko.

4 THE OBJECTIVES OF THE DEVELOPMENT STRATEGY OF ENERGY SECTOR OF THE RS

The general objective of the development strategy of thermal power sector is defined in the Energy Strategy of the Republic of Srpska until 2030. The strategic document defines the general objectives, which are the basis for strategic planning the development of the Gacko thermal power complex. The national strategic objectives are as follows [9]:

- Providing the required amount of energy, primarily coal, for the thermal power plants in order to ensure regular and secure electricity supply to the economy and citizens in the area of the Republic of Srpska. The provision of required energy amount should be done at economically sustainable prices, taking into account the problems of energy poverty;
- Increasing the efficiency of production the non-renewable energy resources;
- Creation the conditions for gradual opening the electricity market and investment in the thermal energy sector;
- Establishment an efficient system for promoting the thermal energy efficiency and use the non-renewable energy sources in accordance with the set goals and obligations that will result from the membership of Bosnia and Herzegovina in the EU;
- Providing a sustainable development of the thermal power sector under conditions of limited greenhouse gas emissions;
- Aligning the legislation with the legal heritage of the European Union.

An ambitious plan of development activities needs to be enacted and implemented to achieve these framework-defined objectives in the coal capacities of the Republic of Srpska. According to this plan, it is estimated that the planned volume of capital should be invested in a new and revitalization the existing equipment and other projects in the coal mines in the Republic of Srpska.

The total energy demand in the Republic of Srpska is met by the consumption of coal, liquid fuels, gaseous fuels, hydropower and firewood. Coal accounts for the largest share of total energy consumption - about 40%. Coal is predominantly used for the electricity production in the thermal power plants (over 90%) while the rest is used for the other commercial purposes.

When considering the energy reserves and potential of the Republic of Srpska, coal represents the dominant energy feedstock with the total balance reserves of 684 Mt, 390 Mt of lignite and 294 Mt of brown coal. This energy resource will continue to be based on the energy development of the Republic of Srpska, given that it is planned to increase the coal production up to 9.3×10^6 tons of coal by 2025, with an estimate of investment in the coal production area in 2010-2030 of 655×10^6 KM.

5 LONG-TERM COAL MINING STRATEGY FROM THE GACKO DEPOSIT

Development strategy of the Gacko Thermal Power Complex, based on the basic document, has the main objective of countering the Gacko coal reserves, whose exploitation at economically favorable values can provide the energy fuel for both the existing and future Thermal Power Plant Gacko 2. On the basis of this, the main objectives have been defined for development the strategic document "Strategy of Mining and Technological Opening, Development, Optimization and Maintenance of the Coal Production Continuity with Preparation the Feasibility Study for Introduction a Dry Gravity Separation Process". Prior to drafting of this document, the objectives have been set that would be solved by the strategy, and the same primarily address the following [4]:

- Defining the basic directions of development the open pit coal exploitation for the purpose of continuous, stable and reliable supply of the Thermal Power Plant Gacko with coal of appropriate quality;
- Defining the optimal technological parameters of the system of open pit exploitation on the basis of the results of conducted analysis and optimization based on the economic criteria;
- Optimal utilization the existing coal resources in the area defined by the Program task;
- Determining the possibilities and conditions of application the new technologies of coal exploitation and processing in order to optimize the techno-economic parameters, i.e. to maximize the financial effects of production with improvement quality of produced coal.

The domain of solution for development the open pit exploitation in the Gacko coal basin is formulated within the following limitations:

- The south and north boundaries of the studied area is defined by the limits of open pits and landfills, according to the Regulation Plan of the Mine and Thermal Power Plant Gacko (2011);
- The east boundary is defined by the existing work front;
- The west border is represented by a geological-exploration profile 55-55'.

After determining the essential parameters of the open pit exploitation, based on the adopted criteria, ranking of the considered alternatives was carried out and thus formed the basis for making decisions on the future development of both the mining and thermal power part of the Mine and TPP Gacko. The expected results of the Strategy are also the formation of technological solutions for coal exploitation and processing, which will represent a framework for opening and development the future Gacko open pit and the basis for mining design.

The future development and level of coal production from the Gacko deposit will depend mostly on the production of electricity in the active Gacko 1 Thermal Power Plant and the future Gacko 2. In this case, the basic condition should be fulfilled, i.e. the cost of coal heat utilization, as in many other countries, be at least approximately competitive with the cost of heat from the other primary energy sources (hydro sources, imported energy, etc.). Since the mine and thermal power plant are the unique enterprises, the revitalization of the existing thermal power plant and development of the mine are interco-nnected. Development of the mine will be enabled by the sale of electricity in the surrounding markets (formation of a free electricity market in the region, shutdown of individual power plants in the region, demand for electricity) and improvement the coal processing technology with a possibility of use the lower coal quality. On the other hand, entering the market also means exposure to the price and demand volatility (uncertainty and instability of income). In addition, the future development will also depend on tightening the environmental requirements [7].

In order to supply coal regularly to the Gacko Thermal Power Plant, a new conceptual solution for the open pit coal exploitation from the Gacko deposit has been adopted since 2015. Excavation of the overburden, coal and seam waste in the area of Field "C", due to a lack of adequate excavation and transport equipment, has been made difficult with constant delays in the implementation of plans for the open pit excavation. This resulted in a stable supply of coal to the Thermal Power Plant from the active open pit (Field “C”). The conducted optimization of possible variants of development the open pit have highlighted two perspective zones with a possibility of efficient and economically favorable coal exploitation, as well as [3]:

- locality of the Field "C" (Central Field), where the main and first sub-coal seams are exploited, and
- roof coal area where the third and second roof coal seams are exploited.

By opening the open pit at the site of the roof coal zone, continuity in the regular supply of coal to the Gacko Thermal Power Plant was ensured.

5.1 Optimum variant of coal exploitation from the Gacko deposit

A long-term strategy of coal exploitation is elaborated in the "Strategy of Mining and Technological Opening, Development, Optimization and Maintenance of the Coal Production with Introduction the Enrichment Process of Coal of Dry Separation at the Open Pit Gacko", done by the Mining and Metallurgy Institute Bor, Republic of Serbia. The following text briefly outlines the mining-geological and economic indicators of Variant 3, which is elaborated in detail in the Strategy [4].

The open pit boundaries in the in a part of the deposit Field C and East Field, without limitation by the geological exploration profile 55-55'. Optimization of the Open Pit contour in a plan and by depth was made using the Whittle Fx software.

Figure 1 shows a contour of the open pit from Whittle, designed after processing in the basic software Gemcom.

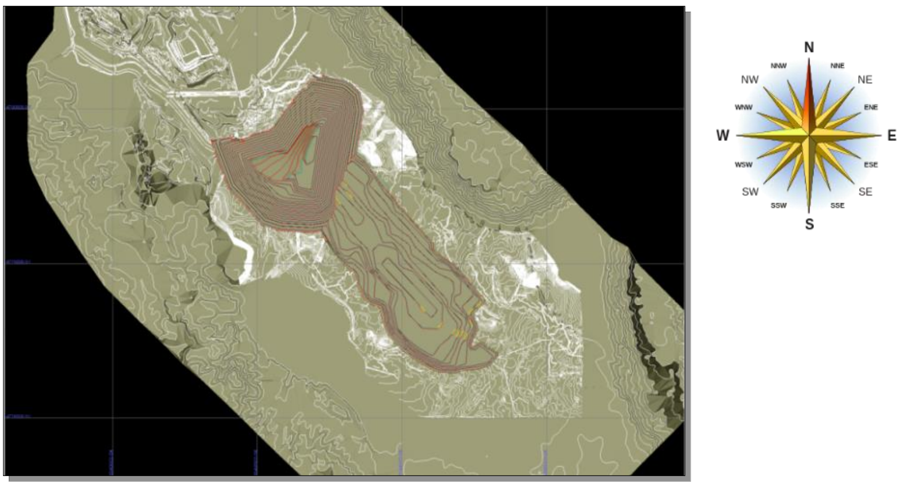

Figure 1 *View of the Open Pit 24 designed in the basic Gemcom software on the basis of contours from Whittle (Source: Z.Vaduveskovic, S. Stepanovic et al., 2015)*

Table 1 shows the calculation of coal amount in the roof and floor seams and overburden and associated interlayer waste.

Table 1 *Amounts of coal, overburden and interlayer waste in a contour of the Open Pit – Variant 3*

Mineral raw material	Volume	Volume mass	Amount	DTE
	m^3	t/ m^3	tx1000	kJ/kg
Roof seam coal	48,246.930	1.300	62,721.006	7,393.35
Main and floor seam coal	32,231.947	1.263	40,722.290	9,531.19
∑ COAL	**80,478.876**	**1.285**	**103,443.296**	**8,234.95**
∑ WASTE 1	**342,040.475**	**1.740**	**594,994.468**	
∑ EXCAVATION	422,519.352	1.653	698,437.763	
K_o=3.04 m^3/t; 5.75 t/t				

(*Source: Z. Vaduvesković, S. Stepanović et al., 2015*)

Based on the needs of the thermal power plant for an adequate amount of energy, the service life is 36.5 years. Considering the qualitative and structural characteristics of coal from the Central Field deposit, using of only selective exploitation cannot ensure the stable production of coal of the minimum required quality. Based on the conducted research, the X-Ray sensor method of coal separation/refining was adopted for further elaboration.

An overview of the work dynamics over five-year periods is given in Table 2.

Table 2 *Dynamics of the work development in Variant 3*

Exploitation period (years)	1-5	6-10	11-15	16-20	21-25	26-30	30-36
Run-of-mine coal (x1000 t)	13,12	14,049	14,25	14,87	15,612	15,519	18,561
Run-of-mine coal on a landfill (x1000 t)	6,100	3,973	4,206	4,863	5,607	5,519	6,561
DTE - run-of-mine coal on a landfill (kJ/kg)	7,664	8,188	8,337	8,043	8,317	8,380	7,844
Refined coal on a landfill (x1000 t)	4,606	6,610	6,588	6,566	6,563	6,560	7,872
DTE - refined coal on a landfill (kJ/kg)	9,318	9,626	9,865	9,088	8,201	8,433	8,657
DTE - coal on a landfill (kJ/kg)	8,375	9,086	9,270	8,643	8,255	8,409	51,942
Total energy on a landfill (TJ)	89,675	96,155	100,01	98,789	100,458	101,568	119,609
Total waste (x1000 t)	81,277	81,397	95,972	96,833	82,543	88,342	68,630

(*Source: Z. Vaduvesković, S. Stepanović et al., 2015*)

The basic economic indicators of exploitation for the adopted variant are presented in Table 3.

Table 3 *Economic indicators of Variant 3*

<table>
<tr><td rowspan="4">Calculation of economic indicators, was made taking into account, in addition to the capital and operating costs of the mining section, also the investments in in refining plant, standardized costs of the refining process and benefits generated in the thermal power plant.</td><th>Profitability indicator</th><th>Variant 3</th></tr>
<tr><td>Internal rate of return (%)</td><td>16.66</td></tr>
<tr><td>Net present value (KM)</td><td>467,010,627</td></tr>
<tr><td>Return period (years)</td><td>7</td></tr>
</table>

(*Source: Z. Vaduvesković, S. Stepanović et al., 2015*)

Based on the performance indicators, the coefficient of waste and contoured coal reserves, the Variant 3 was selected as the most economically advantageous because it shall ensure regular supply of coal to the Thermal Power Plant Gacko 1 and future Thermal Power Plant Gacko 2.

6 NATIONAL COST-EFFECTIVENESS OF COAL USAGE FROM THE GACKO DEPOSIT

In the previous coal and electricity production from the power complex Gacko, a commercial viability was achieved, which is a direct financial benefit to the energy sector of the Republic of Srpska. However, the commercial viability, which is practically determined by the market economy and its principles, cannot give a clear picture of contribution the coal and electricity production to the national economy of the Republic of Srpska.

