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Aleksandar Doderović[*], *Nikola Stanić*[*], *Miljan Gomilanović*[*], *Saša Stepanović*[*]

REDISTRIBUTION OF EXCAVATION EQUIPMENT FOR THE PURPOSE OF ACHIEVING THE DESIRED CAPACITY AND IMPROVEMENT THE UTILIZATION TIME OF EQUIPMENT[**]

Abstract

Minor or greater deviations from the designed technological solutions are mainly due to two reasons: deviation from the design solutions in the previous period as a consequence of organizational factors, and as a consequence of changed parameters of the working environment in relation to those used in the planning and design phase. Ajusting to the newly created situation at the open pit, and in order to ensure a continuous supply of the customer/consumer with the mineral raw materials or fuel, as well as processing (discovery) the new quantities of mineral raw materials that still need to be exploited, it is sometimes convenient to redistribute the equipment at the open pit and adjust the technological parameters of operation to the concrete conditions. In order to improve the effects of equipment operation, reduce the costs and utilize the favorable weather conditions for work at the open pit Gacko - Central Field, a change of designed technology for operation rotor excavator II BTO system and relocation of excavation discontinuous equipment, organized as part of the combined system, has been carried out. This paper presents the technological - organizational measures implemented with the aim of more efficient use the existing excavation and transport capacities.

Keywords: *equipment redistribution, operation technology change, utilization time, OP Gacko*

INTRODUCTION

The Coal Basin Gacko is divided into four exploration exploitation fields: Western, Central, Eastern Exploitation Field and Roof Coal series. The first mass coal exploitation within this basin began in 1978 with the opening of the open pit Gracanica in the western part of Gatacko polje. Exploitation at the open pit Gracanica took place in the Field A, Field B and a part of Field C. Following the break of water into the Field B in 2013, the exploitation continued only from the Field C (Central Field).

The next stage in development the coal mining in the area of the Coal Basic Gacko is the beginning of exploitation in the zone of Roof Coal Series. Considering the existing problems in coal exploitation in a part of Field C, the coal exploitation of the roof

[*] *Mining and Metallurgy Institute Bor, Department Coal Engineering Belgrade, e-mail: aleksandar.doderovic@irmbor.co.rs*

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series has ensured a stable fuel supply of the Thermal Power Plant.

Today, at the open pit Gacko - Central Field, the exploitation is carried out in the central exploitation zone, in which the coal of the main coal seam and the roof exploitation zone are exploited, in which the coal of the roof series is excavated. There is a significant difference in the qualitative coal characteristics within the central and roof exploitation zone. In order to supply coal of the appropriate and uniform quality for the needs of the Thermal Power Plant, the coal amounts excavated in both zones are dynamically coordinated, and their mixing is done on a coal depot of the Thermal Power Plant.

According to the design (The Main Mining Design of the Open Pit Gacko - Central Field for the Capacity of $2.3*10^6$ t/year of the Run-of-Mine Coal - the Mining and Metallurgy Institute Bor) for 2017, it is foreseen at the open pit Gacko that the existing front works expand in the south - southeast. Changes of the existing contours of the open pit and their expansion are aimed at achieving the final contour of the open pit in this zone; creating the conditions for coal exploitation in the currently deepest part of the central exploitation zone characterized by high quality and preparition for transfer of rotary excavators of continuous systems to the designed excavation front of the north – south.

