MINING AND METALLURGY INSTITUTE BOR
UDK: 622
ISSN: 2334-8836 (Štampano izdanje)
ISSN: 2406-1395 (Online)

UDK: 622.271:621.311(045)=111
DOI: 10.5937/mmeb2201035V
Received: 31.05.2022.
Revised: 06.06.2022.
Accepted: 13.06.2022.
Original Scientific Paper
Energetics

Boško Vuković[*]

PROCUREMENT AND CONSTRUCTION OF THE COAL REFINING PLANT IN A FUNCTION OF INCREASING THE ENERGY EFFICIENCY AND LONG-TERM PRODUCTION AND ECONOMIC EFFECTS OF THE MINE AND THERMAL POWER PLANT GACKO

Abstract

Conquering the new technologies for coal purification in the world has enabled the exploitation of coal deposits with similar characteristics as the subject locality, which until a few years ago were not profitable or even "forgotten". In order to exploit such deposits, more systematic research and testing of useful raw material base as a thermal energy fuel is needed [1].

Considering all that, the Gacko Mine and Thermal Power Plant, as the research holder, started drafting the Project of Detailed Geological Explorations on the return coal zone with a clear goal to define the quantities and quality of coal, i.e. obtaining the clear parameters on thermotechnical properties of combustible coal. On the basis of the Exploration Project, the detailed geological explorations of the "return coal zone" were performed and the exploration results served as a basis for the analysis of coal refining possibilities and possible reconstruction projects on the boiler system of the Gacko Thermal Power Plant.

Keywords: *coal, return zone, waste, calorific value, coal refining, X-Ray*

INTRODUCTION

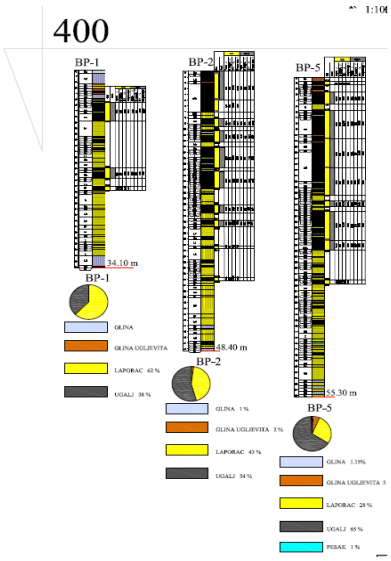
Fossil fuel from the Gacko deposit is primarily used exclusively as the thermal energy fuel for the needs of the thermal power plant in Gacko, and a small share in the total annual production, for commercial placement, and then as an energy raw material. Fossil fuel from this deposit is represented by coal of lignite to brown lignite type of the primary economic and strategic importance for the Republika Srpska. In order to ensure regular supply of TPP with coal of the appropriate and uniform quality, i.e. appropriate calorific value, it is necessary, methodologically, on a concrete example, to perform the coal refining, Combustion of coal without waste, leads to a large number of economically and technologically positive effects in the production process of coal and electricity and at the same time, to reduce and eliminate the negative impact on the environment.

GEOLOGICAL CHARACTERISTICS OF THE COAL DEPOSIT GACKO

Geological research, on the site of the "surface zone - roof coal seams", on the coal deposit Gacko, conducted in the period from 2015 until 2020 have shown that the coal seams are about 15 m thick, with the geological coal columnwith about

[*] *Mine and TPP Gacko*

65% pure coal with an average calorific value of 9.5 MJ/kg, 9% coal clay with an average calorific value of 5 MJ/kg and about 26% stratified waste. The typical appearance of a stratified coal deposit is shown in Figure 1, while the results of exploratory geological drilling are shown in Figure 2.



Figures 1 and 2 *Roof part of the main coal seam in the field "C" (1-left) and geological column of the exploration drillhole at the site "surface zone - roof coal seams (2-right)"*

The appearance of waste layers (marl, coal clay and clay) directly affects the calorific value of coal, which is its most important characteristic and determines its application and price. The calorific value of coal depends on the type of coal defined by the method of its formation, moisture content and ash content. The ash in coal comes partly from coal itself and mostly from waste [4].