In order to measure the contribution of coal production to the national economy, it is necessary to consider the national cost-effectiveness, considering the direct and indirect effects of interest to the Republic of Srpska and its long-term and stable development. National profitability from the Gacko Energy Complex is achieved through the positive effects on employment, foreign exchange inflows and international competitiveness. The effects on employment were achieved through employment of a large number of working-age population of Gacko and neighboring municipalities and foreign exchange inflow through the sale of electricity to the foreign market. The international competitiveness of the national energy sector of the Republic of Srpska is characterized by the ability of energy companies for successful engagement in the international economic relations. The Gacko energy complex achieves the same through the production of goods (coal and electricity) that can meet the international market standards, but at the same time retain and increase a long-term real household income. Due to a high demand for commercial coal, as well as a high electricity demand of the countries in the region, it is expected that the coal prices will increase in accordance with the market principles, in comparison with the current state of free pricing at the company level.

Sustainable use of the coal energy resource in Gacko offers a solution for achievement the basic objectives related to the security of supply the present and future thermal power plant, as well as rationalization in its exploitation. This would provide the conditions to the future generations to use the coal resources within the timeframe and reserves available to Gacko. The main objective in the mineral strategy of this resource is to provide the all necessary preconditions for rational and efficient management and sustainable use of available energy potential in relation to the established reserves, environmental impact and socio-economic development.

CONCLUDING CONSIDERATIONS

The role of thermal power sector that uses coal as a non-renewable energy source is to support the development and growth of the economy of the Republic of Srpska considering the environmental protection. The development of thermal power sector will result in technological development, strengthening of domestic companies, increase of investments and increase of competitiveness of the economy of the Republic of Srpska in relation to the coun-tries in the region. The Gacko mine and Thermal Power Plant have a significant position in the energy sector of the Republic of Srpska. In the strategic document, the countered coal reserves of the Gacko Coal Basin enable a regular supply of coal to the TPP Gacko 1 TPP Gacko 2, and the remain-ning reserves not treated by the selected Variant 3, represent the basis for further mining-geological and economic analyzes and represent the base for construction another one thermal power plant (potential Gacko 3).

The design solution, combined with the coal exploitation from the Field "C" and roof coal zone, provides an economically optimal coefficient of overburden and continuity of coal exploitation from the Gacko deposit.

The planned use of the coal energy resource in Gacko offers a solution for achievement the basic objectives related to the secure supply of the present and future thermal power plant, as well as rationalization in its exploitation. This would provide to the future generations the conditions to use the coal resources within the timeframe and reserves available in Gacko. The main objective in the mineral strategy of this resource is to provide the necessary preconditions for rational and efficient management and sustainable use the available energy potential with respect to the established reserves, environmental impact and socio-economic development [7].

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Radmilo Rajković, Daniel Kržanović*, Miomir Mikić*, Milenko Jovanović**

PUMPING OF CLEAN WATER IN REMOVAL OF PRECIPITATED MATERIAL AT THE BOTTOM OF THE OPEN PIT SOUTH MINING DISTRICT MAJDANPEK**

Abstract

The development of mining operations at the South Mining District Open Pit of the Copper Mine Majdanpek is conditioned in the following short term by removal the accumulated water, sludge and sediment from the inactive water collector from the level +150 m to the bottom of the Open Pit at +122 m. This must be done in order to create the conditions for the smooth development of the ore mining operations. This paper presents the technology of pumping the clean water.
Keywords: *Majdanpek, Open Pit South Mining District, clean water, sludge, sediment, pumping*

INTRODUCTION

The Majdanpek Copper Mine, which also includes the Open Pit South Mining District, is a part of the company Zijin Bor Copper doo. The Majdanpek Copper Mine, in production, technical and technological terms, is a complex mining system that has the activities ranging from the geological exploration of mineral resources, exploitation and processing of ore, to a range of supporting activities as a necessary support for the basic activities [1]. The production and processing of ore in the Majdanpek Copper Mine is currently taking place only at the Open Pit South Mining District and is of great importance for the copper production in the company system [2].

Mining activities at the Open Pit South Mining District are currently taking place in the eastern side of the Open Pit. Based on the current conditions of exploitation and location, the mining activities could be developed to the E140 level. According to the planned capacity, the works would take place in a period of six months. The amount of ore that can be mined during this period is about 4,000,000 tons.

In order to achieve the planned mining and processing capacity of the ore in the next short-term period of 600,000 tons of ore per month, it is necessary to provide the space conditions for the development of ore mining operations at the levels E215 – E110. This requires the drainage and removal of material from an inactive collector of water at the level of K150 m of altitude to the bottom of the Open Pit at the level of K122 m of altitude. This is necessary in order to create the conditions for undisturbed exploitation.

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CHARACTERISTICS OF MATERIALS IN ACCUMULATION POOL AT THE LEVEL K150 m OF ALTITUDE

Figure 1 shows an accumulation pool of K150 m of altitude. It is estimated that three layers can be separated in the accumulation pool: a layer of clean water, layer of slurry, and layer of sediment. It is estimated that the layer of clean water is about 8 m deep, its concentration of solid phase is below 20%, and the total volume of clean water is 350,000 m^3. The slurry layer is about 4 m deep, its solid phase concentration is 20% - 40%, and the total volume is 156,000 m^3. The sediment layer is about 18 m deep, its solid phase concentration is greater than 40%, and the total volume is 460,000 m^3. Figure 2 shows a longitudinal accumulation pool profile [4].

Figure 1 *Location of accumulation pool at the level 150 m of altitude of the Open Pit South Mining District*

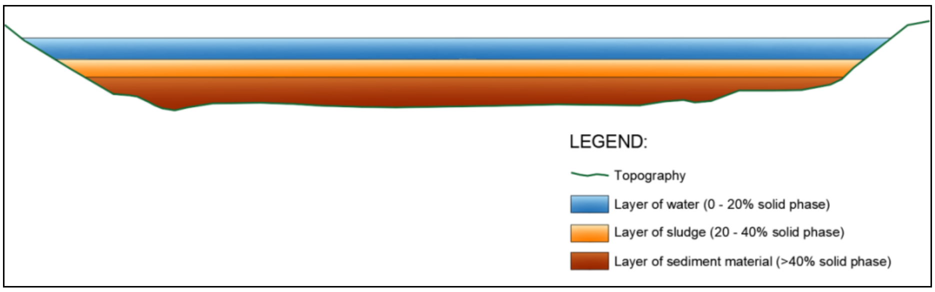

Figure 2 *Longitudinal accumulation pool at the level K150 m of altitude of the Open Pit South Mining District*

PUMPING OF CLEAN WATER

The existing system of clean water pumping

The existing system of water pumping from the Open Pit South Mining District is of the cascade type. A Flygt submersible pump, type BS 2250.011HT, was installed in the water tank at the K125 m of altitude level. The capacity of this pump is 360 m^3/h for a pump head of 22 m. The electric motor power of this pump is 54 kW. Water is pumped through a 200 mm diameter PVC pipe with a length of 135 m into an accumulation pool at K150 m altitude. At the K150 m level, one KSB type centrifugal pump, type VL-200, was installed. The capacity of this pump is 360 m^3/h for a head of 220 m. Water is pumped from the K150 m of altitude level by a 200 mm diameter PVC pipeline and 975 m long to the K350 m of altitude level next to the crushing waste plant. The pumped water is discharged into the Mali Pek River after passing through a zeolite precipitate [3].

Before starting the pumping of clean water from accumulation pool at the level K150 m, it is necessary to relocate the stable pump to a new location, north of the current location, so that the pumped water from the level K125 m does not return to the accumulation pool at the K150 m level. A part of the existing stable pump pipeline of 415 m is also being relocated. The length of the relocated stable pump pipeline is shorter by 195 m than the length of the existing pipeline. The pipeline of the submersible pump is also relocated. The relocated pipeline of the submersible pump is 60 m long. Figure 3 shows a line diagram of the existing water pumping system. The location of the existing water pumping facilities at current and relocated locations is shown in Figure 7.

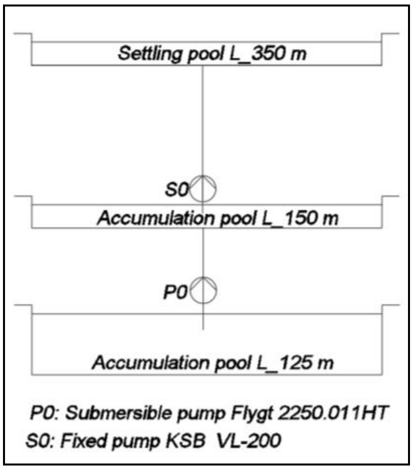

Figure 3 *Line diagram of the existing water pumping system*

Pumping of clean water from accumulation pool at the level K150 m of altitude

In the accumulation pool at the level K150 m, the estimated quantity of clean water is 350,325 m^3. Clean water is from the level K142 m to the level K150 m. The drainage system for this water will be of a cascade type. Submersible pumps will be installed in the accumulation pool which will pump water to the water collector at the level K180 m, from where the stable pumps will be pumped to the settling tank for the physical treatment of particulate matter at the level K350 m next to the waste crushing plant. Such purified water goes into the existing settling pool with zeolite from which it flows into the Mali Pek River. The position of the stable pumping station is conditioned by the state of mine works at the Open Pit and the already existing plateau at the level K180 m.

Submersible pumps in the accumulation pool at the level K150 m are of the KL300-75 type. The estimated pumping capacity of one pump for an average head of 37 m is 330 m^3/h. The electric motor power of one pump is 160 kW. Four pumps of this type are planned. Stable pumps at the level K200 m level are of the type MD360-92x2. For a head of 184 m, the pumping capacity of one pump is 360 m^3/h. The electric motor power of one pump is 315 kW. Three pumps of this type are planned. All pumps are automatically started in synchronization.

To pump the total amount of clean water from accumulation at the K150 m level, the required operating time of the submersible pumps is 265 h, and of the stable pumps is 324 h. With continuous operation of the system, the required pumping time of clean water from the accumulation pool at the level K150 m is 14 days. The required pumping time should be increased by 10-15% due to the water influx of atmospheric precipitation that may occur during this period, which fall directly into the accumulation pool area or reach the catchment areas from which they gravitate towards the accumulation pool. The required pumping time, taking into account the potential atmospheric precipitation is 15-16 days, i.e. the required operating time of submersible pumps is 298 h, and of stable pumps is 364 h.

Submersible pump pipelines are polyethylene 250 mm in diameter and 90 m long. Pipelines for stable pumps are made of reinforced plastic pipes 315 mm in diameter and 860 m long individually. Figure 4 shows a line diagram of the clean water pumping from accumulation pool at the level K150 m. The location of the water pumping facilities at the level K150 m is shown in Figure 7.

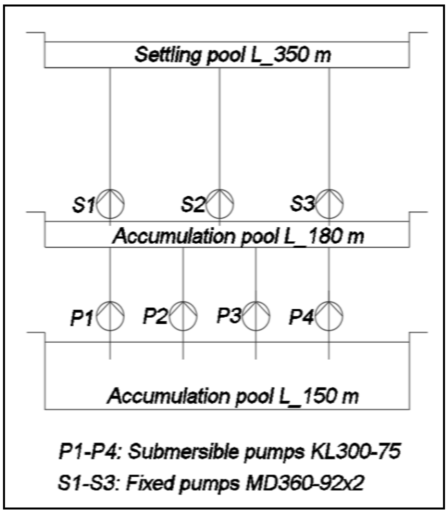

Figure 4 *Line diagram of the water pumping system from the level K150 m of altitude*

Pumping of clean water from water collector at the level K150 m of altitude

After pumping of clean water from accumulation pool at the level K150 m, the sludge layer is removed by cyclone. The amount of sludge in the accumulation pool is 155,700 m^3. Hydrocyclone overflow - clean water, returns to the water collector at the level K125. Dynamics of the hydrocyclone sand removal is such that the whole process takes 8 days. The amount of water from overflow is 121,700 m^3.