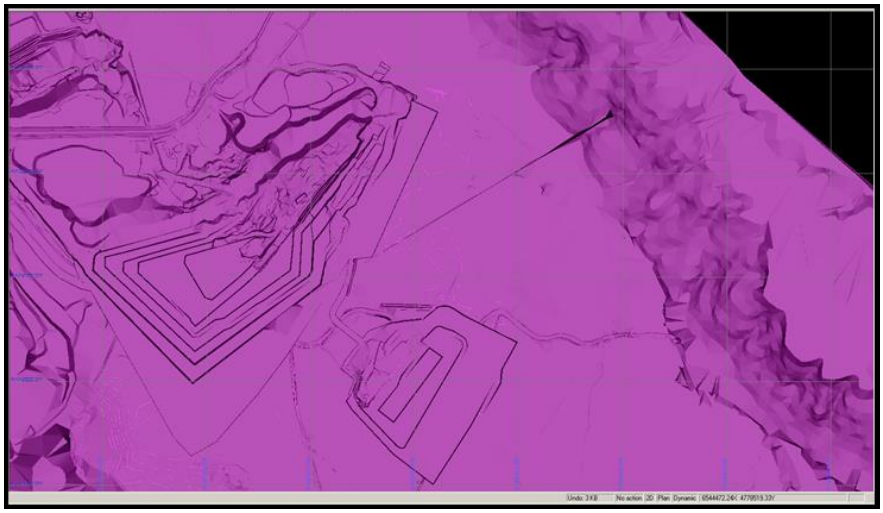

Figure 1 *Designed condition of works from the end of 2017 - View of the Gems program package form*

DESCRIPTION OF THE CONDITION AT THE OPEN PIT AND PROBLEMS

Vertical arrangement of equipment on the southern slope of the open pit is as follows:

- Diskontinuous equipment for excavation the surface quaternary sediments and humus
- I BTO system
- II BTO system
- Comined system
- Coal exploitation system

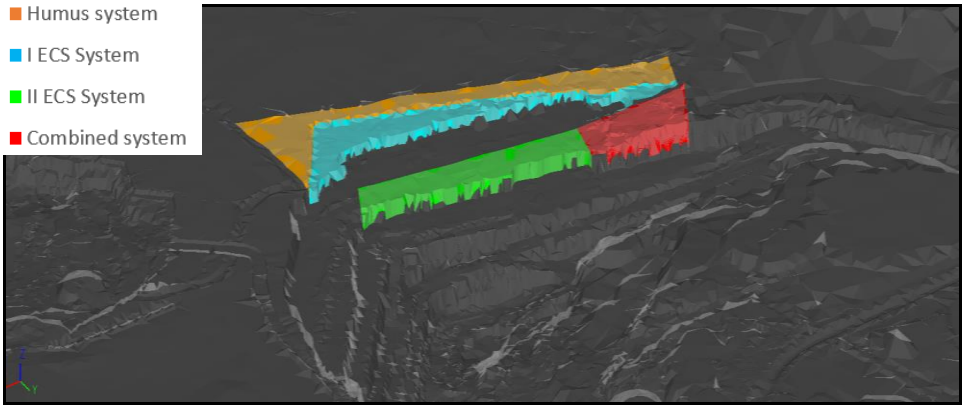

Figure 2 *Schedule of exploitation system at the end of April 2017*

Due to a lack of adequate excavation equipment of surface layers, an external contractor was engaged. Excavation of quaternary sediments is difficult due to the presence of water in them, but also on the terrain surface in the front of works, as they are performed in the area of the old river basin of the Mušnica River, the most important recipient of the Gacko field. The dynamics of quaternary sediment excavation directly affect the work of I BTO system. Humus must be removed separately, primarily because it is intended for remediation. Excavation of these sediments is not performed by a rotary excavator and due to the adverse characteristics in terms of stickiness.

Equipment of the I BTO system (rotor excavator ER 1250 17/1.5, a self-propelled conveyor BRs 1200 and floor conveyor KLM 450) in the excavation zone, is placed at level 926-925. A rotary excavator excavates a floor height of 8-10 m, and the excavated material is deposited by a stacker Ars 1200 depositor on the Large External Landfill. Transport of the excavated material is carried out by the belt conveyors, belt width of 1200 mm.

Equipment of the II BTO system (rotor excavator ER 1250 16/1.5, a self-propelled conveyor P1600 and floor conveyor KLM 500) in the excavation zone is placed at level 909. The rotary excavator excavates a floor height of 15-16, but the height of massif that is provided to be excavated by this system is not the same in all parts of the floor so, in the west part, the floor height exceeds 20 m (Figure 3).