In general, it was found that the LCV - Lower Calorific Value of the analyzed coal - lignite (brown-lignite) decreases by the $\Delta LCV = 0.4\text{-}0.5$ MJ/kg for each percentage increase in ash content in coal [6]. The LCV can be increased either by reducing the ash content in coal or its moisture content.

Reduction of moisture in coal can be achieved by its drying, where it is necessary to consume more energy than it will be returned through increases in the LCV of coal, so this method is justified if the waste heat is available. Reduction of ash content in coal can be achieved, inter alia, by dry methods of an X-Ray sensor sorting, i.e, by removal the inorganic materials (marl, clay, coal clay) as inclusions in the coal seam.

TECHNOLOGICAL PROCEDURE OF THE DRY METHOD OF X-RAY SENSORY SORTING/REFINING OF COAL FROM THE COAL OPEN PIT "GACKO"

In the following text, the technological process of coal refining by commissioning of coal refining plant using the method of dry X-Ray sensor sorting/refining of coal is presented. Coal production at the OP "Gacko" takes place at the open pit - Central field - field "C" and "return coal zone". The excavated coal with the admixture of

layered waste is transported by trucks to the primary crushers, where it is crushed into pieces up to -400 mm. Then, it is transported to the coal refining plant by a system of 5 belt conveyors, 1200 mm wide. Here, the coal is subjected to the secondary crushing, sieving and separation, whereby 3 fractions are obtained: -60 mm + 25 mm, -25 mm + 8 mm, -8 mm (fineness).

Coal refining is done for the first two fractions, the X-Ray sensor sorter and fineness falls on the belt, with the on-line LCV meter. If the lower calorific value (LCV) of coal is satisfactory (9 MJ/kg), the coal falls on the coal conveyor belt, and if it is not satisfactory, it is directed to the waste belt. The quality of coal from the Central Exploitation Zone is such that about 30% of coal can go directly to the TPP landfill and about 70% must go to the additional treatment. Coal from the return zone is of poorer quality, so it must be completely subjected to the additional treatment [8]. The basic operating parameters of the Coal preparation and refining plant for the working hours fund of 5000 h/year are given in Table 1.

Table 1 *The basic operating parameters of the coal preparation and refining plant for the working hours fund of 5000 h/year.*

Products	**Unit measure**	**Scenarion I: Tg = 5,000 h/year**	
		According to sample S1	**According to sample S2**
Total run-of-mine coal (t/year)	(t/year)	3,262,306	3,262,306
Plant input capacity (t/h)	(t/h)	653	653
Discarded fineness (-8 + 0 mm)	(t/h)	196	196
	(t/year)	979,592	979,592
Discarded waste (-60 + 8 mm)	(t/h)	137	137
	(t/year)	685,714	685,714
Total discarded material	(t/h)	333	333
	(t/year)	1,665,306	1,665,306
Refined coal	(t/h)	320	320
	(t/year)	1,600,000	1,600,000
	(MJ/kg)	10.3	10.0
	(TJ/year)	16,522,449	16,032,654

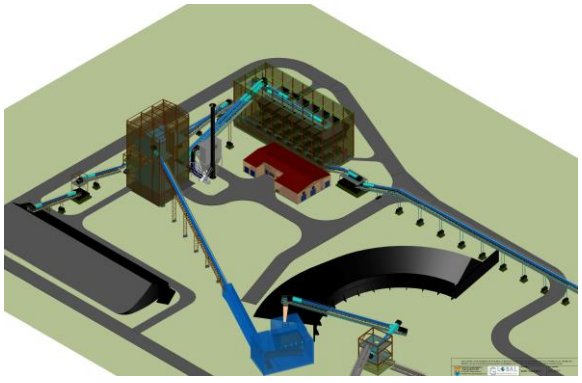


Figure 3 *3D drawing of the coal preparation and refining plant*

ECONOMIC AND TECHNOLOGICAL EFFECTS

Direct profits from the realization of the project for construction the Coal Purification/Refining Plant from the OP "Gacko" are reflected in the effects of the thermal power plant operation, as follows:

- increasing the degree of efficiency of the thermal power plant,
- reduction of the production costs of MWh of electricity.