The pumping system for this water will be of a cascade type. Submersible pumps from the level K150 m will be relocated to the K125 m water collector, which will pump water to the K180 m water collector, from which water will be pumped to the level K350 m by the stable pumps for physical treatment of solid particles next to the waste crushing plant. Such purified water goes into the existing zeolite settling pool from which it flows into the Mali Pek River.

Submersible pumps in the water collector at the K125 m level are of the KL300-75 type. For a 75 m head, the pumping capacity of one pump is 300 m^3/h. The electric motor power of one pump is 160 kW. Four pumps of this type are planned. The position of water collector and stable pumps at the K180 m level is unchanged. An existing drainage system with one submersible and one stable pump remains in operation in the water collector at the K125 m level, which also performs the function of water pumping from the regular inflows. All pumps are automatically started in synchronization.

To pump the hydrocyclone overflow at the K150 m level, the required operating time of the submersible pumps is 101 h, and of the stable pumps is 113 h. With continuous operation of the system, the required pumping time of hydrocyclone overflow from the accumulation pool at the level K125 m is 5 days, however, the pumping dynamics must follow the cyclone dynamics so that the pumping phase will last for all 8 days of hydrocyclone operation. The required pumping time does not need to be increased for the influx of atmospheric precipitation because such water is pumped by the existing drainage system.

Submersible pump pipelines are polyethylene 250 mm in diameter and 300 m long individually. Pipelines for stable pumps are unchanged regarding to the phase of clean water pumping from the accumulation pool from accumulation pool at the level K150 m. Figure 5 shows a line diagram of pumping the hydrocyclone overflow and regular influx from the water collector at the level K125 m. The location of the water pumping facilities from the water collectors at the level K125 m is shown in Figure 7.

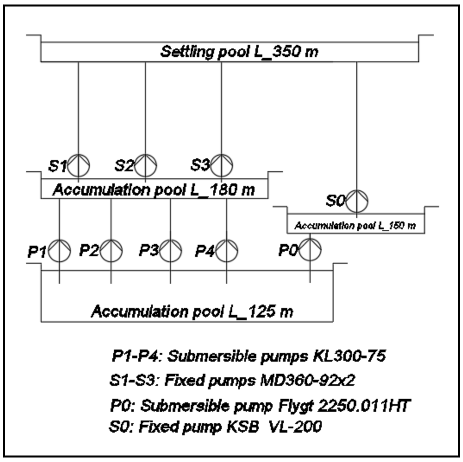

Figure 5 *Line diagram of the water pumping system from the level K125 m*

Clean water pumping in excavation the solid phase

The solid phase is excavated for 117 days. The amount of material is 459,225 m^3 from the K138 m level to the K120 m level. A submersible pump will be installed at the site, which will be relocated from the water collector at the k+125 m level. During the solid phase excavation, the pump changes position depending on the progress of work. The water appearing at the site will be pumped by this pump to the water collector at the level K180 m, from where it will be pumped to the settling pool for physical treatment of solid particles at the level K350 m next to the waste crushing plant. Such purified water goes into the existing settling pool with zeolite from which it flows into the Mali Pek River.

Submersible pump in the excavation of solid phase is of the KL300-75 type. For a 50 m head, the evaluated pumping capacity of one pump is 315 m^3/h. The electric motor power of one pump is 160 kW. The position of water collector and stable pumps at the K180 m level is unchanged. Submersible pump pipeline is polyethylene 250 mm in diameter and maximum length of 250 m. Pipelines for stable pumps are unchanged regarding to the phase of clean water pumping from the accumulation pool from accumulation pool at the level K150 m.

Four submersible pumps will be installed in front of the site in previously excavated depressing funnels, unless the funnel is filled with material. 8 kW individual pumps will be installed in these depressing funnels. Water is pumped through these pumps to the water collector at the K180 m level. For an average head of 51 m the estimated pumping capacity is 7 l/s individually. The average operating time of the pumps is 20 h per day. It is not possible to know the exact inflow of water to the site, so it is estimated that the submersible pump should operate 6 hours a day if no prior drainage of the depressing funnels is performed, or shorter if a prior drainage of the depressing funnels is carried out, so that the electricity consumption is the same in both variants [3]. Figure 6 shows a line diagram of pumping water during solid phase excavation. The location of water pumping facilities from the solid phase is shown in Figure 7.

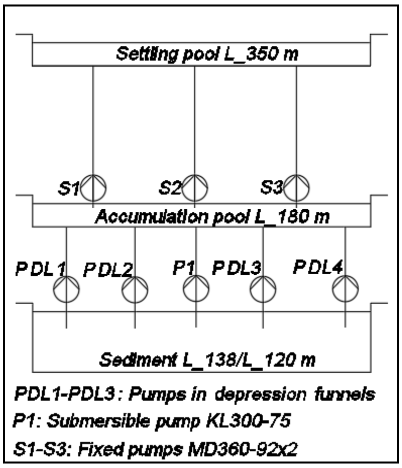

Figure 6 *Line diagram of the pumping system in the solid phase excavation*

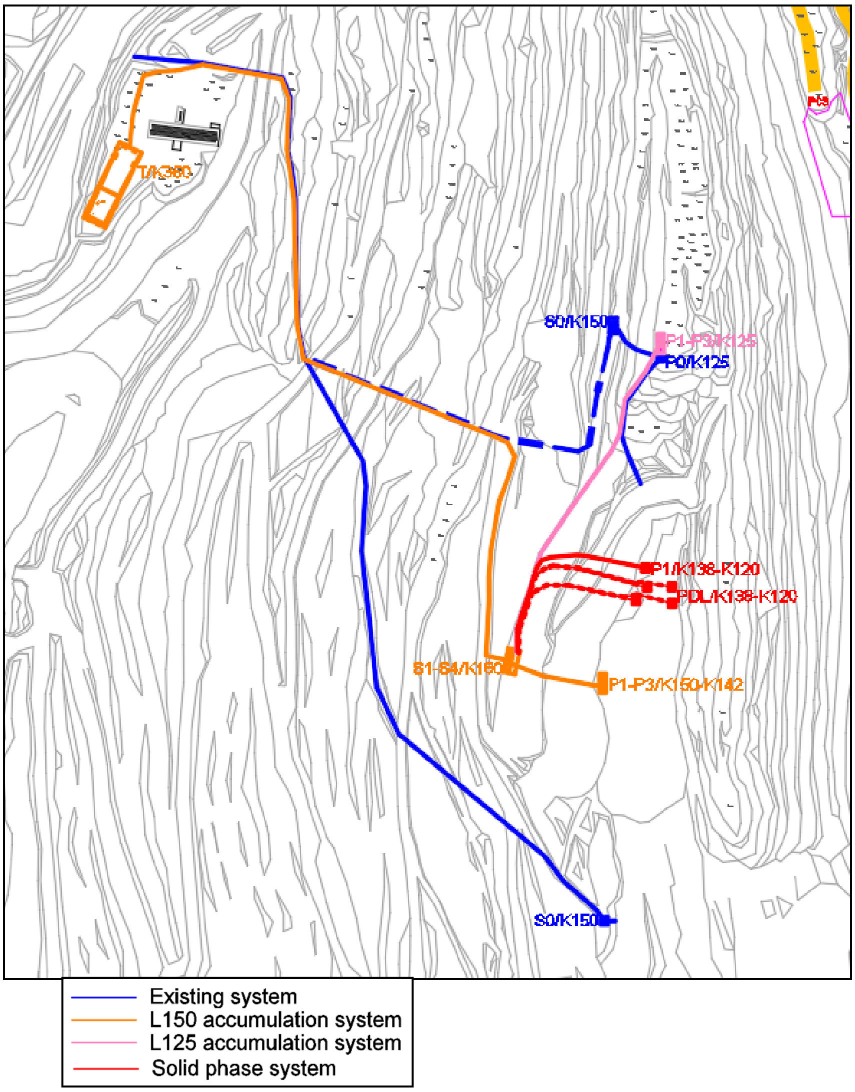

Figure 7 *Position of facilities for pumping of clean water*

CONCLUSION

In order to ensure the realization of 600,000 tons of ore excavation and processing per month, it is necessary to create the spatial conditions at the bottom of the Open Pit South Mining District. To this end, it is necessary to remove layers of water, sludge and sediment from the inactive water collector at the level K150 m of altitude. The works will be carried out in three phases. Clean water will be removed first, then the sludge layer will be removed, and eventually the sediment layer will be removed.

All three stages of material removal include the pumping of clean water. The proposed technology foresees the maximum utilization of existing, and engagement a new drainage equipment, which is needed due to the time limitation of the works. Technology designed to ensure the safe operation of people and equipment during mining operations has also been proposed.

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METHODOLOGY FOR ANALYSIS AND CALCULATION THE DISCONTINUOUS LOADING AND TRANSPORT SYSTEMS IN PREPARATION THE TECHNICAL DOCUMENTATION USING THE RPMGLOBAL - TALPAC SOFTWARE[**]

Abstract

This paper presents the software methodology of modeling load and haulage systems in open pit mining, necessary data required for modeling and analysis, methods of simulation for the purpose of optimisation and some of the final optimisation results. Although there are more than one software programs that are in use for this purpose, this paper is focused exclusively on software RPMGlobal Talpac. The paper's goal is to show the importance of accuracy of input parameters for realistic modeling and simulation of load and haulage systems for the purpose of correct results from the analysis.

Keywords: *mine planning software, modeling of open pit transport systems, load and haul optimisation and analysis*

INTRODUCTION

For the purpose of calculation and analysis the technological phase of truck transport, several software programs are applied in the preparation of technical documentation in the surface exploitation. This paper describes the methodology for implementation the Talpac software of the RPMGlobal Company. The Talpac software is used worldwide to analyze the productivity of surface transportation and loading systems. The software, by modeling the real operating conditions, determines the necessary parameters for the technological and economic evaluation of discontinuous loading and transport systems [1, 2, 3]. The aim of these efforts is to determine the most profitable excavation plan and the highest rate of return of invested funds [4, 5, 6, 7].

DESCRIPTION OF THE INPUT PARAMETERS FOR THE SIMULATION PROCESS OF DISCONTINUOUS LOADING AND TRANSPORT SYSTEMS

Modeling of the real operating process is achieved by simulating the same, with the input parameters varying within the real operating limits. Depending on the need, i.e. whether studies, technical projects or operational plans are made, the various capabilities of the Talpac software are used. The basic Talpac software window is shown in Figure 1.

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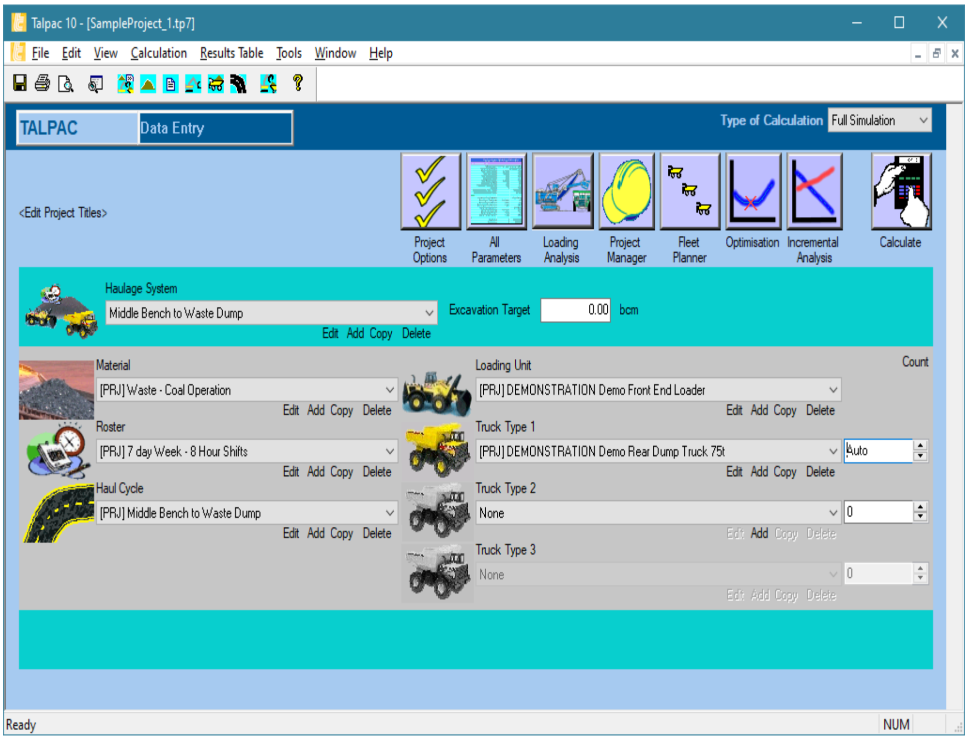


Figure 1 *The basic Talpac software window*

The loading and transport system is defined in the Talpac software by the following software components [8, 9]:

- type of material (physical mechanical characteristics, technological parameters such as coefficient of loosening and loading of a bucket),
- production "roster" (number of operational days in a year, operational and non-operational time losses in a year and shift and organization of work),
- selected loading equipment (type and technological parameters of loading equipment),
- selected transport equipment (type and technological parameters of a truck),
- transport cycle (transport relation characteristics).

