VALORIZATION OF MINERAL RAW MATERIALS FROM MAN-MADE DEPOSITS AT THE KOVIN MINE

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Abstract: *The Kovin mine exploits two mineral raw materials: coal and gravel. Tailings from the process of coal production, that is, tailings from the process of digging overburden and gravel, are deposited in separate landfills.*

At the Kovin mine, a whole series of procedures are undertaken in order to maximize the valorization of mineral raw materials. By processing the material from the coal tailings, the production increased by 20%, and in the following period, the subsequent processing of the tailings from the gravel excavation process is planned.

By increasing the mass and thermal utilization of coal, the mine's income increases and the amount of waste decreases.

Key words: COAL, GRAVEL, TAILINGS, VALORIZATION, MINERAL RAW MATERIALS

INTRODUCTION

Overburden and coal are mined on the banks of the Danube river, at the Kovin mine, using the method of underwater exploitation. Since 1991, only sandy-clay sediments and gravel have been excavated, and from 1994, coal mining began. By the end of 2023, with the excavator "Kovin I", in 39.532 hours, 19.092.586 m^3 of overburden was excavated and in 66.056 hours of work, 4.400.863 t of commercial coal was produced. The gravel and coal deposit "Kovin" is located in southern Banat, about 50 km from Belgrade in the east direction and administratively belongs to the municipality of Kovin. The deposit represents the northern part of the unique Kostolac-Kovin sedimentation area, which is separated by the Danube River. The area of 60 km^2 is divided into two coal fields; western "A" and eastern field "B". The exploitation field of the underwater coal mine "Kovin" represents the "undefended", southern part of the coal field "A".

In a stratigraphic sense, the metal deposit is part of a larger sedimentation environment, the Danube coal zone, to which the coal deposit in Kostolac also belongs. The entire

sedimentation area of the left and right banks of the Danube where real coal is stratigraphically belongs to the upper Miocene, i.e. the younger part of the Pontus - the upper Pontus. Coal from the metal part of the Kostolačko - Kovinsko Basin deposits is a representative of soft brown coals, i.e. humus coal of the xylitic type is close to the coal from Kostolac according to its petrological and chemical-technological properties. The basic lithotypes of metallic coal are xylitic, baric, earthy, as well as their varieties.

OVERBURDEN AND COAL MINING TECHNOLOGY AT KOVIN MINE

Two mineral raw materials are exploited at the Kovin mine: gravel and coal.

OVERBURDEN EXCAVATION TECHNOLOGY

Given that the Mine owns one dredger (refueling dredger "Kovin I"), it also hires other dredgers, primarily floating dredgers, to realize the planned annual production.

EXCAVATION OF TAILINGS AND GRAVEL WITH BUCKET-CONVEYOR EXCAVATORS

At the Kovin mine, bucket excavators are used to unearth sand in the gravel roof (tailings) and unearth gravel - useful mineral raw materials. Excavation of the surface layer of tailings (sand in the roof of gravel) is carried out by floating bucket-conveyor excavators. Excavated tailings are loaded into sinker barges that transport and deposit the tailings to a suitable location in an internal disposal facility. A bucket-conveyor excavator, which has a screen system on it, excavates, sifts (remove silt and iberlauf) and loads gravel into customers' vessels. A bucket-conveyor excavator loads gravel with an average hourly capacity of 230 m^3/h. The daily capacity depends on the dynamics of the arrival of vessels. It takes at least an hour, under ideal weather conditions, to separate the loaded vessel (barge) from the dredger and place the other one for loading. Unfavorable weather conditions can make it difficult or completely impossible to manipulate empty barges. The daily capacity is about 1.000 m^3 of excavated and loaded gravel.

EXCAVATION OF OVERBURDEN WITH THE REFULER EXCAVATOR "KOVIN I"

In addition to the small capacity, the disadvantage of engaged dredgers is the small reachable digging depth. After the work of the bucket-conveyor excavator, there is still about 20 m of tailings left to the coal seam, which is excavated by the dredger "Kovin I". The discovery, excavated by the refueling dredger "Kovin I", is transported to the shore by a navigable steel pipeline with an internal diameter of Ø900 mm. After exiting the pipeline, the hydromix loses speed, as a result of which sedimentation occurs, first of the heaviest gravel, then pieces of clay and finally sand (Figure 1).