According to the available literature, for each increase in LCV by 0.5 MJ/kg of coal, the production costs of 1 MWh is reduced by 1 EUR, with data relating to the lignite-like thermal power plants of similar quality, mining and thermal power complexes in Greece [5].

In our case, the coal purification/refining process is planned to increase the LCV from 7 MJ/kg to 10 MJ/kg (at humidity of 35%), which would correspond to a reduction in the electricity production costs by about 6 EUR/MWh.

Indirect profit - benefit from this project for the Mine and TPP Gacko and company as a whole is reflected in:

- Ensuring a continuous and quality supply of the thermal power plant with coal of the required quality (required minimum LCV)
- Prevention of possible negative consequences for the company reputation, if it does not comply with the environmental regulations, which is the basis of business and quality policy and maintaining a positive image through the implementation of an integrated environmental management system, according to ISO standards.

Introduction of such plant into operation leads to a uniform quality of refined coal at the landfill, which will be characterized by [3]:

- uniform ash content up to 15%,
- uniform lower calorific value: LCV = 9.5-10.5 MJ/kg.

Using the refined coal for boiler operation, the following will be achieved:

- increased efficiency of boiler, increase in boiler power, increase in generator power and amount of electricity produced at the same or lower consumption of run-of-mine coal,
- reduction the amount of ash and slag after coal combustion by at least 50%, as follows:
  - reduction the fine ash particles at the outlet of electrostatic precipitator, i.e. at the outlet of a stack below the upper emission limit prescribed by the Law,
  - reduction the amount of ash and slag at the landfill,
  - reduction of gas emissions (CO_2, SO_2, NO_x …).
- elimination of the need to enter the missing energy and maintain the temperature in the furnace with the additional burners on fuel oil,
- elimination of slagging the pipe screens and frequent cleaning interventions.

SOCIAL ASSESSMENT/NATIONAL FEASIBILITY OF THE PROJECT

There is a high degree of interdependence between investment and economic growth since investment strengthens the material basis of society and provides the accelerated economic and social development. When drafting and evaluating an investment project, the macroeconomic effects should be taken into account, i.e. effects from the aspect of society [2]. This

valuation of the investment project aims to review the economic effectiveness of the project from the point of view of society and its contribution to the socio-economic development.

The assessment of the project is based on the socio-economic flow, which has the elements of economic flow, but differs in that it excludes the so-called transfer payments. In the revenue part, recourses, subsidies, donations and export premiums are excluded, and in the expenditure part, taxes, contributions, customs duties, taxes, etc. are excluded. The amount of net income represents the project contribution to the creation of social accumulation. In this case, there are no corrections on the income side, the only correction is the exclusion of income tax, on the expenditure side. The parameters for assessment the socio-economic effectiveness of the project are [3]:

- Social net present value, and
- Social internal rate of return.

Contribution of the project to the socio-economic development is not always quantitatively measurable, so the qualitative assessments are used:

- Meeting the needs of society – implementation of the project directly helps the production of electricity, which is necessary for both the economy and the population,
- Increase in employment - although the project does not envisage employment of the new workers, redistribution of jobs has been provided, for 21 workers,
- Faster regional development - increasing the material base of the region and increasing the living standards of employees,
- Protection and preservation of the environment - refined coal will produce less ash and harmful gases during combustion, which go into the atmosphere, and therefore less ash will be deposited on the internal landfill.

SUMMARY WITH THE FINAL EVALUATION OF THE PROJECT

Further exploitation of coal in the Gacko coal deposit, after the end of exploitation at the open pit Gračanica, in the fields "A", "B" and part of field "C", is directed to the Central and Eastern fields. Coal exploitation is currently taking place within the boundaries of the new open pit Gacko – Central field (field "C" and "roof coal seams - return zone"). In the next period of coal exploitation, a lower quality coal is expected, which was determined by the exploratory drilling. The expected lower quality of coal will be reflected in:

- lower LCV values (up to 6 MJ/kg),
- increased waste content, up to 40%, which also entails the increased moisture content.