The following Figures 2 and 3 provide an overview of a window for adjustment the basic components of loading and transport systems.

SIMULATION METHODS OF THE DISCONTINUOUS LOADING AND TRANSPORT SYSTEMS

Production analysis of the loading and transport system in the Talpac software is achieved through two types of simulation or type of calculation, as follows [8, 9]:

- "Quick Estimate", and
- "Full Simulation"

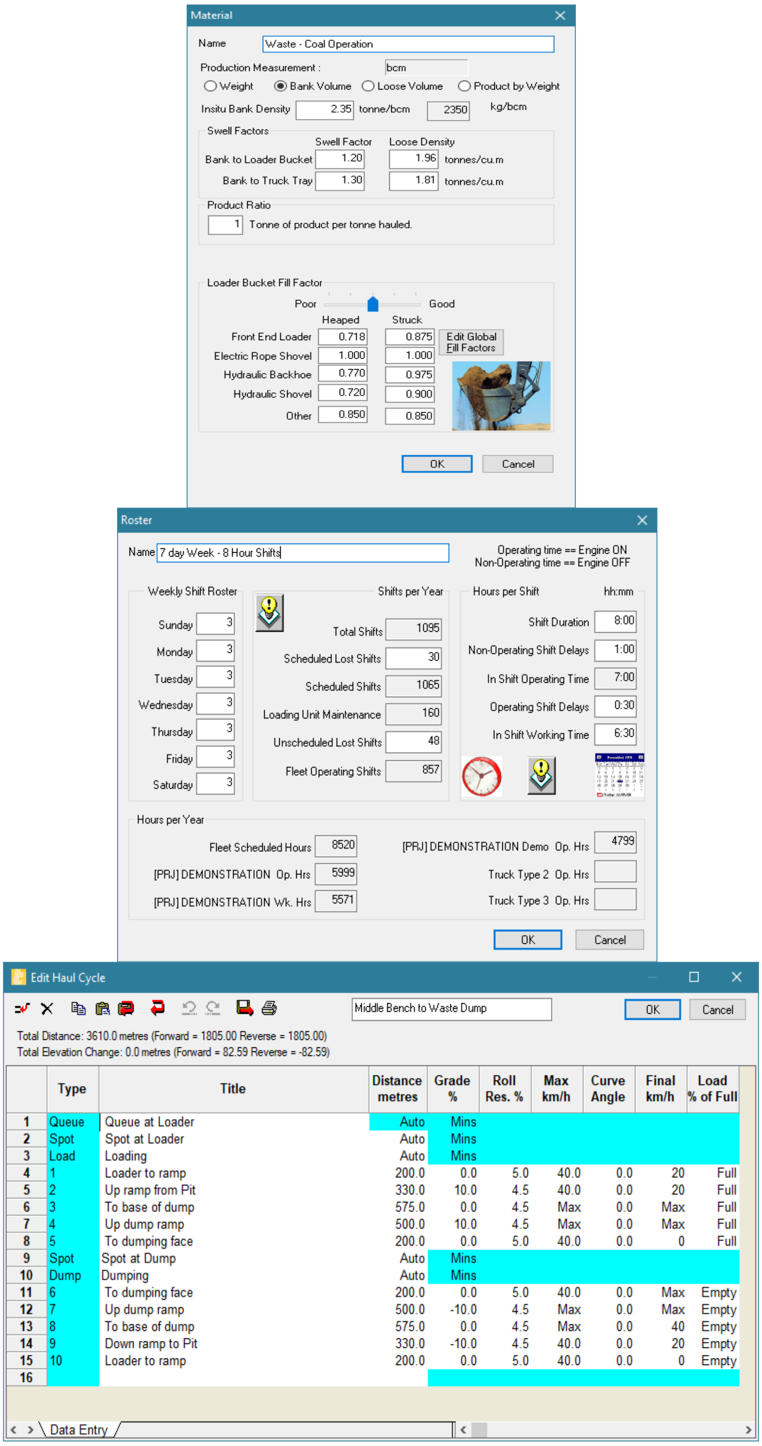


Figure 2 *Windows for adjustment the Material, "Roster" and Transport Cycle components*

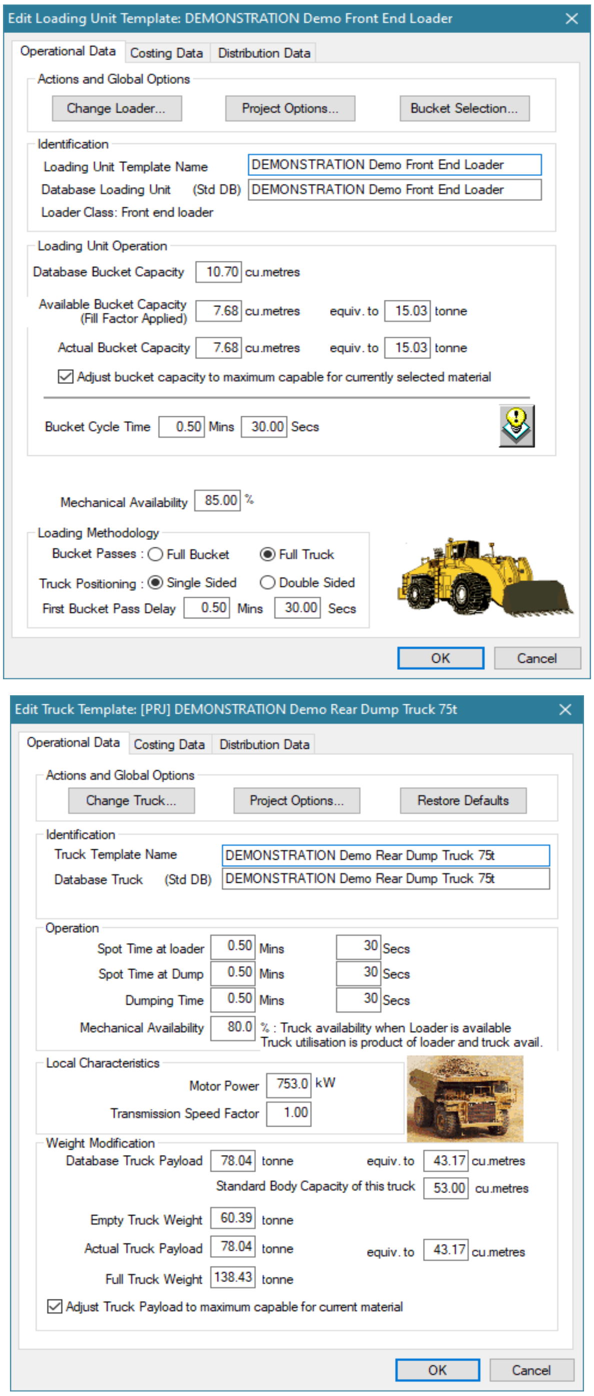


Figure 3 *Windows for adjustment the selected loading and transport equipment*

The "Quick Estimate" calculation implies that there is no variability in the technological parameters of loading and transport equipment and is a deterministic type of analysis.

The "Full Simulation" calculation is a stochastic type of analysis that takes into account a variability of operational loading and transport parameters such as the loading cycle time, amount of material in a loading bucket, and the transport cycle time due to the variability of time losses (truck waiting for loading). Due to the simulation of real-life conditions in production, the "Full Simulation" results are more credible and this type of simulation is a fundamental for calculation the technological phase of transport. The following figure (Figure 4) shows the graphs of the distribution of parameters that vary with loading and transport.

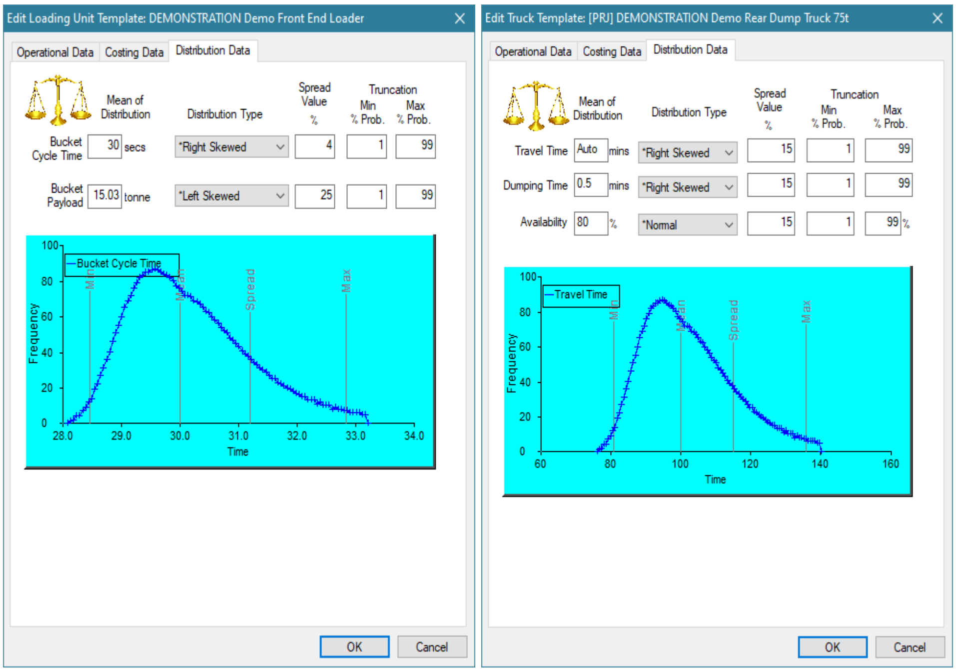


Figure 4 *Window for distribution the loading and transport parameters whose variability is simulated in the "Full Simulation" analysis*

Since that the Talpac analyzes in detail one specific transport route, the result is an analysis of the truck operating (exploitation) capacity and fuel standard for that specific route, for example the route of ore transport from a particular bench to the primary crusher. The number of trucks required to achieve the planned production in a given period is obtained by the weighted average the truck operating capacity for all active benches during that period. In the same way, the weighted average of fuel standard is calculated on the basis of the individual values of fuel standards for specific routes that are active in a given period.