In the zone of the southern slope of the open pit, or in the zone where the excavation works are currently the most intensive, there are also the routes of the BTO coupling conveyors and Combined system. In order for smooth works on extension the southern slope, it is designed that the new conveyor routes are formed by the operation of continuous excavation equipment with minimum participation of discountinuos auxiliary equipment. This implies the operation of rotary excavators in tandem with self-propelled conveyors to form the cross-linking cuts in the slope, with loading on conveyors below the level of standing and with the radial advance of the front. Due to the small dimensions of the site and complicated technological scheme, the time and capacity utilization of the rotor excavators is low. Due to the aforementioned and since the rotor excavator is not able to excavate at

places where the floor height exceeds maximum excavation height, the excavation equipment of the combined system, a hydraulic bucket excavator, type PC 2000, is engaged on excavation of these floor parts. The excavated material within the II BTO system is transported by a belt conveyor, 1200 mm wide, and deposited in the excavated area of the Field B by a stacker, type P 1600.

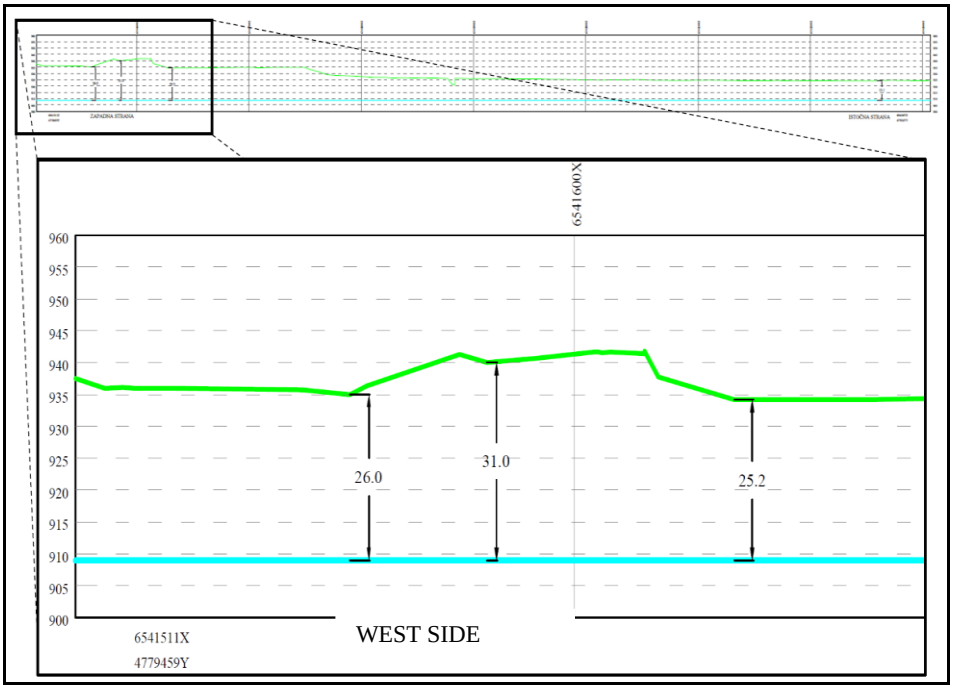

Figure 3 *Longitudinal profile of the II BTO system with maximum heights per individual sections in the western part*

Discontinuous excavation equipment within the Combined system is distributed at many locations - sites. The excavated material from the eastern slope is transported by the trucks to the crusher for waste and after crushing is transported by the 1400 mm wide conveyors to a landfill in the excavated area of the Field B. The hydraulic bucket excavator, type PC 2000, located on the southern slope of the open pit, excavates the material that is transported to a truck and bulldozer landfill, located on the northern slope of the Large Exterior Landfill. This excavator primarily excavates masses on the parts of floor that are higher than the excavation height of the rotor excavator of the II BTO system, participates in excavation of the waste masses in formation the connecting cuts for the BTO conveyors and combined system and parts of floors which the rotary excavator, due to its constructive and technical characteristics, cannot excavate. The work of this hydraulic excavator also forms the level for movement of trucks from the site to the Extenal Landfill.

