POREĐENJE ENERGETSKE EFIKASNOSTI RAZLIČITIH MLINOVA SA KUGLAMA

COMPARISON OF ENERGY EFFICIENCY OF DIFFERENT SIZE BALL MILLS

Ivana JOVANOVIĆ*[1], Sanja PETROVIĆ[1], Zoran STEVIĆ[2], Daniel KRŽANOVIĆ[1], Dragan MILANOVIĆ[1]
[1] Mining and Metallurgy Institute Bor, Bor, Serbia
[2] University of Belgrade, TF Bor, ETF Belgrade, CIK Belgrade, Serbia

U radu je izvršeno poređenje energetske efikasnosti mlinova sa kuglama različitih dimenzija, a akcenat je stavljen na mlinove u postrojenjima za flotacijsku koncentraciju Majdanpeku i Velikom Krivelju, koja su vlasništvo kompanije Zijin Bor. Poređenje je izvršeno na primeru iste mineralne sirovine (ruda bakra), identičnih polaznih karakteristika (granulosastav, Bondov radni indeks, itd). Utvrđeno je da je specifična potrošnja energije po toni prerađene rude u mlinovima iz majdanpečkog postrojenja nešto veća u odnosu na mlinove iz kriveljskog flotacijskog postrojenja.

Ključne reči: *mlin sa kuglama; energija usitnjavnja, kapacitet*

The paper compares the energy efficiency of ball mills which differ in their dimensions and the emphasis was placed on mills in flotation concentration plants in Majdanpek and Veliki Krivelj, owned by Zijin Bor company. A comparison was made for the case of the same raw material (copper ore), which has the same starting properties (particle size distribution, Bond work index). It was found that the specific energy consumption per ton of processed ore is slightly higher in mils from Majdanpek processing plant, then from Veliki Krivelj processing plant.

Key words: *ball mill; comminution energy; capacity*

1 Introduction

It is well known that in mineral processing plants the most energy is consumed in the comminution processes, i.e. crushing and grinding. The energy consumption in the grinding process even exceeds the energy consumption in the crushing process. The usefully consumed energy is considered to be the energy consumed to create new mineral surfaces, while much of the energy is lost, primarily on friction between the mineral grains, as well as friction between the grains and the working surfaces of the comminution device [1].

The specific energy consumption in ball mills depends on the grinding conditions, i.e. on a number of factors affecting the process, such as: device dimensions, feed and product particle size, grinding method (dry or wet), whether the mill operates in a closed cycle with a classifier, etc.

In particular, this paper is focused on examining the influence of ball mill dimensions on the specific energy consumption of grinding. The specific energy consumption is determined by the well known Bond formula, given in equation (1):

$$W = (k_1 \cdot k_2 \cdot \ldots \cdot k_n) W_i \left(\frac{10}{\sqrt{P}} - \frac{10}{\sqrt{F}}\right) \tag{1}$$

where:
W – specific energy consumption,
$k_1 \ldots k_n$ – correction coefficients for grinding conditions,
Wi – Bond work index, [kWh/t],
F – 80% passing size in µm of the feed
P – 80% passing size in µm of the product

* Corresponding author: ivana.jovanovic@irmbor.co.rs

2 Starting parameters

The specific energy consumption was calculated using the example of copper ore with the following properties: F=1900 μm, P=147 μm, Bond work index in a ball mill Wi=13.5 kWh/t. The capacity of the mills was determined by the standard procedure of F.C. Bond.

The calculations were carried out for several mills of different dimensions, including mills from flotation plants in Majdanpek and Veliki Krivelj. By doing so, certain parameters relevant to the calculation were considered constants, that is, the same values were taken for all mills (see Table 1). The relative rotation speed of mill was adopted according to the recommendations in the literature [1], and the ratio of mill diameter and length was L = 1.5D (except for mills from Veliki Krivelj and Majdanpek plant, whose properties are known).

Table 1: Some of the parameters (constants) for the mill calculation

Parameter	Value
Maximum ball diameter	60 mm
Grinding media bulk density	4.65 t/m^3
Coefficient of mill filling by grinding media	40%

3 Results and discussion

The results of the calculation of specific energy consumption and capacity of the mills are shown in Table 2, and their dependence on the dimensions (diameter) of the mill is given in Figures 1 and 2.

Table 2: Specific energy consumption and capacity of mills

	Internal mill diameter, m	Mill length, m	Relative rotation speed	Specific energy consumption, kWh/t	Mill capacity, t/h
Mill 1	1.0	1.8	0.80	9.61	1.98
Mill 2	1.4	2.4	0.79	8.98	6.13
Mill 3	1.8	3.0	0.78	8.54	14.33
Mill 4	2.2	3.6	0.77	8.21	28.28
Mill 5	2.6	4.2	0.75	7.94	49.32
Mill 6	3.0	4.8	0.74	7.71	80.06
Mill 7	3.4	5.4	0.72	7.52	153.61
Mill Majdanpek	3.74	5.49	0.735	7.38	189.01
Mill Krivelj	4.78	7.8	0.705	7.35	365.62