SOFTWARE CALCULATION OF A TRUCK CAPACITY

The software calculation of the exploitation capacity of a truck in the Talpac can be represented by the following formula:

$$Q_h = \frac{N_k}{T_c} \cdot k_{vi}, t/h$$

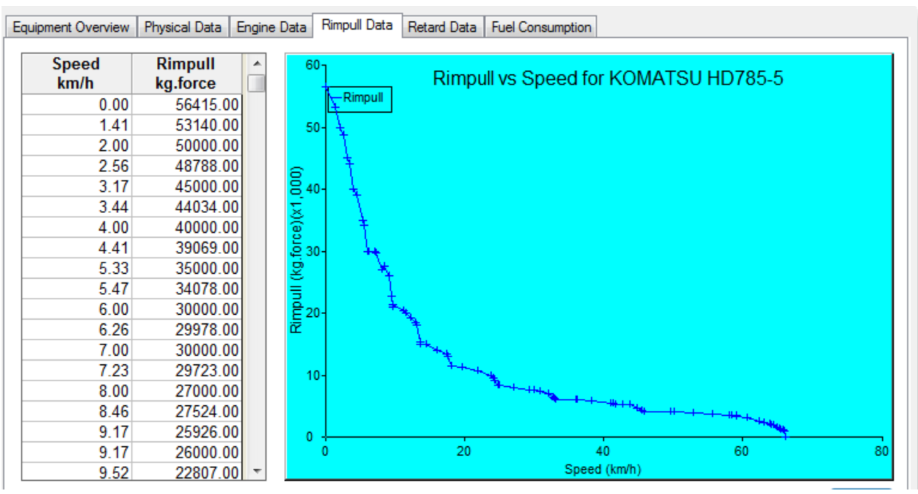
where:

- N_k – actual truck capacity (t),
- Tc – time of a transport cycle (Talpac simulation of real conditions),
- k_{vh} – time utilization (adopted as 50 min / 60 min or 0.833)

It is specific is that the software simulates the loading into trucks for all shifts in a year and as a result gives an average, so that the exploitative, i.e. the truck operating capacity is represented by the following formula [10]:

$$Q_h = \frac{\sum\left(\begin{matrix}\text{All simulated}\\ \text{transport cycles in a year}\end{matrix}\right)}{\left(\begin{matrix}\text{Total number of}\\ \text{simulated shifts in a year}\end{matrix}\right)} \div (\text{Operative time in a shift})$$

The speed of a truck is affected by the characteristics of a transport route (slope and rolling resistance), technical characteristics of a truck and classic driving conditions such as the periods of acceleration, deceleration and constant driving on a given transport route. From the technical characteristics of a truck, the Talpac uses the "rimpull" and "retard" graphics, i.e. a dependence of the movement speed and force that a truck can overcome at that speed. The following figure shows an example of the rimpull and retard curve for one truck from the Talpac software database (Figure 5).



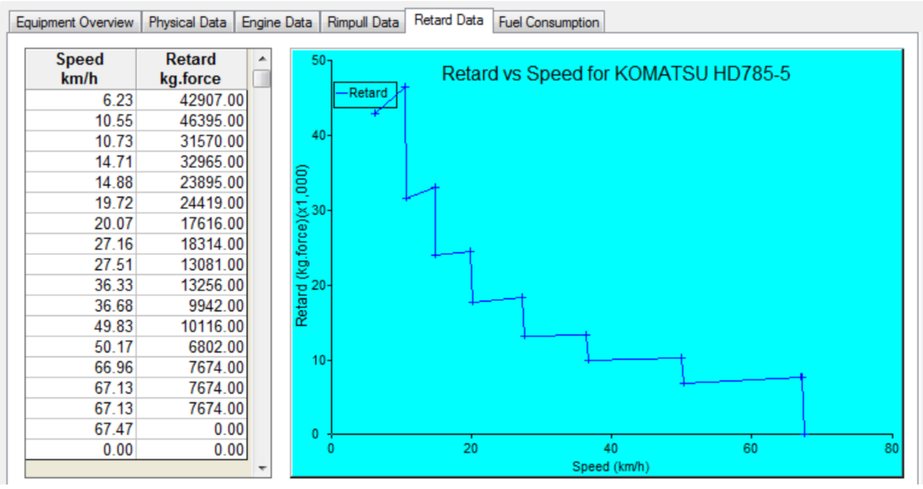


Figure 5 *"Rimpull" and "Retard" graphics of a truck from the data base of the Talpac software*

The force that a truck must overcome is affected by the force created by the truck weight and material in a truck basket, the rolling resistance force and the characteristics of transport route (slope). The geometric relationship of these forces is shown in the following figure in an example of the truck slope (Figure 6) [10].

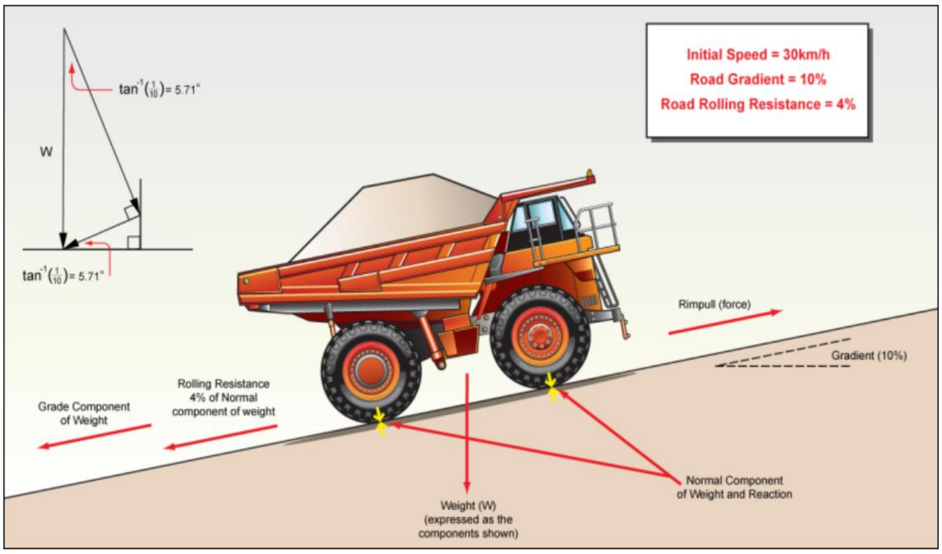


Figure 6 *Schedule of forces affecting the movement of truck* [10]

SOFTWARE CALCULATION OF THE TRUCK FUEL CONSUMPTION

To calculate the fuel consumption, the assumption is that the fuel consumption is directly related to the percentage of "rimpull" force used to the maximum. The software calculates the fuel consumption for each segment of the route separately, for the movement of full and empty truck, thus resulting in the final fuel consumption for the entire transport route. The following figure shows a diagram showing the ratio of actual and maximum "rimpull" force of a particular truck, which is the basis of software determination the fuel consumption (Figure 7) [8, 9, 10].

Software calculation of the fuel consumption in each segment of the relation is performed by the following formula [7]:

$$\Delta f = \left(\frac{R_u}{R_m}\cdot\frac{(F_{100}-F_0)}{60}+\frac{F_0}{60}\right)\cdot\Delta t$$

where:

- Δf – fuel consumption for individual segment of the transport route (l),
- R_u – required rimpull force
- R_m – maximum rimpull for the selected truck type
- F_{100} – fuel consumption at 100% of rated engine power (l/h)
- F_0 – idle fuel consumption (l/h)
- Δt– time of truck movement on a single route

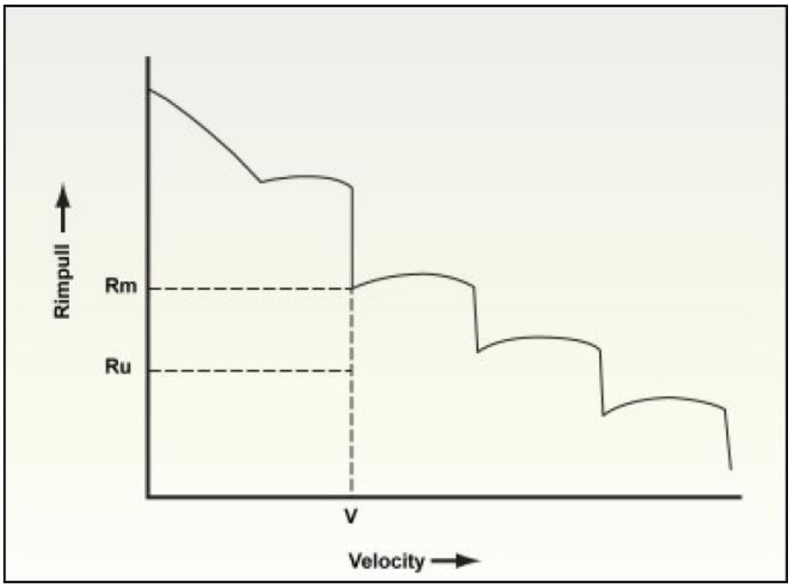


Figure 7 *Ratio of the used and maximum"rimpull" force* [10]

The total fuel consumption (f_t) is obtained by accumulating the fuel consumption in all individual segments, with the addition of fuel consumption in which the machine did not operate effectively, i.e. losses due to a truck waiting for loading whereby the fuel consumption is determined solely by the idle fuel consumption (F_0). So the average hourly fuel consumption for a transport route can be represented by the following formula [10]:

$$F = \left(f_t \cdot N_{\frac{cycle}{h}}\right) +$$
$$+\left[60 - \left(N_{cycle/h} \cdot T_{cycle}\right)\right] \cdot \frac{F_0}{60}, l/h$$

where:

f_t – total fuel consumption of a transport cycle (l)

$N_{cycle/h}$ - number of transport cycles in one hour

T_{cycle} – transport cycle time (min)

The fuel consumption standard (l/t) is obtained from the calculated values of operating hour capacity (t/h) and the average hourly fuel consumption (l/h) for each transport route, while the average weighted value of the standard of all transport routes is taken as the annual fuel standard in that year.

The Talpac does not calculate the oil and lubricant consumption, but it is adopted up to 5% of the weighted average fuel consumption software results, or if known, the oil and lubricant standard is adopted according to the manufacturer's recommendations for the equipment selected.

DETERMINING THE REQUIRED NUMBER OF TRUCKS

Since the Talpac processes one route in detail, and there are several routes over a period (year), the determining the number of truck is done by the classical procedure, i.e. over the truck annual capacity.

The annual capacity of a truck is calculated by the following formula:

$$Q_{year} = Q_h \cdot n_{h/year} \cdot k_{mr} \cdot k_r, \text{ t/year}$$

where:

Q_h(t/h) – exploitation (operating) hourly capacity of a truck (average weighted value of software results)

$n_{h/year}$ – number of working (operating) hours per year

k_{mr} – coefficient of the mechanical machine availability (to be adopted around 85% provided that it is not calculated through the number of operating hours in the year $n_{h/year}$)

k_r – coefficient of the physical machine availability (about 90 to 95% is adopted)

The required number of trucks is determined by the following formula:

$$N_{truck} = \frac{A_{year}}{Q_{year}},$$

where:

A_{god} – annual production of the ore and waste (t).

CONCLUSION

The advantage of using the Talpak software in analyzing the discontinuous loading and transport connections is the ability to quickly see the impact of a route change, loading and transport mechanization and other technological parameters of loading and transport on the economic parameters of the transport system and expected production results. The software has a database of loading and transport equipment most commonly used at the open pits in the world. Since the accuracy of the software results depends on the accuracy of input data, the software application is conditioned by the qualitative determination of all the necessary input parameters of the transport system being analyzed.

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Cornelia Muntean, Adina Negrea*, Narcis Duteanu*, Mihaela Ciopec*, Petru Negrea*, Oana Grad**

MINING ACTIVITY - ENVIRONMENTAL IMPACT IN THE WEST AREA OF ROMANIA**

Abstract

Pollution is a major problem updated in every corner of the world. The sources of pollution are diverse, from the natural pollution to the anthropogenic pollution. Anthropogenic pollution has a significant impact. Industrial activity, with all its fields, represents one of the most important sources of anthropic pollution. Also, the mining activities can be a source of pollution worth considering. Even if the mining activity has been completed, the possibility of pollution exists. Mining activity is the major source of industrial waste. At present, the mining units can fall into three categories: active mining, where the activity continues; in conservation mining, where the closing and greening program has not yet been applied; closed mining, which are in the Closing and Greening Program. The most affected environmental factors can be the sources of water, soil, but also air.