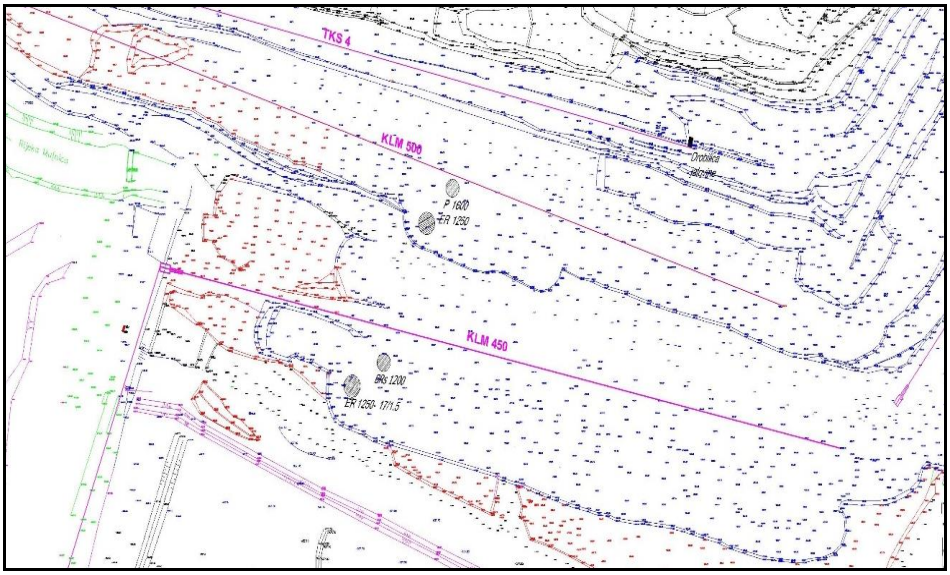

Figure 4 *Situational map of the southern slope of the beginning of April (04/05/2017)*

PROBLEMATICS

At the end of April 2017, the overhaul of the II BTO system was completed. It was anticipated that this excavator would continue its work from the position of its overhauling and continue its progress towards the design solution. This development of works did not come due to the following reasons:

1. Engagement of continuous excavation equipment must be predicted in the conditions in which their capacity will be high.
2. Capacity of a continuous part of the Combined system is not fully utilized due to the characteristics of stacker and a lack of another crusher for waste.
3. Existing sites of a discontinuous excavation equipment are characterized by the cramped working conditions and small lengths of front, and there is a need for a more favorable site of excavation equipment of the Combined system.
4. In order to stabilize the general slope of the landfill, it is necessary to form a floor in a foot of the Large External Landfill.
5. Engagement of a combine Wirtgen SM 2500, due to the specific requirements for corresponding dimensions of the site, is advantageous to form in the southern slope zone, since there are no necessary conditions on the working floores of the east slope (the previous front of works).

Within the limits of expansion the exploitation central zone, the connecting conveyors of BTO and Combined system are located in the southern slope of the open pit. The design envisaged that the new routes of belt conveyor would be made by the operation of rotary excavators with minimum

participation of the discontinuous excavation and auxiliary equipment. The operation of rotary excavator, in tandem with the self-propelled conveyor, in a slope, with the narrowed front of works and at the level above the level of conveyor belt, is characterized by the low time and capacitive utilization. Incorporating of a discontinuous equipment in the zones of irrational engagement of the rotor excavator would enable a greater engagement of continuous excavation equipment at locations with more favorable conditions for its operation.

Discontinuous excavation equipment of the Combined system is currently is deployed in many sites. Excavation at the existing sites on the eastern slopeis limited due to the position of higher floores of continuous systems, and on which the current works are not in progress. Therefore, the space for engagement of discontinuous equipment is narrowed, which affects reduction of capacity utilization degree. This is especially significant for the bulk of discontinuos excavation equipment with a bucket capacity of 10-12 m^3.