Figure 1, Exploitation system when working on gravel: excavator - pipeline – place of discharge

The discovery is deposited in the area where coal was previously mined, and its disposal represents the first stage of reclamation of the terrain. The hourly capacity during overburden excavation ranges from 800 to 1.000 m^3/h and depends on the size of the overburden, the length of the pipeline and the current technical condition of the dredger pumps and the pipeline. In order to prevent major breakdowns at the Mine, it is insisted on daily preventive inspections of elements of the cutting organ, dredger pumps and pipelines lasting 2-3 hours. The daily capacity of the excavator is from 16.000 to 20.000 m^3 of overburden per day [1].

COAL MINING TECHNOLOGY

Underwater coal mining is carried out by the floating dredger "Kovin I". The coal is cut from the layer by turning the cutting wheel, and then it is transported by pumps, together with water, through the waterway and land pipeline to the EHS III coal dewatering and classification plant.

Coal production at the underwater pit of the Kovin mine is carried out by the system:

- floating suction dredger "Kovin I" with cutting wheel UCW 450,
- steel pipeline Ø900 mm (sea and land) i
- coal dewatering and classification plant EHS III.

FLOATING SUCTION DREDGER UCW450 - "KOVIN I"

The floating suction dredger "Kovin I" with a cutting wheel UCW 450, a product of the German company Orenstein & Koppel (Orenstein & Koppel), started operating at the end of 1991.

The main parts of the excavator are (Figure 2 and 3):

1) Pontoon structure on the water surface with mechanical and electrical

equipment, 65 m long, 15 m wide and 4 m high;
2) dredge arm 58.6 m long with a cutting wheel composed of two halves with a diameter of 4.5 m, which is driven by a three-phase motor with a power of 750 kW;
3) Dredging pipeline Ø900 mm with 3 pumps of power of 3 MW each;
4) Pylon construction for moving excavators with 2 pylons.

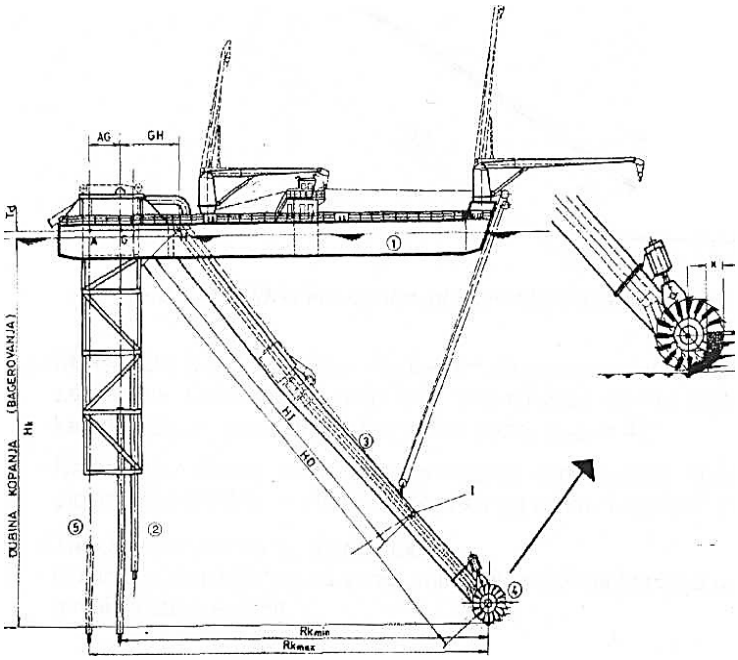

Figure 2, Floating suction dredger "Kovin I" with UCW 450 cutting wheel

The dredger is powered by a cable wound on a drum located on shore. The total installed power on the dredger is 10.126 MW. Three series-connected pumps are intended for suction and transport of the hydromix. In the current work, two pumps are used [1].

Figure 3, Floating suction dredger "Kovin I" with UCW 450 cutting wheel

The forward-backward movement of the dredger is realized by means of two pylons (fixed and working), and the left-right movement is achieved by means of mooring cables (a system of ropes fixed at one end on the coastline). It is anchored with two side anchors (anchors) which are used for the circular movement of the excavator. The center of the circular movement and digging radius is the working pylon, which is located in the rear part of the dredge pontoon. Lateral movements around the pylon are achieved by tightening the anchor ropes to the left and right in relation to the direction of movement of the excavator.

Sediment is excavated by rotating the cutting wheel from top to bottom (counter-clockwise) and circular movement of the excavator to one side or the other. By cutting the material from the layer with cutting teeth, the buckets, of which there are 14 on each of the two halves, are filled, which are brought unearthed to the suction zone of the cutting wheel, and then transported by pumps along with water through the pipeline to the discharge place. The minimum digging depth is 6 m, and the maximum is 45 m. The width of the exploitation block depends on the working depth, and the largest is 80 m [1].

