A. HAXHIAJ, E. HAXHIAJ

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THE OPTIMIZATION OF THE QUANTITY OF COKE AND AGGLOMERATE IN LEAD PRODUCTION IN "WATER-JACKET" FURNACE

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The dependence of technical lead production on the composition of the agglomerate has been analyzed on "Water-Jacket" furnace in Trepça. Additionally, the theoretical and real raport of coke consumption per ton of technical lead was studied. The goal of this study was to optimize the parameters of the process with respect to the amount of technical lead produced, the amounts of lead in the agglomerate and the air in the furnace. Special attention was also placed on minimization of energy consumption and environmental pollution.

Key words: Lead, coke, agglomerate, Water-Jacket furnace, optimization

Optimizacija količine koksa i aglomerata u proizvodnji olovo u "Water-Jacket" peći. Ovisno o proizvodnji olova, sastav aglomerata je analiziran u „Water-Jacket" peći u Trepči. Osim toga, teoretski i stvarni odnos potrošnje koksa po toni tehničkog olova je studira. Cilj ovog istraživanja bio je optimizirati parametre procesa s obzirom na količinu olova tehničke proizvodnje, količine olova u aglomerata i zraka u peći. Posebna je paźnja bila posvećana na smanjenje potrošnje energije i onečišćenja okoliša.

Ključne riječi: olovo, koks, aglomerat, „Water-Jacket" peći, optimizacija

INTRODUCTION

The capacity of furnaces is depen-dent on many factors and is an area of interest for scientific and research institutions, as well as industry. Under-standing furnace capacity helps to maximize production capacity and to minimize environmental pollution. Con-struction, electrical energy, load, and load composition are important precon-ditions for the productivity of furnaces and as such they are analyzed with mathematical models and production parameters in lead metallurgy in the "Trepça" complex. The "Water-Jacket" furnace which is used in the lead production is made of three main parts: the bottom, the well, and the neck of the furnace. The "Water-Jacket" furnace in Trepça has these parameters: the width of the first line blowers is 1,3 m, and the width of the second line blowers is 2,9 m. The length of the furnace is 7,5 m, and it has a capacity of 260 tPb daily when the second line blowers do not work. The fundamental measure of heat energy is the temperature of a system and the amount of heat energy in the system determines the kinetic energy of the molecules in the furnace charge, i.e. the coke that is burned during the process. Pyrometallurgical processes are characterized with chemical reactions, and exchange of heat which is a result of burning coke and convey release of heat from reactive systems. The consumption of coke in reduction processes depends on many factors including: the percentage of lead in agglomerate, and thermal value of coke all of which influence quantity of technical lead produced.

A. Haxhiaj, Faculty of Mining and Metallurgy, Mitrovica, University of Prishtina, Mitrovica, E. Haxhiaj, American University in Kosovo, Prishtina, Republic of Kosova

THE THEORETICAL CONSUMPTION OF COKE

The theoretical consumption of coke is calculated with this formula [1-3]:

$$k' = 0{,}20U + 0{,}20 \; tcoke / tPb \qquad (1)$$

U –represents the mass (weight) of load minimized from coke weight, metal and dust which is calculated with the formula [4]:

$$U = \frac{100}{netproduction} \; tcoke / tPb \qquad (2)$$

The net production is the production of lead per ton of load and depends on lead percentage in agglomerate.

The theoretical consumption of coke is calculated based on the formula (1) for four different percentages of lead in agglomerate.

The results of the calculations are presented on Table 1 Alternative: 1 (50 % Pb); 2 (48 % Pb); 3 (43,6 % Pb); 4 (41 % Pb).

Table 1 **The theoretical consumption of coke based on the percentage of lead in the agglomerate**

The percentage of lead in the agglomerate / %	The theoretical consumption of coke / *tcoke / tPb*
50	0,600
48	0,616
43,6	0,658
41	0,687

The Real Consumption of Coke

The real consumption of coke is calculated with the formula [4]:

$$k = k' \cdot f_4 \cdot f_5 \cdot f_6 \cdot f_7 \cdot f_8 \cdot f_9 \; tcoke / tPB \qquad (3)$$

k' – The theoretical consumption of coke that is calculated above.

f_x – The corrective factors of coke con-sumption, $f_4, f_5, f_6, f_7, f_8, f_9$ [4].

The real consumption of coke is calculated based on the formula (3) for four different percentages of lead in agglomerate.

The results of the calculations are presented on Table 2. Alternative – 1 (50 % Pb); 2 (48 % Pb); 3 (43,6 % Pb); 4 (41 % Pb).