Overburden that is excavated by the equipment of Combined system is transported to the crusher, and after crushing, it is transported by the belt conveyors to the landfill in the Field B. In case of planned or unplanned downtime of the continuous part of the Combined system, it is convenient to have a storage space for waste deposition, or maintain as operative a discontinuos part. In the previous period, an internal landfill in the Field C had this role. Further disposal on the internal landfill is not possible, so it would be convenient to find a new landfill for overburden that will be deposite by the truck and bulldozer, and with the operation costs being not significantly higher than the combined system costs. One of the causes of frequent delays on the waste crusher are the characteristics of waste that is excavated by the combine Wirtgen SM 2500. The excavated material by the combine has fine granulation and significant adhesion, causing numerous delays ion the wasten the crusher crusher. During the time that is required to clean the crusher, a discontinuous part of the system is operative and, in case of finding a suitable storage space, the time utilization of the system would be significantly improved.

The Combined system at the open pit has a limit on capacity of continuous part of the system, primarily in terms of the stacker capacity. Due to the short transport lengths from the site to the wastew crusher and availability of discontinuous excavation capacities, a discountinuous part of the system currently capaciously exceeds the possibilities of continuous part. It is advantageous to use the available capacity of discontinuous excavation and transport equipment, especially in the period of favorable meteorological conditions.

A continuous disposal of waste is carried out on the Large External Landfill, and the engineering-geological processes are present on the existing slopes of the landfill resulting in instability. Due to this reason, it is necessary to carry out the activities to stabilize the existing slopes by the mass deposition in the landfill foot. This disposal of excavated waste would be done by the masses excavated and transported within a discontinuous part of the Combined system.

In order to avoid longer delays of the Combined system equipment, especially in the period of the year when the largest production is expected and to avoid the costs arising from equipment delay, it is necessary to establish the new worksites for this equipment as soon as possible. One solution that is imposed is to redistribute the existing equipment at the open

pit in relation to the design positions within the technological exploitation system in a way that would allow a greater time and capacity utilization (Figure 3).

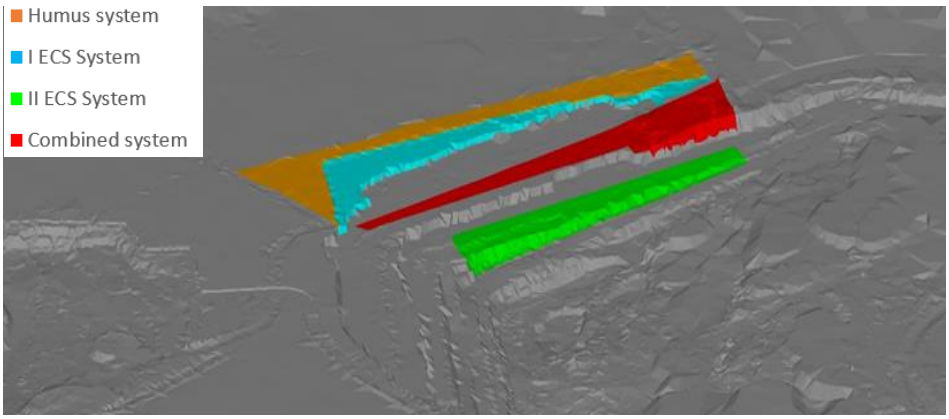

Figure 5 *Proposal of equipment redistribution*

PROBLEM SOLUTION

Upon completion the overhaul of the II BTO system, the rotor excavator and self-propelled transporter should move to the side of conveyor KLM 500 towards the bottom edge of the floor, i.e. in the mining vocabulary "to cross over the belt." This changeover is performed such as the rotory excavator is bypassing the floor conveyor KLM 500 around the return station and comes in a parallel position to the original one. During movement from the initial position to the return station, the rotary excavator excavates a block of 20 m width. After bypassing the return conveyor station, it starts with excavation of a depth floor.

After the rotary excavator of the II BTO system leaves its level, the whole plateau at the level 925-926 m is released, where a part of excavation Combined system equipment can be accommodated. In contrast to the designed equipment layout in this case, a part of discountinuous equipment will work above the rotary excavator of the II BTO system. During the mass excavation by a discountinuous equipment and combine, from this level, the overburden wouls be transported discontinuosly to the external landfill. The most favorable location for this is the space on the northern slope of the Large External Landfill, on the south side of the old old riverbed of the Musnica River. At the same time, the following is carried out:

- Development a floor in a foot of the Large External Landfill in order to stabilize the slope,
- Capacitively relieves a continuous part of the Combined system,
- Increase the degree of capacity utilization of discontinuous equipment of the combined system at the expense of shortening the transport length,
- Formation the landfill for discontinuos equipment of the Combined system in case of delay pn a continuous part of the system.