PIPELINE

The pipeline (pulp line) for hydraulic transport is made of steel pipes with a length of 12 m and a diameter of 900 mm. From the dredger to the land, the pipes are placed on two pontoons each, and rubber pipes (cuffs) 1.5 m long are installed between them [1].

EHS III COAL DEWATERING AND CLASSIFICATION PLANT

The hydromixture of excavated coal is pushed by means of two pumps (total installed power 6 MW) through a pipeline (diameter 900 mm) to the dewatering and classification plant (EHS III – Figure 4) where three commercial size fraction ("Large-Cube" with a size range of - 300+30 mm, "Nut" - 30 + 15 mm and "Bean" - 15 + 5 mm) and sieve size range - 5 + 0.0 mm that goes to the sedimentation field (sedimentary).

Figure 4, EHS III dewatering and classification plant

Screen undersize consists of water with fine coal, fine-grained particles of quartz sand and dispersed clay from the layers of tailings in the exploited coal seam. Coal and solid

particles are deposited in thin layers over the previously deposited material, while clear water flows into the Danube via five pipes [1]. The technology of underwater exploitation and the process of dewatering and classification of coal leads to a mass loss of pit coal, but also to an improvement in the quality of the final products manifested through an increase in heat value by 25÷30% and a decrease in ash content by 3%. The produced coal has an average calorific value of about 10,000 kJ/kg. The hydro-construction facility, sedimentation field, is an integral part of the technological process of underwater coal exploitation at the "Kovin" mine and an inseparable part of the constructed mining complex. Sub-sieve masses from the grading and dewatering process are deposited in it. The sedimentation field has the function of separating the solid mass and draining category II water into the Danube (Figure 5). Thirty one percent of coal from the trench goes to the sedimentation field, which amounts to 150.000 m^3 of material (sand, clay and coal) annually. In the sedimentation field, on an area of about 450.000 m^2, there is currently about 750.000 m^3 of material [1]. The composition of the material in the sedimentation field (ratio of sand, coal and clay) is not the same throughout the sedimentation field. As the hydromixture loses its speed, the heaviest fractions of gravel and sand are successively deposited first, then coal and finally clay minerals.

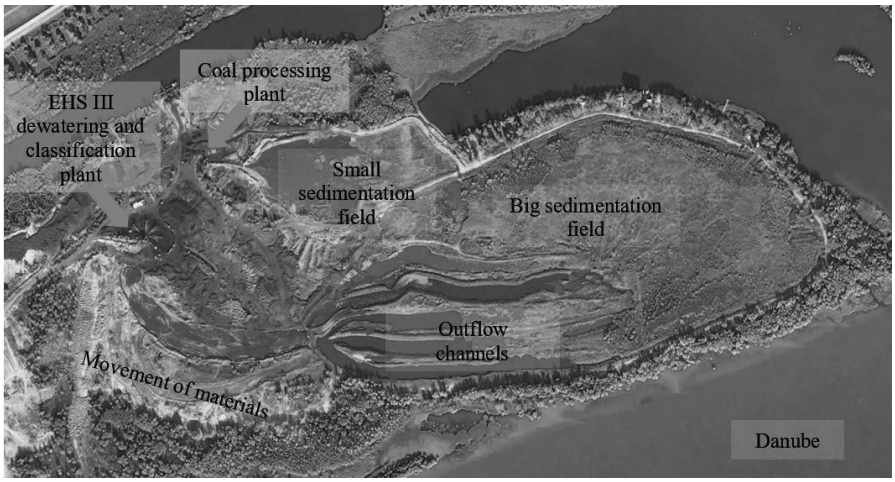

Figure 5, Satellite image of the location of the plant and the deposition field

Depending on the content of coal (size range +0.5 mm), the content of quartz sand and the bearing capacity of the substrate (the material is transported by dump trucks), an area of about 140.000 m^2 is intensively used. The rest of the precipitator is not available for operation with the existing machinery or the content of the useful component (coal) is too small (low mass utilization) [1].

VALORIZATION OF MINERAL RAW MATERIALS FROM MAN-MADE DEPOSITS AT THE KOVIN MINE

After the completion of the exploitation process, small coal and dirty gravel dumps remain from the primary deposit.

