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# ENERGY CONSUMPTION IMPACT OF BELT CONVEYANCE SYSTEMS ON THE OPERATION OF THE FACILITIES OF SERBIAN TRANSMISSION SYSTEM AND MARKET OPERATOR

**Miloš Grujić[1], Miloš Milanković[2], Žika Jovanović[3]**

[1] *Faculty of Mining and Geology, University of Belgrade, Djusina 7, 11000, Belgrade, Serbia, e-mail: milgru@yahoo.com*

[2] *Serbian Transmission System Operator, Kneza Miloša 11,Belgrade, Serbia, e-mail: milos.milankovic@ems.rs*

[3] *Serbian Transmission System Operator, Kneza Miloša 11,Belgrade, Serbia, e-mail: zika.jovanovic@ems.rs*

***Abstract:*** *Continuous conveyance systems are increasingly present in Serbian mining industry. A great number of belt conveyorsare used for the conveyance of excavated ore. All conveyors have electric drives with the installed powerranging from several tens of kWto several MW. Their consumption affects the operation of the electric power transmission systemsand facilities. This paper gives an analysis of the impact of continuous conveyance systems on the operation of the facilities of Serbian transmission system and market operator*

***Key words:*** *belt conveyors, energy consumption, transmission system*

## 1 INTRODUCTION

Mines, regardless of whether it is about open-pit or underground exploitation, are largeelectric power consumers. The volume of consumption depends on many factors; however, we shall talk about the following parameters:

- Annual production of masses,
- Exploitation and preparation technology of mineral raw materials,
- Conveyance of mineral raw materials,
- Mechanization degree of the production process, etc.

Conveyance, as one of the most important phases of ore exploitation falls into the category of the largest electric power consumers. Many electric-powered conveyorsare in operation for several hours, and, on yearly level, the number of their working hours sometimes exceeds 6000 hours.

The objective of this Paper is to show the electric power consumption impact of continuous conveyance systems on the operation of „Elektromreža Srbije“. Thereat, as an example of such impact, the operation of two conveyance systems in RTB Bor was analysed.

## 2 SOME CONSIDERATIONS OF THE RATIO BETWEEN THE ELECTRIC POWER CONSUMPTION OF CONVEYANCE SYSTEMS AND FACILITIES FOR THE ELECTRIC POWER SUPPLY

In Serbian mines there are more than 300 belt conveyors, almost 200 km long in total. The installed power of these conveyors is about 50 MW. If we also add conveyors, situated on ore preparation facilities and plants, like on big excavation machines (excavators), we could say that the estimated installed power of belt conveyors is approximately 70 MW. Out of the total electrical energy consumption in mines, about 40% is spent on conveyance.

Mines, especially the ones with dispersedand big exploitation, are also large energy consumers. This is one of the prevailing reasons why in the vicinity of mines there are also transformer substations of 110-400 kV voltage category. Among the most important facilities of „Elektromreža Srbije“, in the vicinity of the mine there are: Majdanpek 1, Zaječar 1, Majdanpek 2, Vranje, Novi Pazar, Knjaževac,Sjenica, Veliki Krivelj, Majdanpek 3, Obrenovac A, Raška, Aleksinac, Gornji Milanovac, TS Obrenovac TENT A, Kraljevo 3, Bor 2, Jagodina 4, Bor 3, etc.

**Figure 1** *A transformer substation in the vicinity of the mine*

A high consumption of the electric power by belt conveyor systems requires the compliance with the rules of the energy efficiency. The Energy efficiency in ore transportation by means of continuous conveyance is achieved by taking necessary measures on:

- Individual conveyors in the system,
- Conveyance system as a whole.

In taking measures for enhancing the energy efficiency of transportation units (conveyors), it is necessary to reduce energy losses due to improper operation and defects of conveyor parts, to reduce the consumption by improving the construction qualities of a conveyor, by reducing the idling time, by increasing the automation degree, and alike. A special place for enhancing the energy efficiency of a conveyor gives the possibility for a better utilization of the conveyor belt cross section.

In mining industry, particularly in underground mining, there is a relatively low fullness of a conveyor belt section. This leads to a negative ratio between the mass of the net load and the mass of the conveyor belt, which increases the energy consumption per unit of the transported load. In the

problem diagnostics at the Faculty of Mining and Geology in Belgrade [], the following pattern for identifying the degree of energy utilization of the conveyor e is used:

$$e = 1 + \frac{(p-1)\cdot Q_h}{3{,}6 \cdot M \cdot v + Q_h} \quad (1)$$

where: p –utilization factor of the belt section, $Q_h$- hourly capacity of a full-belt conveyor, M–mass of moving parts of a conveyor per m',v –belt speed.

The energy efficiency of the conveyance system as a whole can be achieved by a combined application of technical and organizational measures. The goal of these measures is to increase the system reliability, the throughput capacity, i.e. to increase the utilization factor of conveyance systems through a better utilization of all functions. In this way, we can come to significant savings in energy consumption for powering all transportation units in the system. The most efficient are the organizational measures that, along with automatic control of conveyance systems, contribute to the reduction ofthe idling time of the system and of the unnecessary energy consumption.

