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The Management of Slag and Lead with Slag in Prot-Piri Furnace

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Abstract: The paper analyzes technologic process depending on percentage of lead (Pb) in agglomerate and theoretical and real proportion of production of technical lead and slag. Data presented rely on the work of Water-Jacket furnace, and they emerge as a result of theoretical and experimental studying about the amount of the slag and the percentage of lead in the slag. During the technological process analyses of lead production we researched to increase the technical lead amount produced and the reduction of the lead amount in the slag. Through the amount of slag and the technical lead produced we aimed to optimize the lead percentage in a load as well as the parameters of the technological process with an economical and environmental stability. During the calculations we identified the optimal percentage of the lead (Pb) in agglomerate which enters in the process of reductive melting in the Water-Jacket furnaces in "Trepçë", which amount of the lead is the cause to increase technological capacities.

Keywords: Lead, Load, Slag, Water-Jacket Furnace, Optimum, Technological Process

1. Introduction

Management quantity of technical Lead, quantity of slag and slag losses on melting Lead to reductive complex service in ducts furnaces is important in the process of obtaining technological Lead. At the bottom of the furnace have melted material which consists technical Lead and slag, where stratification and their division is made according to the specific weight.

The composition of the technical Lead, slag and slag losses Lead with is complex and depends on many factors. Managing the amount of slag and slag losses Lead to the subject of study in this paper which refers to technological parameters of melting process. Parameters influence the losses of Lead in slag are: load balance, load temperature, amount and composition of the load which is dosed in furnace to melting. Analysis of the load melting process and products of Lead melting in profitability made to achieve technical and technological and economic effects.

2. From Literature

2.1. Indirect Smelting

Before lead concentrate can be charged into traditional blast furnaces for smelting, it must be roasted to remove most of the sulfur and to agglomerate further the fine flotation products so that they will not be blown out of the blast furnace. Various fluxing materials, such as limestone or iron ore, are mixed with the ore concentrate. The mix is spread on a moving grate, and air is blown through at a temperature of 1,400°C (2,550°F). The sulfur, along with coke additions, serves as a fuel and is combusted to sulfur dioxide gas, which is usually recovered for the production of sulfuric acid as a by-product.

Roasting fuses the remaining ingredients into a brittle product called sinter, which consists of oxides of lead, zinc, iron, and silicon along with lime, metallic lead, and some remaining sulfur. This material is broken into lumps as it is discharged from the moving grate. The prefluxed, lumpy sinter is then loaded into the top of a heated blast furnace, along with the coke fuel. A blast of air is admitted to the lower part of the furnace to aid combustion of the coke, generating a temperature of about 1,200°C (2,200°F) and producing carbon monoxide. This gas then reacts with the metallic oxides, producing carbon dioxide and molten metal. Nonmetallic wastes form a slag with the fluxing materials.

When reduction is complete, the furnace is tapped and the lead drawn off to flow into drossing kettles or molds. At this stage, the semifinished product, 95 to 99 percent lead and containing dissolved metallic and nonmetallic (oxide and sulfide) impurities, is known as base bullion. The bullion is maintained at a temperature just above its melting point, about 330°C (626°F). At this temperature, the solubility of copper in lead is very low, so that the copper content segregates and forms a scum, or dross, on the surface of the bath in the drossing kettle. After this is skimmed off, more copper and other impurities are brought to the surface by stirring sulfur and lead pyrite into the bath or by agitating it with submerged air lances. These impurities are also skimmed off, and the remaining base bullion is refined to yield lead of commercial quality.