Table 2 **The real consumption of coke based on the percentage of lead in the agglomerate**

The percentage of lead in the agglomerate / %	The real consumption of coke / *tcoke / tPb*
50	0,744
48	0,711
43,6	0,753
41	0,802

The Reprise of Theoretical and Real Consumption of Coke Depending on Lead Percentage in Agglomerate

Based on the analytical and graphical analyses of theoretical and real coke consumption as a function of lead in the agglomerate, it may be concluded that by increasing lead content, the theore-tical and real consumption of coke are both minimized, as shown in Table 3, Figure 1. Alternative – 1, 2, 3, 4.

Table 3 **The theoretical and real consum-ption of coke, and the difference between them depending on the lead percentage in agglomerate**

The percent-age of lead in the agglom-erate / %	The theoreti-cal consump-tion of coke/ *tcoke / tPb*	The real consumption of coke / *tcoke / tPb*	Difference between theoretical and real consumption of coke/ *tcoke / tPb*
50	0,600	0,744	0,144
48	0,616	0,711	0,095
43,6	0,658	0,753	0,095
41	0,687	0,802	0,115

The Real Capacity of Coke Combustion

The theoretical combustion of coke depends on many factors and can be calculated with the formula [4]:

$$K_r = K \cdot f_1 \cdot f_2 \cdot f_3 \; tcoke / 24\,h \qquad (4)$$

$K = 22{,}6 \cdot d_b^2$ this formula is valid for $d_b < 5m$ (5)

d_b – is the diameter inside the furnace and its length is 2,4m in the “Water-Jacket” furnace in Trepça.

$f_1 \cdot f_2 \cdot f_3$ - are corrective factors [1].

$K = 2{,}6 \cdot 2{,}4^2 \; tcoke / 24\,h$

$K = 130{,}176 \; tcoke / 24\,h$

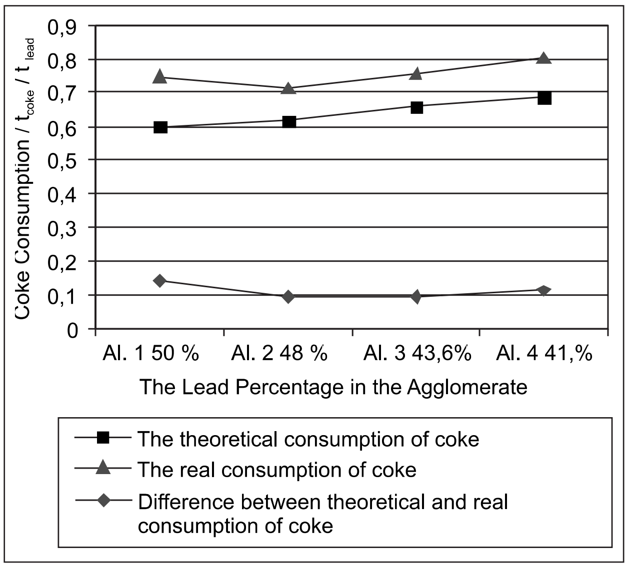

Figure 1 Theoretical and real consum-ption of coke, and the differ-ence between them depending on the lead percentage in the agglomerate

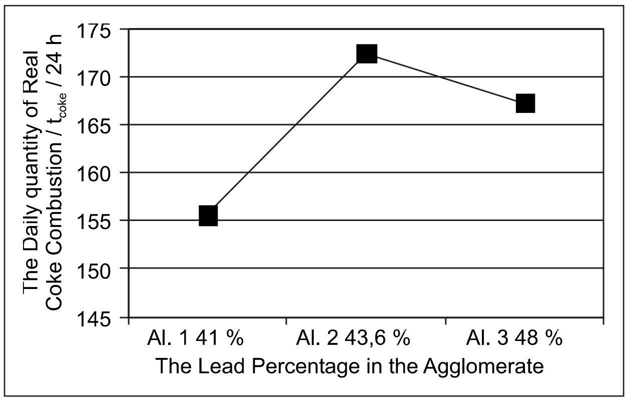

Figure 2 The daily quantity of real coke combustion depending on lead percentage in the agglomerate

The real daily coke combustion is calculated based on the formula (4) for three different percentages of lead in agglomerate.

The results of the calculations are presented on Table 4, Figure 2. Alternative – 1 (41 % Pb); 2 (43,6 % Pb); 3 (48 % Pb).