Keywords: *environment, West area of Romania, pollution*

INTRODUCTION

The West area Mining activity of Romania is bordered by the Danube River and Serbia in the South-East and Hungary in the North-West. The area includes four counties Arad, Caraş-Severin, Hunedoara and Timiş.

The total surface of west area is 32.034 km^2 which represents 13.44% from surface of Romania. The area has a diversified and harmonious relief distributed in plains, hills and mountains.

The plains are part of the Western Plain and predominate in the Timiş County. In Caraş-Severin and Hunedoara the mountains occupy 65% of the surface and the most important mountain altitudes of the region are: Parang Peak 2519 m (Parang Mountain), Peleaga Peak 2509 m and Retezat Peak 2482 m (Retezat Mountain) [1].

The Banat Hydrographic area is 18,393.15 km^2, which represents 7.7% of the Romanian territory and extends from the South of Mures to the Cerna river confluence with the Danube. The hydrographic network includes 389 watercourses, with the total length of 6,705 km (excluding the length of the Danube River section that borders the Banat Hydrographic Area and which is 145 km) and the average density of 0.36 km/km^2, the value very close to the density of the hydrographic network of Romania (0.33 km/km^2).

The Banat Hydrographic Area is composed of six hydrographic basins and hydrographic basins of the direct left tributeries of the Danube River between the Nera and Cerna basins [2].

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The climate is moderate-continental, with the Mediterranean influences on the Danube and Cerna Valley (CS) with the multiannual average temperatures ranging from 10-12°C. The multiannual average rainfall is between 560-580 L/m^2 that is significantly higher in the mountain areas [1].

NATURAL RESOURCES

As a result of the varied relief, the area possesses rich and diverse natural resources: *liquid and gaseous hydrocarbons* in the plains (Pecica, Turnu, Șandra, Calacea, Dudeştii Vechi), *metalliferous ores* (iron, manganese, molybdenum, copper, uranium, precious metals) in the hill and mountain areas. *Gold and silver* are found in Chisnidia, Dud, Cladova, *iron* in Dezna, Moneasa, Ocna de Fier, Dognecea.

In Hunedoara and Caraş-Severin counties the coal deposits are concentrated at Lupac, Doman, Secu, Sinersig, etc. Anina is the oldest coking coal mine in Romania. Construction materials are located along the Mures Valley (sand, granite, granodiorite and diorite) and Crişul Alb (andesite, asbestos) in the Western Plain (refractory clays), in Carpiniş, Biled, Jimbolia marble at Ruşchiţa, crude oil and gas at Biled, Satchinez, sand for glass in Tomeşti [1].

The thermal and mineral springs are also important natural riches of the region, which are known and captured since ancient times. The spa potentials of thermal water from Băile Herculane (Caraş-Severin county), Geoagiu Băi (Hunedoara county) are exploited.

The mineral waters from Lipova (Arad County), Buziaş (TimişCounty) and the flat water from Băile Herculane (Caraş-Severin County) are intensely used.

The important forest resources of the area (31% of the total area) exceeds the national average (28%). In Hunedoara and Caraş-Severin counties, this percentage is much higher (44% - 46%) [1].

Water resources consist of surface and groundwater. They can be alimiting factor of the regional economic development especially if is comparative with the demands of populations [3].

In Caraş – Severin County, the total technically usable water resources of the Banat Hydrographic area are approximately 1.50x10^9 m^3/year, from which 392.2x10^6 m^3/ year are surface water and 1.11x10^9 m^3/year underground water.

In the Banat Hydrographic area of Caraş-SeverinCounty, a number of 247 bodies of water in the natural state were delimited. From 247 bodies of water, 33 are monitored and 214 are not monitored. The total number of monitoring sections is 36.

The results indicate that 165 (66.80%) natural water bodies are in a good ecological condition, 82 (33.20%) bodies of water are in a moderate ecological state. Chemical status was good in 212 (85.83) %) bodies of water and poor in 35 (14.17%) bodies of water.

In the Caraş-Severin county, a number of 66 highly modified and artificial bodies of water (65 highly modified bodies of water and 1 artificial body of water) were delimited, of which 23 monitored (22 CAPM and 1 artificial) and 43 unmonitored, with a number of 26 monitoring sections.

The chemical state was determined for cadmium, lead (dissolved fraction) and organic micro pollutants. The results indicate that 24 (36.37%) of strongly modified bodies of water have good ecological potential, and 42 (63.63%) strongly modified bodies of water have moderate ecological potential. The chemical state of the highly modified bodies of water was good in 34 (51.52%) and bad in 32 (48.48%) of them [3].

The total theoretical water resources of the Banat Hydrographic Area in Timis Countyare approximately 4.58x109 m^3/year, out of which 3.38 x 109 m^3/year surface water and 1.20 x 109 m^3/year underground water.

In the Banat Hydrographic Area of Timiş County, in the rivers subsystem, a number of 247 bodies of natural water were delimited. Out of these, 33 bodies of water are monitored and 214 are not monitored. The total number of monitoring sections is 36.

The results of classification the bodies of water (monitored and not monitored) in the corresponding ecological and chemical states indicate that 165 (66.80%) bodies of water fall into a good ecological state, 82 (33.20%) bodies of water fall into a moderate ecological status.

In the Bega river basin, 37 surface bodies of water were delimited, out of which 6 bodies of water were monitored and 31 bo-dies of water were interpreted by similarity. The largest river in this river basin is the 170.132 km Bega River, which gathers its springs from the North-West slope of the Poiana Ruscăi Mountains, receives tributaries from their western slopes and from the southern half of the Lipova hills. From Timisoara, the Bega river continues through the Bega channel which drains a basin area of 2362 km^2 with an average altitude of almost 240 m.

In the Timiş river basin, 99 bodies of water were delimited, out of which 10 bodies of water were monitored and 89 bodies of water were interpreted by similarity. The Timiş River is the richest water resource in the Banat Hydrographic Area which drains a basin area of over 5677 km^2.

Its length totals 234,748 km. The river Bârzava with its boundary in the area of the western side of the Semenic mountain captures the streams of the Semenic channel which drains the basin area of 38 km^2 (25 km^2 in the upper basin of the Timiş river) and take from the upper Nera basin the water on a receiving surface of approx. 13 km^2 [3].

The surface freshwater represents the majority of the fresh water reserves. The water surfaces are classified as a standing water (seas and oceans, lakes, ponds, marshes) and flowing water (spring - stream - river).

The results of classification the water bodies, lakes, in the categories of ecological potential and the corresponding chemical state, in the Caras-Severin County, reveals that the 8 (100.00%) bodies of water have moderate ecological potential. The chemical condition was good.

THE IMPACT OF MINING ACTIVITIES ON THE ENVIRONMENT

The quantities of pollutants discharged by economic activities (tones/year) - 2011 in Bega Timiş, Timiş County are presented in table below [3].

The pollution produced by different industrial activities affects the quality of soils, in different degrees. In the field of soil protection, generally by pollution is understood any disturbance that affects the quality of soils from the qualitative and / or quantitative point of view.

In the Caraş-Severin county, the area occupied with industrial waste and house hold inventory so far is 459.32 ha, out of which: 5.15 ha covered with ash from CTE Crivina Anina; 29.25 ha covered with the household waste, in the urban environment from which (those from rural area were closed on July 16, 2009, rehabilitated and reproduced in the natural circuit); 245.01 ha are occupied with tai-lings from the extractive industry; 60.51 ha are covered with slag resulting from the processes of ferrous metallurgical industry [3].

In the Timis County, the soils are affected by different industrial and agricultural activities on an area of 3764 ha, as follows:

- Code. 01. Pollution (degradation) of soils by up-to-date mining, ballast, quarries - areas heavily and excessively affected by ballast and quarries, 3350 ha. These deepen the waterbeds causing the decrease of water level to and consequently reduce the water reserves in the surrounding areas, but also disturb the soil by depositing extracted materials.

- Code 02. From recordered data pollution with deposits, dumps, tailings ponds, tailings dumps, floating dumps, etc. affects excessively on 85 ha.
- Code 06. Pollution with the organic waste, resulted from the food industry and light industry affects the soil strong and excessive on an area of 12 ha, much smaller than that caused by the other industrial activities.
- Code 07. Pollution with the agricultural and forestry waste and vegetable residues - from the statistical data results that this type of pollution affects the soil on an area of 15 ha in a strong and excessive mode.
- Code 08. Pollution with animal manure - this type of pollution affects in strong and excessive mode the soil on an area of 282 ha.
- Code 20. Pollution with fuel from the extraction, transport and processing - this type of pollution affected a small areas of soil, especially the soil in the fuel parks of SC Petrom SA[3].

CONCLUSION

Mining activity is the major source of industrial waste. At present, the mining units can fall into three categories: active mining, where the activity continues; in conservation mining, where the closing and greening program has not been yet applied; closed mining, which are in the Closing and Greening Program [4, 5].

The exploitation of useful resources from mining areas, following the exploitation is imperative necessary in order to reduce the environmental pollution.

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Ivana Jovanović, Daniel Kržanović*, Vesna Conić*, Dejan Bugarin**

REMOVAL OF A SLUDGE LAYER FROM A PART OF THE OPEN PIT SOUTH MINING DISTRICT MAJDANPEK**

Abstract

This paper describes one of the phases of the technological solution for removal the accumulated material from a part of the Open Pit South Mining District – Copper Mine Majdanpek. It is necessary to clean the material for the purpose of undisturbed further work at the Open Pit. Three layers can be separated in the accumulated material. Each layer requires the use of a different removal technique, where this paper describes the technology of cleaning the middle sludge layer. Hydrocyclone application was proposed to remove the sludge layer, whereby the sludge contains 20-40% of solids. Classification of the sludge will be performed to obtain the underflow containing about 70% of solids and overflow containing 7-20% of the solid phase. The overflow would be gravitationally transported to the water reservoir within the Open Pit, while the underflow would be transported by trucks to a separated waste landfill.

Keywords: *South Mining District Majdanpek, sludge removal, hydrocyclone, pump*

INTRODUCTION

The Open Pit South Mining District Majdanpek operates within the company Copper Mine Majdanpek, which is a part of the company Zijin Bor Copper doo Company (former Mining and Smelter Basin Bor Group) [1]. Mining activities at the South Mining District Majdanpek currently take place in the eastern side of the Open Pit. The ore excavation takes place at the bench B 215. Based on the current exploitation conditions and situation on the site, the mining operations can be developed to the bench B 140. However, in order to maintain the continuity of ore excavation and to follow the short-term schedule defined in the Annual Operational Plan, it is necessary to enable the development of mining works on the benches B 215 to B 110 within the designed boundaries. This requires the drainage and removal of materials from the water accumulation pool from the level +150 m to the bottom of the pit, which is at the level of +120 m. This is necessary in order to create the conditions for the ore excavation to be carried out smoothly [2].

Material in the accumulation pool comes from excavation works and atmospheric precipitations. According to the assessment, the three layers can be separated:

1. Clean water layer
2. Sludge layer
3. Sediment layer.

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It is estimated that the clean water layer is about 8 m deep with the solid phase concentration below 20% and the total water volume is 350,000 m^3. The sludge layer is about 4 m deep with the solid phase concentration 20-40%, and the total volume is 156,000 m^3. The sediment layer is about 18 m deep with the solid phase concentration greater than 40%, and the total volume is 460,000 m^3. Figure 1 schematically shows the accumulation pool with clearly separated layers.

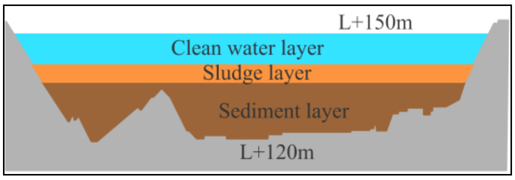

Figure 1 *Profile of the accumulated layers*

Drainage of the clean water layer will be a cascade type. Submersible pumps will be installed in the accumulation to pump water to the water collector at the level L+180 m, from where will be pumped by the stable pumps to the precipitator for physical treatment the solid particles at the level L+350 m next to the crushing plant. This purified water goes into the existing precipitator with zeolites from which it is discharged into the Mali Pek River.