Improving the energy efficiency by taking appropriate measures, which include investments in the conveyance system, may be presented through economic parameters that both Elektromreža and mine could have together. As a parameter that shows that the taken measures were justified, we usually take the level of savings from the aspect of Elektromreža Srbije U:

$$U = T_{god} - T'_{god} + I/n_{god}. \quad (2)$$

where: $T_{god}$ – costs of electric power transmission, which include all the costs of Elektromreža due to the energy supply to the mine conveyance system, $T'_{god}$ – costs of transmission after having taken measures for the improvement of the energy efficiency, $I$ – investments in the improvement of the energy efficiency of the conveyance system, $n_{god}$ – number of years for which the measures apply.

## 3 EXAMPLE OF THE ENERGY CONSUMPTION OF THE CONVEYANCE SYSTEMS IN BOR

The Mining Basin Bor (RBB) includes two open-pit mines (Cerovo and Veliki Krivelj) and two flotations. The supply of the plant RBB-Bor with the electric power is made through two transformer substations with the nominal voltage of 110/35/6 kV/kV/kV, namely:

- **TS Veliki Krivelj** (in the close vicinity of the Flotation Veliki Krivelj)

  Installed power 3 x 31.5 = 94.5 MVA
  1 x 20.0 = 20.0 MVA
  Total 114.5 MVA

- **TS Bor 3** (in the close vicinity ofNew haulage shaft of the Bor mine.

  Installed power 3 x 40.0 = 120.0 MVA
  Total for both transformer substations 234.5 MVA

The most significant consumers, supplied from the TS Veliki Krivelj are the following plants, with the specified installed power:

- **The Plant Cerovo** (open pit and facilities for the preparation of mineral raw materials). The whole plant is supplied through a transformer substation with the nominal voltage 35/6/5 kV/kV/kV, and installed power 2 x 8 MVA = 16 MVA

- **The Plant Open-pit Veliki Krivelj.** This plant is supplied through two transformer substations with the nominal voltage 35/6 kV/kV, and installed power 2 x 4 MVA = 8 MVA
  Installed power of important consumers:
  Primary crushing 2 MVA
  Conveyance system for tailings (residue) 9 MVA

- **The PlantFlotation Veliki Krivelj**
  Installed power 43 MVA
  The following plants, with the specified installed power, are supplied from TS Bor 3:

- **The Plant FlotationBor**

Installed power 22 MVA

– **The Plant Jama Bor**

| | | |
|---|---|---|
| Installed power | New haulage shaft | 9.0 MVA |
| | New service shaft | 12.5 MVA |
| | Total | 21.5 MVA |

On the basis of the previously shown data we can see that, after plants and facilities for the preparation of mineral raw materials, conveyance systems are the largest consumers. For the copper mines in Bor, two conveyance systems are characteristic, by their significance and energy consumption*:*

- The conveyance system for the transportation of tailings from the open pit Veliki Krivelj and its disposal in the excavated space of the open-pit mine Bor,
- The conveyance system for ore in the underground mine JAMA Bor.

The conveyance system for the transportation and disposal of tailings from the open pit Veliki Krivelj consists of 3 belt conveyors, T-1, T-2 and T-3, whereby T-3 is non-stationary. In addition to these, the conveyors T-4 and T-5, which represent parts of loading-disposing devices, are also considered as parts of this system. The installed power of these conveyors is as follows:

- Conveyor T-1 (21 m long).....110 kW
- Conveyor T-2 (2765 m long)..... .... 4 x 1000 kW = 4,000 kW
- Conveyor T-3 (300 mlong)..... 1,000 kW
- Conveyor T-4 (20 m long)..... 110 kW
- Conveyor T-5 (45 m long) ..... 160 kW

Total ..... .....5,380 kW.....5.38 MW

**Figure 2** *A part of a conveyor system for the transportation and disposal of tailings*

The continuous conveyance system in the plant JAMA Bor consists of 2 conveyors. Within the whole conveyance and hoisting system of JAMA Bor there are also the primary crushing plant in the mine, hoisting system in the haulage shaft, and the crushing plant on the surface. Their installed power is specified below:

- The crusher at the 17$^{th}$ horizont …… …… 200 kW
- Horizontal conveyor …….. 160 kW
- Incline conveyor……... 2x200+1x160… 560 kW

- Hoisting system……..……. ……..... 2,600 kW
- External crushing……..…… … . 1,000 kW

Total.....4,520 kW.....4.52 MW.

Within both flotations a large portion of the electric power consumption goes to internal transportation systems, which increases the share of conveyance systems in the electric energy consumption for the needs of RBB Bor.

**4 CONCLUSIONS**

The electric power consumption must be, in general, connected to the energy efficiency, i.e. to the rationalization (effectiveness), in all production segments. Conveyance systems in mines fall into the category of large consumers, which have a significant share in the total electric power consumption. Serbian transmission system and market operator, as one of power suppliers, adapts to the needs of a mine and reacts to any change in consumption. In order to rationalize the operation of facilities (transformer substations) in the vicinity of a mine, it is necessary to, first of all,analyse the impact of consumers (in this case of conveyance systems) and then to find, by joint efforts, the optimal method of operation and optimal power supplier.

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