Table 4 **The daily quantity of real coke combustion depending on lead percentage in the agglomerate**

Lead percentage in agglomerate /%	The daily quantity of real coke combustion / *tcoke / 24 h*
41	155,6
43,6	172,6
48	167,3

The Determination of Thermal Value of Combusted Coke

The thermal value of coke depends on the percentages of carbon, burning matter and non-burning matter, and the strength and metallurgical composition of coke which is based on alternatives 1, 2, 3 of lead composi-

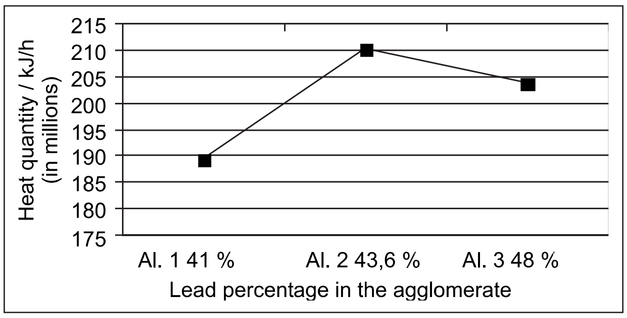

Figure 3 The real quantity of coke com-bustion and thermal value of coke which depends on the lead percentage in the agglomerate

tion in agglomerate [4]. The average value for calories of coke used as a reagent is Q_f = 29228 *kJ/kg* as calculated in "Water-Jacket" furnace [3]. The results are shown in Table 5, Figure 3.

Table 5 **The real quantity of coke com-bustion and thermal value of coke which depends on the lead percentage in the agglomerate**

The lead percentage in the agglomer-ate /%	The real quan-tity of daily coke combustion / *tcoke / 24 h*	The real hourly quantity of coke combus-tion / *tcoke / h*	Quantity of heat / *kJ / h*
41	155,6	6,48	189332640
43,6	172,6	7,19	210077420
48	167,3	6,97	203649460

The Capacity of "Water-Jacket" Furnace

The calculation of furnace capacity based on the amount of coke used is one of the most preferred meth-ods and is calculated using the following mathe-matical model [5-9].

$$N = \frac{K_r}{k} \; tb / 24\ h \tag{6}$$

K_r – The real capacity of daily combus-tion of coke which is calculated with the equation (4).

k – The real consumption of coke depending on percent-age of lead in agglomerate which is calculated with the equation (3).

The capacity of "Water-Jacket" furnace is calculated based on formula (6) according to alternatives 1, 2, and 3. The results are presented on Table 6, Figure 4.

Table 6 **The capacity of the furnace based on the quantity of burnt coke and lead percentage in agglomerate**

The percentage of lead in ag-glomerate / %	The quantity of burnt coke */tcoke / 24 h*	The real con-sumption of coke / *tcoke / tPb*	The capacity of furnace / *tPb / 24 h*
41	155,6	0,802	189,7
43,6	172,6	0,753	229,2
48	167,3	0,711	235,3

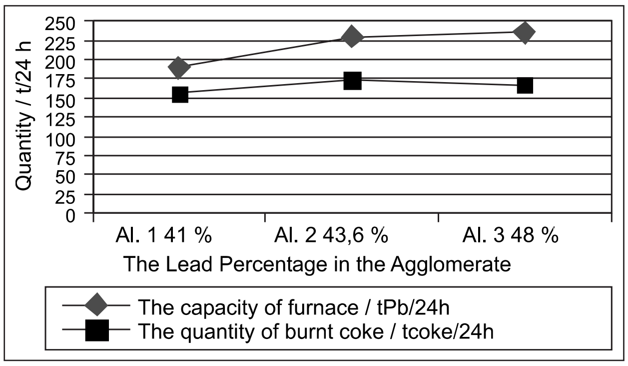

Figure 4 The capacity of the furnace de-pending on quantity of burnt coke and percentage of lead in agglomerate

CONCLUSION

The results analyzed in this scientific paper are based in perennial, profess-ional and scientific work in "Wa-ter-Jacket" furnace in lead metallurgy in Trepça. The work method is based on theoretical and experimental elabora-tions of industrial parameters used during the operation of "Water-Jacket" furnace. The following conclusions have been deduced from the analytical and graphical results for theoretical and real coke consump-tion, and the amounts of lead obtained from agglomer-ates of varying composition:

If the percentage of lead in the agglomerate is less than 43 %:

- Productivity of technical lead is poor.
- The consumption of coke is higher for a tonne techni-cal lead produced.
- The quantity of dust produced increases.

If the percentage of lead in the agglomerate is 48 %:

- Productivity of technological lead is high.
- The consumption of coke is smaller for a ton technical lead produced.
- The quantity of dust produced decreases.

If the percentage of lead in the agglomerate is higher than 48 %:

- The decreased tendency of technological lead produc-tivity.
- The consumption of coke increases for a tonne tech-nological lead produced.
- The quantity of dust gained in process increases.

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