Cleaning of the sediment layer involves the excavation of material, its loading into trucks and transportation to the waste landfill. This technology is well described in [3]. Removal technology of the sludge layer will be outlined below.

MATERIAL PROPERTIES

In the Laboratory for Mineral Processing of the Mining and Metallurgy Institute Bor, the pH value of water, as well as density and particle size distribution were determined on samples from the sludge layer. Particle size distribution is shown in Table 1. The density of the solid material is 2.764 kg/m^3, while the water pH is 6.69. The bulk density of material in the dry state is 1.8 t/m^3.

Table 1 *Particle size distribution of sample from the sludge layer*

d(mm)	m%	R%	D%
-16.0+10.0	10.80	10.80	100.00
-10.0+8.0	2.80	13.60	89.20
-8.0+3.35	0.60	14.20	86.40
-3.35+1.70	0.20	14.40	85.80
-1.70+0.600	0.60	15.00	85.60
-0.600+0.300	0.40	15.40	85.00
-0.300+0.180	1.00	16.40	84.60
-0.180+0.150	1.00	17.40	83.60
-0.150+0.106	2.80	20.20	82.60
-0.106+0.075	4.00	24.20	79.80
-0.075+0.053	3.40	27.60	75.80
-0.053+0.038	6.00	33.60	72.40
-0.038+0.020	9.20	42.80	66.40
-0.020+0.000	57.20	100.00	57.20

In order to gain a clearer insight into the distribution of fine particles in the sample of sludge from the accumulation pool, an additional testing of class –0.180+0 mm is performed on a Malvern Mastersizer 2000 device. The results are shown in Figure 2.

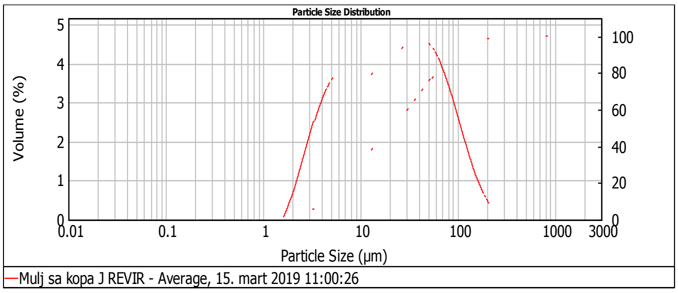

Figure 2 *Particle size distribution of sample from the sludge layer (class –0.180+0 mm)*

PROCEDURE FOR A SLUDGE LAYER REMOVAL

The technical solution of cleaning the deposited material in a sludge layer from a part of the Open Pit South Mining District Majdanpek is presented in accordance with the basic data and requirements provided by the Zijin Bor Copper doo Company.

The planned procedure would include the following: material would be pumped out with a centrifugal slurry pump installed at the pontoon pump station, which can be moved as needed (in accordance with the operating requirements). The pumped material would be transported through the pipeline to the hydrocyclone battery for classification, i.e. for separation into the underflow and overflow. Hydrocyclones are located near the water collector, on its north side, at the elevation of L+135 m.

The hydrocyclone underflow, containing 70% of the solids, will be deposited at the site provided therein within the Open Pit, northern from the existing water collector. The settled underflow would be further loaded onto trucks by the excavator, and transported to a landfill outside the open pit. The overflow, which, depending on the amount of solids content in the feed pulp, contains 7.5-20% of solids, would be transported to the existing water collector at the level L+125 m. From there, water will be further pumped into the Mali Pek River. The technological scheme of sludge layer cleaning is shown in Figure 3.

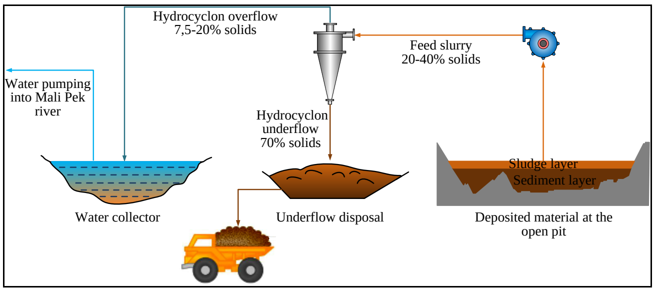

Figure 3 *Technological scheme of pumping and cycloning of the sludge layer*

The expected processing rate of the system is 1,019.46 m^3/h with the solid phase content in the feed slurry 20-40%. Thereby, the expected underflow rate is 221 m^3/h (percentage of solids in the underflow is 70%). On the other hand, the volume rate of overflow, as well as its pulp density, will vary depending on the feed parameters. As the basic data for the mass balance calculation, the mean value of solid content in the feed slurry is taken and it amounts 30%. Mass balance is shown in Table 2 and corresponds to the given input parameters. Each change in the composition of the feed slurry consequently influences a change in mass balance.

Table 2 *Mass balance in the process of sludge layer cycloning*

Technological line	Feed	Hydrocyclone underflow	Hydrocyclone overflow
Dry ore quantity, Q (t/h)	378.26	279.62	98.64
Water quantity, Q_W (t/h)	882.61	119.84	762.77
Slurry quantity, Q_S (t/h)	1,260.87	399.46	861.41
Ore density, ρ (kg/m^3)	2,764.0	2,764.0	2,764.0
Percentage of solids, S (%)	30	70	11.45
Slurry density, ρ_S (kg/m^3)	1,236.80	1,807.48	1,078.84
Ore volume, V (m^3/h)	1,36.85	101.16	35.69
Water volume, V_W (m^3/h)	882.61	119.84	762.77
Slurry volume, V_S (m^3/h)	1,019.46	221.00	798.46

In order to reconcile the capacity of cycloning plant with the capacity of truck transport, the plant is scheduled for 8 days operation, in three shifts, 20 working hours per day.

Considering the slurry characteristics, its transport capacity of 1,019.46 m^3/h, the pumping height difference of 28 m, and the transport length of 600 m, installation of two centrifugal slurry pumps (Q=1,271 m^3/h; H=64.6 m, Ne=355 kW) are predicted. One pump will be in operation and one is for reserve.

In the slurry cycloning procedure, it is planned the installation of 12 hydrocyclones with a diameter of 500 mm. Depending on the working conditions, i.e. the density of the feed slurry, a different number of hydrocyclones will be used (6–9), while the other hydrocyclones will serve as a reserve.

For the slurry transportation, it is planned the installation of the polyethylene pipeline with the pipe diameter of 250 mm.

CONCLUSION

The accumulation pool is located in a part of the Open Pit South Mining District Majdanpek, consisting of material from the excavation works and atmospheric precipitation. In order to create the conditions for the undisturbed ore exploitation, it is necessary to clean this material from the Open Pit. The accumulated material can be separated into three layers (water, sludge and sediment), where each layer requires the use of a different removal technique. The hydrocyclone technology will be applied for cleaning the middle sludge layer. Slurry from this layer will be classified into the underflow containing about 70% of solids and overflow containing 7-20% of solids. The underflow would be transported by trucks to a separated waste landfill, while the overflow would be gravitationally transport-ted to the water reservoir within the Open Pit. The expected feed slurry capacity is 1,019.46 m^3/h, where the underflow capacity amounts 221 m^3/h. The proposed technology involves the installation of two centrifugal slurry pumps, a 600 m long pipeline and a battery of 12 hydrocyclones.

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VALORIZATION OF THE MINERAL AND THERMAL WATER OF KOSOVO AND METOHIJA IN A FUNCTION OF HEALTH TOURISM

Abstract

Valorization of the mineral and thermal water of Kosovo and Metohija in a function of health tourism is an important issue for recognizing the Autonomous Province of Kosovo and Metohija (AP KiM) as a significant tourist destination. Valorization of the mineral and thermal water in the territory former SFRY, to which Kosovo and Metohija belonged was largely based on the applicable legal regulations in the observed time period. The economic valorization of mineral and thermal water was generally lacking. The situation has changed significantly in recent years in the area of health tourism, which needs yet to get its portion of the budget while competing with the other social areas. Therefore, health tourism itself should become the very source of profit. Valorization of the mineral and thermal mineral water of Kosovo and Metohija should be based on the world criteria that contribute both to the economic development and reconciliation process. Furthermore, a part of research in the study paper, the special emphasis has been placed on the identification of sources of thermal and mineral water as a natural attraction in Kosovo and Metohija, elements of tourist valorization and the importance of mineral and thermo mineral water for development the tourist economy in Kosovo and Metohija.

Keywords*: mineral and thermo-mineral water, spas, valorization, tourist product, health tourism*

SUBJECT OF RESEARCH

The chosen research problem is a result of years of analytical work in the fields of economics, hydrogeology and balneology. As well as the identification of thermal mineral water in Kosovo and Metohija, analysis and their definition as a tourist potential and attractiveness and creating opportunities for their tourist presentation and valorization. The problem of research in this study dealt with the question: How to create the modern tools that will valorize the mineral and thermo mineral watering a function of health tourism in a way that will contribute to the promotion of health tourism as an industry branch and overall economic and social progress of population, considering numerous current problems in the area Kosovo and Metohija after years of conflict?

GENERAL HYPOTHESIS

The mineral and thermo-mineral water of Kosovo and Metohija in a function of health tourism and as a tourist product are individually and as a whole economically congruent. The study is based on a hypothesis that the valorization of mineral and thermo mineral water of Kosovo and Metohija contributes to raising the awareness of all interested parties about a need to create the tools necessary for their

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recognition as an attractive, contemporary and competitive tourism product. This hypothesis as such is proven by the authentic statements.

OBJECTIVE

Scientific objective of research is to gain a knowledge at the level of scientific description and classification with the elements of scientific explanation. A special aspect of research is aimed at diagnosing the basic problems evident in the field of health tourism development in Kosovo and Metohija. The scientific objective is reflected in the initial exploration of application conditions and adaptation the general economic principles important in the field of tourism management in a context of specific and turbulent relations between people regarding the unresolved political issues. Moreover, it is necessary to present scientifically the based evidence on complementaty the mineral and thermo mineral valorization with function of tourist product and tourist offer. The practical aim of research is to define and regulate the activities and measures to be taken in order to achieve an adequate level of development the health tourism as an important segment in a path of society development. In order to achieve this objective, it is necessary to investigate objectively, clarify and properly present all important in the field of health tourism development in relation to the mineral and thermo mineral water in the area of Kosovo and Metohija.

The practical value of research is reflected in a proposal of certain practical solutions for development the health tourism, in a way that enables those solutions to be adapted and incorporated while respecting the real needs and opportunities in a holistic approach to the development of health tourism.

METHODOLOGY

Considering that the study is of an interdisciplinary character, a characteristic, generally accepted methodology in the field of social sciences has been used. The authors of the study believe that there is no absolutely correct methodology for the field of social research, but that it presents different ways of viewing the world, measuring and understanding the social reality. The selection of research methods was carefully performed in accordance with their own experience and research problem.

The scientific and logistical methods used were: synthesis and deduction analysis, induction and content analysis. Out of the general scientific methods, the statistical method and comparative method were used. The collecting data survey was conducted on the basis of pre-prepared and formulated questions.

INTRODUCTION

Valorization has become a priority issue under current circumstances at every level, starting from the global to local. The developed countries make great efforts to valorize the mineral and thermo mineral water as it contributes to preservation of its essential value, but at the same time emphasizes the increasing importance of health tourism. Mineral water should prove their worth in a way that is understandable to the decision makers. Value means both the preferences and desire of someone for a specific service at a specific point of time.