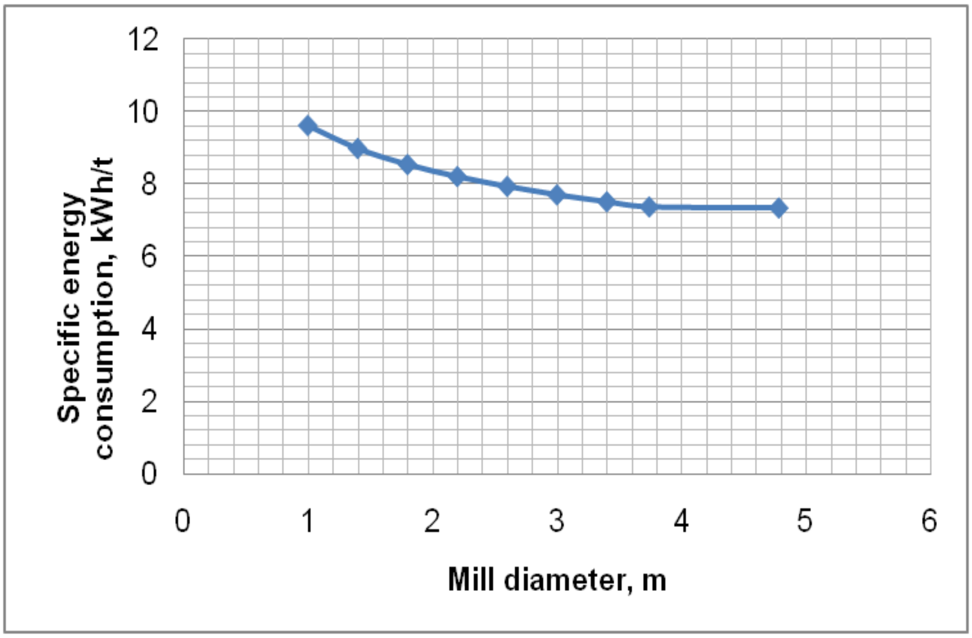

Figure 1. Dependence of specific energy consumption on mill diameter

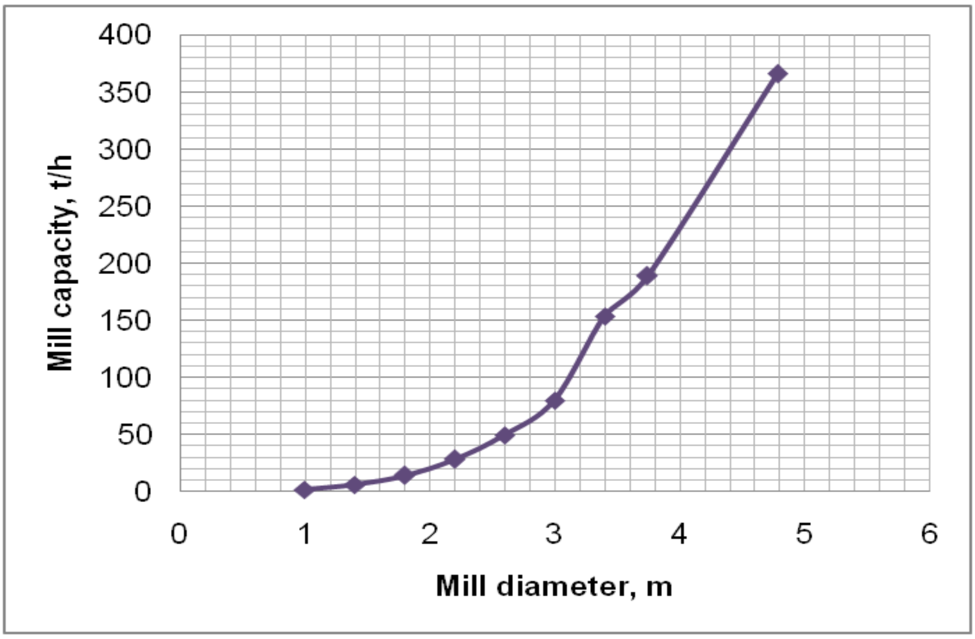

Figure 2. Dependence of mill capacity on mill diameter

Based on the results obtained in Table 2 and Figures 1 and 2, it is evident that with the increase in mill diameter, specific energy consumption decreases, while capacity is practically increasing exponentially. This indicates the advantage of choosing a smaller number of larger mills over a larger number of smaller mills. Six mills with dimensions D×L = 3.96×5.49 m are currently in operation at the flotation plant in Majdanpek, while three mills with dimensions D×L = 5.00×7.80 m are in operation in the Veliki Krivelj plant. Choosing a smaller number of mills of larger dimensions results in, above all, energy savings. However, there are also other benefits that can be achieved in this way:

- One larger mill takes up less space
- Easier process control due to fewer number of control points
- Easier adjustment of the process parameters of rougher flotation due to the uniform particle composition of the grinded product
- Avoidance of errors due to possible variability in the composition of the raw material dosed in several mills, etc.

It should be noted that if ore of different properties were selected, it would certainly affect both the specific energy consumption and the grinding capacity that the mills could achieve. But in any case, specific energy consumption per tone of processed ore would decline with the increase in mill dimensions.

4 Conclusion

By comparing the energy characteristics of different size ball mills, it can be seen that as mill diameter increases, the energy consumption decreases, while the grinding capacity increases exponentially. Hence, preference is given to the choice of a smaller number of larger mills than a larger number of smaller mills, primarily due to lower energy consumption and also due to other benefits such as easier process control, a more uniform particle size composition of grinding products, etc.

5 Acknowledgement

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6 References

[1] **Magdalinović, N.**, *Usitnjavanje i klasiranje*, Nauka, Belgrade, Serbia, 1999.