VALORIZATION OF SCREEN UNDERSIZE FROM
THE DEWATERING AND GRADING PROCESS

Hydraulic excavators are used to excavate the material from the sedimentation field, and articulated trucks (dumpers) are used to transport the excavated material to the entrance to the processing plant. Excavation of material is done from previously formed channels. The material is directly loaded (by self-discharge) into the loading frame of the plant.

FACILITY FOR PROCESSING MATERIALS FROM SETTLEMENT „KUÇUK MAKINA“

Valorization of material from the sedimentation field has been carried out by wet sieving since the mid-1990s. Annual capacities did not exceed 10-20 thousand tons of final product. In November 2007, a coal cleaning plant ("Kuçuk makina") was put into operation, with the primary goal of using it to valorize coal from the sedimentation field (sub-sieve product from the EHS III plant).

By the end of 2023, 1.535.398 t of material from the sedimentation field was processed at the plant for an effective 43,434 hours of work, from which 617.340 t of commercial coal of the "Finished beans" assortment was obtained. The average mass utilization of the material from the sedimentation field is 40.1%. The average hourly capacity of the plant, in relation to the input, is 26.7 t/h or 14.2 t/h of the final product.

A coal cleaning plant is technologically a gravity concentration plant in a hydrocyclone with a heavy medium. The manufacturer of this equipment is the company "Kučuk Makina" Turkey. Due to the low price of the final product and large losses of suspezoid (magnetite), the plant processes material from the sedimentation field without magnetite (it switched to autochthonous suspension).

The technological scheme of the reconstructed plant is shown in the following picture.

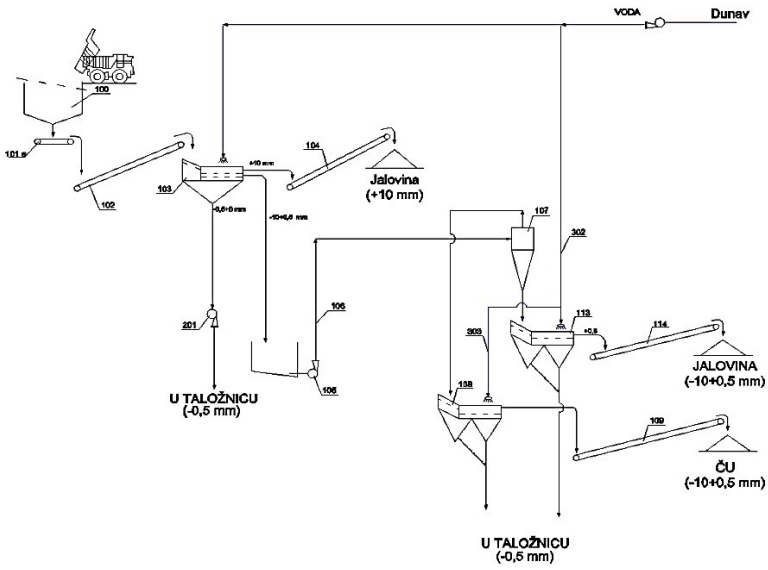

Figure 6, Technological scheme of the coal processing plant

Figure 7, Plant for processing materials from the sedimentation field

The final product of the plant for the processing of materials from the sedimentation field is coal at the Mine defined as the commercial assortment "Finished Beans" with a size range of -5+0.5 mm and a lower calorific value of over 9.500 kJ/kg. 35.000 t are produced annually (±10,000 t depending on demand). Finished beans are mostly bought by industrial consumers: thermal power plants (TE TO Morava Svilajnac), cement factories (Titan Kosjerić), sugar factories (SUNOKO Vrbas), dryers, brick factories, etc. The share of the final product of the processing plant in the total annual production of the Mine in the last ten years is 18%. The following graph shows the share of processed beans in relation to the annual primary production of coal [2].

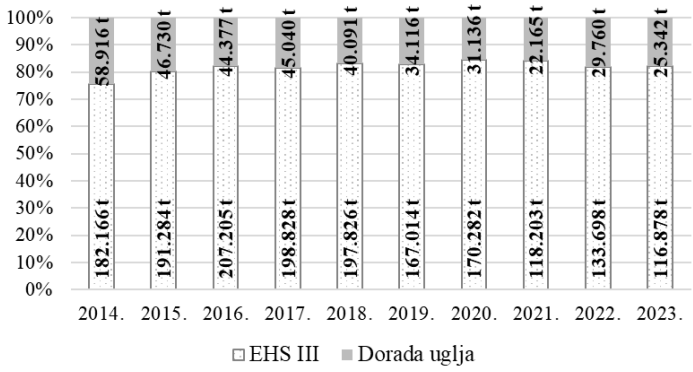

Figure 8, Share of the final product of the processing plant in the annual production of the Mine

VALORIZATION OF PART OF THE TAILINGS FROM THE PROCESS OF MATERIAL PROCESSING FROM THE SEDIMENTATION FIELD

Part of the tailings from the material processing process from the sedimentation field, with water, goes to the "Small sedimentation field " where it settles, and the water overflows into the large sedimentation field. The material is size range - 1(0.5)+0.0 mm and consists of sand, coal and clay. Sand is deposited in the first third of the small sedimentation field, coal predominates in the central part, and sludge in the last third.