Due to all the above, it is necessary to build an X-Ray sensor sorting/purification plant for coal [9].

The X-Ray sensor sorting plant will be located on a free flat surface on the northwest side of the existing coal dump.

Optimization of providing a continuous coal capacity should enable the Coal Mine Gacko to be stable, rational and economical production with all economic parameters to the TPP Gacko landfill, as a product for the TPP supply and product with its selling price including all costs to the TPP Gacko landfill.

Analyzing the financial cash flow has determined the permanent liquidity of the project, the total accumulated amount, net financial flow, i.e. cash at the end of the project life is **79,175,701 KM.**

Economic cash flow provides the basic indicators of profitability of the planned investment and the success of the project as a whole [9]:

- Internal rate of return is **16.98%,**
- Net present value (6%) is **37,881,597 KM,**
- The payback period is **7 years** (including an investment period of 2 years).

The internal rate of return is satisfactory, since that it is an investment in the field of mining where, due to large capital investments, the high rates of return are not expected (on average about 13%).

The net present value is satisfactory, as it is discounted at a rate of 6%, which is higher than the projected interest rate on loans, if the interest rate on loans is higher than projected, the project will continue to be positive.

A payback period of 7 years or 5 production years is also acceptable, as the invested funds will be returned after 1/3 of the production life of project [7].

The final conclusion is that the construction of a coal processing plant by the method of dry X-Ray sensor separation, at the OP Gacko – Central field, is economically completely justified.

REFERENCES

[1] Jovanović, A. Jungmann, M. Bugarin, Possibility of Lignite Enrichment by Dry X-ray Sensor Sorting Technology, 48th International October Conference on Mining and Metallurgy, Bor, Serbia, 2016, pp. 212 -215.

[2] Jovanović A., Bugarin M., Jungmann A., Possibility of Coal Enrichment by Dry Process of Concentration, 1st International Symposium: Investment and New Technologies in Energy and Mining, Šabac, Serbia, 2016, pp. 118-127.

[3] Robben Ch., Takala A., High Volume Sensor Ore Sorting Solutions, 8th Sensor Based Sorting & Control, Aachen, Germany, 2018, pp. 13-19.

[4] Nadolsky S., Samuels M., Klein B., Hart C., Evaluation of Bulk and Particle Sensor -Based Sorting Strategies for the New Afton Block Caving Operation, 8th Sensor Based Sorting & Control, Aachen, Germany, 2018, pp. 103-104.

[5] Jovanovic A., Bugarin M., Application of the Sensor Sorting Technique in Processing of Primary and Secondary Raw Materials, 50th International October Conference of Mining and Metalurgy, Bor, Plenary Lecture, Serbia, 2018)

[6] Semi-industrial Test and Definition the Technological Parameters for Industrial Application the Dry Process of Coal Separation/Refining from the Open Pit "Gacko" -Central Field for Capacity of 600 t+/h of coal, Mining and Metallurgy Institute, Bor, GLOBAL Innovation Projects d.o.o, Belgrade, CALA GmbH, Aachen, 2015 (in Serbian)

[7] Strategy of the Mining-Technological Opening, Development, Optimization and Maintenance the Continuity of Coal Production with the Preparation of the Feasibility Study for Introduction the Dry Separation in Order to Improve the Economic Effects of the Mine Operation, Mining and Metallurgy Institute, Bor, GLOBAL Innovation Projects d.o.o, Belgrade, 2015 (in Serbian)

[8] Industrial Testing of Coal Sorting/Refining of Roof Coal Series and Roof Lithological Members of Coal Seams of the Central Exploitation Field, Mining and Metallurgy Institute, Bor, GLOBAL Innovation Projects d.o.o, Belgrade, CALA GmbH, Aachen, 2019 (in Serbian)

[9] MMD - Main Mining Design of Coal Preparation and Refining and Construction of theCoal Refining Plant by a Dry X-Ray Sensor Separation Method at the Open Pit Gacko - Central Field, Mining and Metallurgy Institute, Bor, GLOBAL Innovation Projects d.o.o, Belgrade, 2020/2021 (in Serbian)