Plateau on the north side of the KLM 450 conveyor at the level 925-926 has a sufficient width so that it is possible to engage the Wirtgen SM 2500 combine. The excavated overburden with combine will be transported by a truck to the external landfill. This ensures better worksite for a combine and eliminates jams of rakes on the waste crusher due to the material bonding that is excavated by a combine.

TECHNOLOGY OF WORK

After bypassing around the KLM 500 conveyor and installing the equipment to the starting position, it is envisaged that the rotary excavator starts with excavation of deep floor. This implies that the rotry excavator builds a transit ramp, or more precisely, a cut to descend to the level of 895 m. When operating, a longitudinal slope of the ramp must not be greater than 3%, and the floor height will excavated in direct dependance on the equipment capability.

Since the distance between the KLM 500 floor conveyor and edges of the floor varies, the block width also varies. Initially, a rotary excavator excavates a block. Over time, because the conveyor KLM 500 is not installed in parallel to the floor edge, the block is expanded. As the works continue and the rotary excavator goes deeper into the massif, the distance between the rotary excavator, or more precisely the self-propelled conveyor and floor conveyor increases. After a certain time, the arrow of the self-propelled conveyor is not able to hand overthe material on a belt. This situation requires the rotary excavator to be returned and to open a semi-block, to allow unhindered loading of excavated material onto the floor conveyor.

Due to the constructive characteristics of equipment, the rotary excavator will work until it reaches the excavation height of 12m. After that, the standard altitude work will be done in a a block and a semi-block with material unloading above the level of standing.

For the Wirtgen SM 2500 combine, the standard work technology is provided, making the parallel cuts of 2.5 m width on a prepared plateau of 30-40 m wide. After completing the overhaul of the I BTO system and moving the conveyor KLM 450, the plate for combine operation will be expanded. This combine will be provided with a safe worksite for a longer period of time.

Figure 6 *Work of the Combined system equipment at the plateau 925-926*

In addition to the excavator combine on this floor, there is a hydraulic bucket excavator PC 2000. The task is to excavate material from a part of floor that the excavator combine cannot excavate. For this equipment, the technology of work in a deep block with material loading below the standing level in the trucks, type Belaz 75135, is predicted. As the plateau will be expanded, the conditions will be created to open the site for a number of excavators of the Combined system.

The material excavated by the Combined system equipment is deposited on a truck landfill positioned in a foot of the Large External Landfill.

CONCLUSION

Redistribution of equipment and change in the technology of work can be successfully applied in order to improve the working conditions and increase the utilization degree of equipment capacity, all in order to increase the production of useful mineral raw materials and overburden at the open pit. This method of organization is indispensable in cases when a variety of equipment is included in the production process. Due to the maneuverability of discontinuous equipment, it is possible to change the positions of excavation equipment and thus with minimum delays to provide better working conditions such as shorter transport lengths, relieving of transport systems, positioning equipment of higher power at worksites where the working environment is characterized by the increased excavation resistance.

In the case, described as a result of equipment redistribution and change the technology of work, more favorable working conditions of the equipment and increased degree of capacitive utilization of equipment were provided in the period of favorable weather conditions. A necessary prerequisite for these operations is a good knowledge of equipment and working conditions at the open pit.

In the case of unplanned delays and interruptions in the operation of certain parts of the equipment in system (especially discontinuous), it is necessary to define the priorities of work and to redistribute the remaining available equipment based on them. Redistribution should be as efficient and cost-effective as possible. It should also be taken into account that the equipment is not exposed to high loads (large excavation resistances, high slopes of the transport route, overload of transport equipment) achieved by its engagement in parts of the working environment with favorable physical-mechanical characteristics and technological parameters adapted to the constructive kinematics characteristics of the equipment.

If it is not possible to perform a location redistribution of equipment (this is the case for large continuous systems), the next solution is to change the technology of work of the excavation and disposal equipment.

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