On the basis of a representative sample from the central part of the "small sedimentation field ", the laboratory of the Belgrade Mining Institute (February 2014) performed a test - technical analysis and analysis of the granulometric composition [3]. Part of the results is shown in the following table and graphic.

Table 1, Technical analysis of the material in the central part of the small sedimentation field

moisture (%)	ash (%)	sulfur (%)	coke (%)	combustible (%)	calorific value (kJ/kg)	
					net calorific value	gross calorific value
48,60	23,89	0,51	34,92	27,51	5.385	6.827

The next picture graphically presents the granulometric composition of the material from the central part of the small sedimentation field.

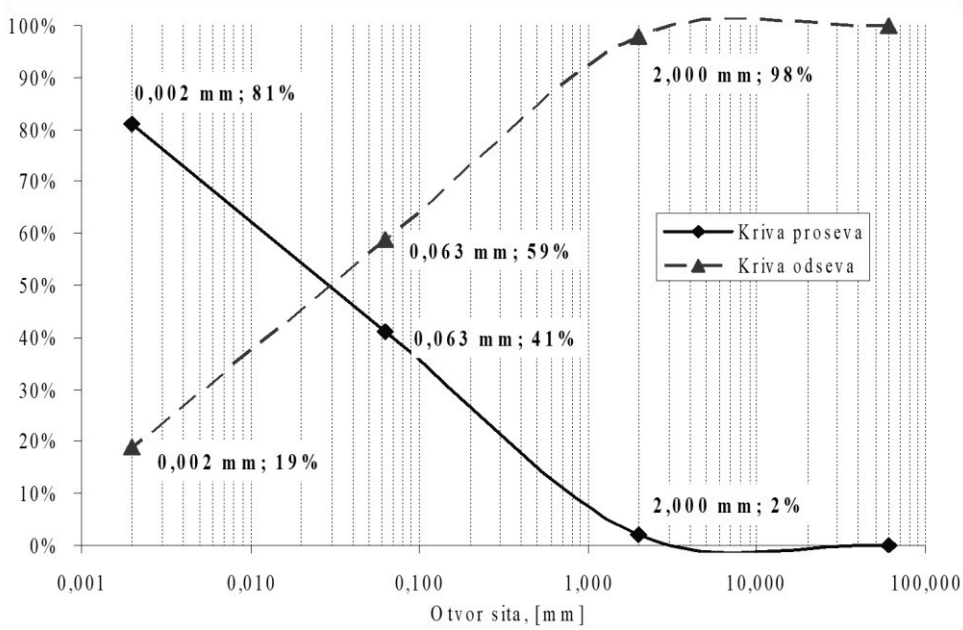

Figure 9, Granulometric composition of the material in the central part of the small sedimentation field

During the period when the plant is operating, it is not safe for construction machinery to enter the small sedimentation field, but the material can only be removed from the embankment of the small sedimentation field. The material extraction technology consists of two steps: extracting the material outside the small sedimentation field, and when it is filtered, loading it into the customers' trucks. Hiring an excavator with a longer dredge arm increases work efficiency. The material from the small sedimentation field is not processed at Rudnik, but is sold directly to customers.

VALORIZATION OF DEPOSITED OVERBURDEN FROM THE GRAVEL EXCAVATION PROCESS

The deposited overburden is a mixture of gravel, sand, clay and coal that was deposited in an internal landfill as the first stage of technical recultivation. For now, the material is sold directly to customers who use it for filling. Starting next year, the material will be used as a material base for gravel separation, which will extract organic matter.

CONCLUSION

The company for underwater coal mining - mine "Kovin" is market-oriented and has a need for maximum valorization of mineral raw materials in order to achieve the highest possible profit. The location of the Mine imposes the obligation to maximize the valorization of mineral raw materials in order to preserve the ecology of the banks of the Danube River. The valorization of man-made deposits at Rudnik increases income and reduces the amount of waste.

LITERATURE

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