Movable goods have a market in which their price is defined according to supply and demand, while the real estate does not have a market in which its economic value can be determined. The total economic value consists of the “use value”, or in the other words the “passive use value” of resource. The value of nonuse (existence value) has emerged as a result of numerous debates in the scientific community. [1] Back in 1967, in his article in the American Economic Review, John Krutilla proposed a compromise that initiated the desired changes. He emphasized that the economic science should adopt a concept that has become known as the "existence of value". The concept has been accepted and consequently many economists have made or are making efforts to express the value in currency. [2]

It is necessary to initiate a process of economic value assessment in a timely manner that can be compared with the investment cost of preservation of each good individually. [3]

ECONOMIC VALORIZATION TECHNIQUES

Specific valorization techniques are required for determination the total economic value of mineral and thermo mineral water. In such cases, it is impossible to use the Cost Benefit Analysis (CBA), which has a significant place in the applied economy. Bedate points out the importance of three methods: hedonic pricing, travel costs and conditional valuation. [4]

There are two groups of techniques that can be applied in the valorization of mineral and thermo mineral water: techniques of discovered preferences, where preferences are derived from information collected in the real market; stated preference techniques used when information and data are collected directly from consumers through the use of various questionnaires; techniques of revealed preferences when the value of goods is derived from data on realized transactions in the market; hedonic pricing refers to the analysis of those markets where certain activities have an impact on price; [5] method of travel cost is based on the fact that the value of resources is viewed through the cost of travel and stay in certain properties [6].

IDENTIFICATION OF THE THERMOMINERAL WATER SOURCES AS THE NATURAL ATTRACTIONS IN KOSOVO AND METOHIJA

The area of Kosovo and Metohija is characterized by a very complex geological structure and numerous thermo mineral water and springs where the famous spas were built: Pećka Ilidža near Peć, Klokot Banja near Vitina, Banjska (Rajska Banja) near Zvečan, Kmetovska near Gnjilane, Ugljarska near Gračanica, and Žitinje near Klokot Spa. There are also so-called the "wild spa" near Kaljare with a temperature of 28.6°C, spa Vuča near Leposavić, so-called Slatina thermo-mineral source of salt water near the village of Slatina, and Kisela spa is near Podujevo. The Smrdan Spa located at the mouth of Sitnica into the Ibar River, as well as Glamska Spa near Novi Brdo, Gatnjanska Spa near Uroševac, Dečanski Kiseljak located in Dečani, should be included in this group. The spas are ideal places to meet the human recreational needs. [7]

Pećka Banja - Spa (Ilidža) near Peć is the most famous spa in Kosovo and Metohija. There is a number of thermo mineral watering Banja and its immediate vicinity with water temperatures ranging 12-47.5°C. [8]

Klokot Banja is located in the Binačka Morava valley in place Klokot. Thermomineral water of Klokot Banja belong to cold, hypo and homeothermal (18-37°C) containing metasilicic acid (up to 174 mg/l), metabolic acid (up to 53 mg/l), lithium (1.06 mg/l), fluorine (2.4 mg/l), iron (up to 15 mg/l), radium, strontium, etc. Mineral water from the spring in Klokot Banja belongs to alkaline water in terms of mineral composition. Cold mineral water from one of the source contains carbon dioxide, and is used for drinking and bottling.

Banjska (Rajska spa) is located on the southeastern slopes of Mount Rogozna (1504 m), at 533 m above sea level. The water temperature at the springs is: 40.1°C, 58.1°C, 28.3°C, 38.4°C. [10]

Kmetovska Banja near Gnjilane has seven springs of thermo mineral and mineral water. The juvenile water of Kiseli source (acid source) giving 1 liter/sec was analyzed algological and its temperature is 27°C. [8]

ELEMENTS OF THE TOURIST VALORIZATION OF THE SPAS IN KOSOVO AND METOHIJA

The geographical position is a key element of the tourist valorization of the spa. In doing so, it is necessary to observe the geographical location of the spa according to the major communication routes, attractive tourist environment and populated areas.

The Kosovo Metohija spas have the most favorable position in terms of communication routes. Also, spas in this area have a favorable position towards urban settlements as the emission areas and towards the attractive tourist facilities, i.e. monuments as the tourist motives (Pećka Banja (Spa) is close to the Monastery of the Patriarchate of Peć and Rugova Gorge; Banjska (Rajska Spa) near Zvečan is in the immediate vicinity of Banjska Monastery, etc. which can be successfully integrated with the tourist offer of spas.

Namely, a large number of Kosovo Metohija spas are located in the area of mountains that form an important natural motivational basis for the tourism development (Šara Mountains, Prokletije, Rogozna, and Kopaonik). Based on the overall analysis of the tourist geographic location, the spas of Kosovo and Metohija are divided into three groups:

- First group - Banjska (Rajska banja) in the immediate vicinity of the major communication routes
- Second group - Pećka and Klokot Spas located in the vicinity of other tourist motives
- Third group - other spas

THE IMPORTANCE OF THERMO MINERAL WATERFOR DEVELOPMENT THE TOURIST ECONOMY IN KOSOVO AND METOHIJA

Each country has characteristics that make it different and typical, and tourism is actually based on that diversity. [11] One of the basic balneological features of thermo mineral water is their healing function.

Thermal mineral water sources represent the basis of health tourism development in Kosovo and Metohija. The importance of thermo mineral water is multifunctional regarding the development of health tourism, because in combination with balnotherapy as a special therapeutic discipline and wellness programs, it influences the preservation of population health, recreation, prevention, treatment and rehabilitation. Sources of healing water, with the exploitation of peloids, the use of gases in balneological treatment offer a perspective of development the spa tourism.

The oldest form of tourism is health, but it is not the only one. The spas become city centers, destinations for picnics, excursion, cultural-sport events, cultural manifestation and congress tourism, as well as the tourism for the third age and transit tourism. [12]

Banjska (Rajska Spa) has springs of thermal and healing water that have been irreversibly flowing into the Ibar River for decades. Its utilization is almost negligible. Instead of being wasted, this natural gift could be used to heat up the settlements of Banjska and Zvecan. Geothermal or hydrothermal water is a unique source of renewable energy because its use in healing requires relatively simple and inexpensive technology.

Many countries use the energy of geothermal sources to generate the electricity. The use of geothermal energy and its resources in Kosovo and Metohija is almost negligible in comparison to its potential. The reasons for this situation are unclear, bearing in mind that some sources are the best in the region and that the development of geothermal technology in Europe has advanced. Unfortunately, the use of geothermal water is mainly represented in the spa treatment and for sports and recreational purposes. Globally, the geothermal sources are mainly used for space heating, but also for the production of vegetables in greenhouses, in livestock breeding, in various production processes, etc.

RESEARCH RESULTS

The following tables provide a detailed analysis of data collected on the potential of Kosovo and Metohija for development the spa and health tourism.

Table 1 *Number of respondents and percentage per gender*

Gender	Number of respondents	Percentage
Male	39	52 %
Female	36	48%
Total	75	

The survey covered 75 respondents, out of which 39 were men (52%) and 36 women (48%), broken down by the age group:

Table 2 *Number of respondents and percentage per age*

Age	Number of respondents	Percentage
Up to 25	/	/
26-35	14	19.5 %
36-44	22	30.6 %
45-54	25	33.3 %
55 and more	14	18.6 %

Survey covered the respondents of all levels of education:

Table 3 *Number of respondents and percentage per level of education*

Level of education	Number of respondents	Percentage
Primary school	1	1.4 %
High school	26	36.1 %
Junior College	9	12.5 %
Faculty	29	40.3 %
Master	5	7 %
Master	/	/
PHD	2	2.7 %

The majority of respondents have higher education in order to provide more meaningful answers to the survey. Considering that the cultural tourists are persons with relatively higher education and above average incomes, this market segment will be increasingly significant from the point of view of economic impact. [13]

The next question was whether Kosovo and Metohija had an adequate potential for development the health tourism, and a large number of respondents, 86.7%, thought it had one.

Table 4 *Number of respondents and percentage of question asked*

Answer	Number of respondents	Percentage
Yes	65	86.7 %
No	6	8 %
I do not know	4	5.3 %

When a large number of respondents was asked which of the following elements are considered as important for the tourism offer of Kosovo and Metohija, they made up their mind for the sacral sites of the Serbian Orthodox Church 24.3%, Winter Ski Center in Brezovica 16.9%, Gazimestan Memorial Park 12.1%, Gazivode Lake 13.7%, Rajska Banja (Spa) in Banjska 7.9%

Table 5 *Number of answers given and percentage of question asked*

Offered elements	Number of answers	Percentage
Sacral sites	46	24.3 %
Winter Center Brezovica	32	16.9 %
Crkvina, old cemeteries and inscriptions	6	3.1 %
Memorial sites	4	2.1 %
Rural tourism	16	8.4 %
Memorial park Gazimestan	23	12.1 %
Lake Gazivode	26	13.7 %
Tradition, folklore and gastronomy	11	5.8 %
Rajska banja in Banjska	15	7.9 %
Natural sites	9	4.7 %
Old villas	1	0.5 %
others	1	0.5 %

Table 6 *Number of answers given and percentage of question asked*

Offered elements for enhancement of the cultural tourism offer	Number of giver answers	Percentage
Health and spa tourism	39	23.2 %
Organization of gastronomic events	7	4.1 %
Creation of cultural routes	13	7.7 %
Linking the cultural tourism offer of Kosovo and Metohija with the offer of the surrounding countries, which have rich cultural and historical heritage	19	11.2 %
Organization of greater number of events throughout the year	19	11.2 %
Transit tourism	5	2.9 %
Collaboration of tourism providers and cultural institutions aimed at introduction of innovations into the existing cultural tourism offer	11	6.5 %
Legal regulation on the preservation, protection of sites of cultural and historical heritage	12	7.1 %
Complementing the cultural tourism offer with the additional amenities such as active holidays, sports and recreation, spa and wellness services	9	5.3 %
Monastery tours	32	19 %

According to the respondents, the most significant offered elements that would contribute to the improvement of tourism offer of Kosovo and Metohija are the health and spa tourism with 23.2%, monastery tours with 19% of the given answers.

CONCLUSION

This study has been based on the hypothesis that the valorization of mineral and thermal waters of Kosovo and Metohija in the function of health tourism contributes to raising awareness of all interested parties about the need to create tools (models) necessary for their recognition as an attractive, modern and competitive tourism product. This hypothesis is proven by the realization of research sub problems. The basic hypothesis indicated the need for valorization process to be envisioned and created in such a way as to avoid the popularization of mineral and thermo mineral water individually due to ethnic groups living in the territory of Kosovo and Metohija. Valorization should be designed in a way that takes into account numerous indicators. The experience of developed countries in valorization is of imeasurable importance in this process. This process will not be easy or straightforward due to many undesirable circumstances, of which, above all, are the political instability and problem of securing the necessary financial resources provided for this purpose. The valorization process is an interdisciplinary work. This important task should be done by a group of experts of various profiles. The valorization process should be carried out with a particular sensitivity in the territory of Kosovo and Metohija given the centuries-old conflict between Serbs and Albanians. Expectations that the valorizetion process can be done in the short term are unrealistic.

The conclusion is that the valorization process is a continuous, dynamic process and that it can never be completed in its entirety. The survey has shown the aspirations of respondents to visit a tourist destinations that have spiritual contents, natural beauty. The results of research indicate that a systematic approach to organizing the tourist offer and supply of additional tourist facilities is needed in order to provide tourists with a high quality experience during their stay in Kosovo and Metohija. It should be remembered that the new tourism products are aimed to reduce the marketing costs. Modern technologies and improvement of customer service in this process are indispensable.

Health tourism for the development of Kosovo and Metohija is very important. In a period of stagnation, significant economic crisis and certain disappointment of population with a high unemployment rate and poor economic situation, every step aimed at offering a greater employment and better living and working conditions means progress towards the sustainable development of society. The valorization of mineral and thermo mineral water is one of the most important tasks on this path that leads from the past to the future that can and should be a significantly different.

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[3] www: http://www.vanguard.edu/psychology/apa.pdf (for web document)

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