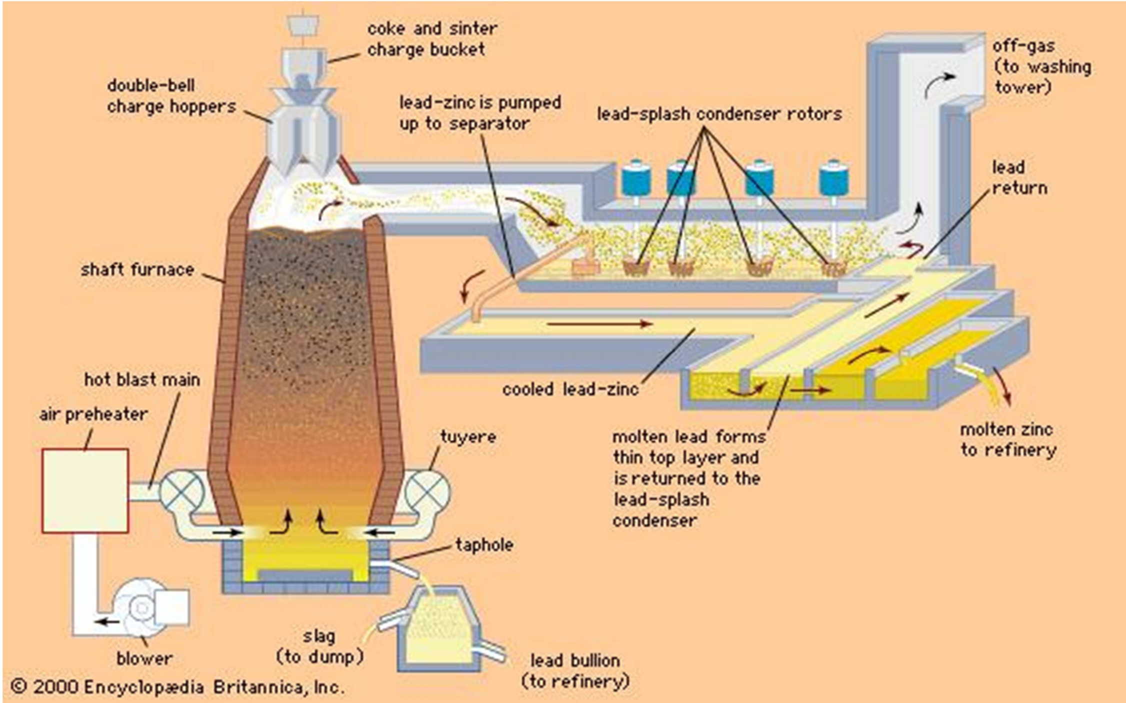

Fig. 1. *Presentes smelting process of lead aglomeration.*

2.2. Direct Smelting

Indirect smelting in roasters and blast furnaces began to be replaced in the 1970s by several direct smelting processes conducted in relatively small, intensive reactors. These processes require neither the sintering of feed materials nor the use of metallurgical coke; also, they produce lower volumes of gas and dust that would require treatment with pollution-control equipment. In general, direct smelting can be divided into two categories: (1) submerged smelting, as in the QSL and Isa smelt processes, in which the refining reactions occur in a liquid (i.e., molten metal, matte, or slag), and (2) suspension smelting, as in the KIVCET process, in which the reactions occur between gases and solids.

KIVCET is a Russian acronym for “flash-cyclone-oxygen-electric-smelting.” A three-part KIVCET furnace comprises the reaction shaft, waste-gas shaft, and electric furnace, all connected with a common settling hearth. It employs the autogenous (that is, fuel-less) flash smelting of raw materials, with the heat-producing oxidation of the concentrated sulfide ore raising the temperature to 1,300–1,400°C (2,375–2,550°F), which is enough to reduce the oxidized materials to metal. In operation, the process involves the proportioning, drying, and mixing of the lead-bearing materials and fluxes, followed by their injection into the reaction shaft, where they are ignited by a heated blast of commercially pure oxygen. The smelted lead bullion and slag collect in the hearth, while zinc vapour undergoes combustion with carbon monoxide in the electric furnace to produce zinc oxide. Sulfurous gases generated by the smelting process are tapped from the waste shaft to heat steam and to produce sulfuric acid as a by-product.

The KIVCET process appears to produce significantly less flue dust than other direct processes, and its furnace brickwork has a longer service life. However, its use of electricity rather than fossil fuel usually militates against its use for eliminating zinc from the slag.

3. Experimental Part

The furnace capacity is limited by many factors and so far this field has not been much attention.

Recently become the object of study is scientific institutions and manufacturing companies to increase productivity [1]. Calculating the capacity of the furnace is made with the following mathematical model for different amounts of Lead in agglomerate.

Alternative I, the calculation of the benefit of Lead technical when agglomeration contains 43.6% Pb:

$$N = \frac{K}{k}\,\frac{t_{Pb}}{24h}$$

K - real capacity of the coke combustion is 170.93 $\frac{t}{24}$

calculated on paper.

k - real coke consumption is $0.753\frac{t_{coke}}{t_{pb}}$ calculated on paper.

$$N = \frac{170.93\ \frac{t_{coke}}{24}}{0.753\,\frac{t_{coke}}{t_{pb}}}$$

$$N = 227.01\ \frac{t_{Pb}}{24}$$

Alternative II, the calculation of the benefit of Lead bit technical when agglomeration contains 48% Pb :

$$N = \frac{K}{k}\ \frac{t_{Pb}}{24h}$$

K - real capacity of the coke combustion is 167.36 $\frac{t}{24}$ calculated on paper.

k - real coke consumption is $0.711\frac{t_{coke}}{t_{pb}}$ calculated on paper.

$$N = \frac{167.36\ \frac{t_{coke}}{24}}{0.711\,\frac{t_{coke}}{t_{pb}}}$$

$$N = 235.3\ \frac{t_{Pb}}{24}$$

Alternative III, the calculation of the benefit of Lead bit technical when agglomeration contains 50% Pb:

$$N = \frac{K}{k}\ \frac{t_{Pb}}{24h}$$

K - real capacity of the coke combustion is 170.93 $\frac{t}{24}$ calculated on paper.

k - real coke consumption is $0.709\frac{t_{coke}}{t_{pb}}$ calculated on paper.

$$N = \frac{170.93\ \frac{t_{coke}}{24}}{0.709\,\frac{t_{coke}}{t_{pb}}}$$

$$N = 230.2\ \frac{t_{Pb}}{24}$$

Alternative IV, the calculation of the benefit of Lead bit technical when agglomeration contains 51% Pb:

$$N = \frac{K}{k}\ \frac{t_{Pb}}{24h}$$

K - real capacity of the coke combustion is 160.36 $\frac{t}{24}$ calculated on paper.

k - real coke consumption is $0.700\frac{t_{coke}}{t_{pb}}$ calculated on paper.

$$N = \frac{160.36\ \frac{t_{coke}}{24}}{0.700\,\frac{t_{coke}}{t_{pb}}}$$

$$N = 229.06\ \frac{t_{Pb}}{24}$$

Sizes obtained during calculations of the Alternative I-IV are presented in Table 1 and Figure 1.

Table 1. *Presentation of obtaining technical Lead in function of the composition of Lead agglomerate with scope (43.6-51) Pb%.*

Percentage of Lead in agglomeration (%)	The amount of technical Lead "t_{Pb} / 24h
43	227.01
48	235.30
50	230.20
51	229.06

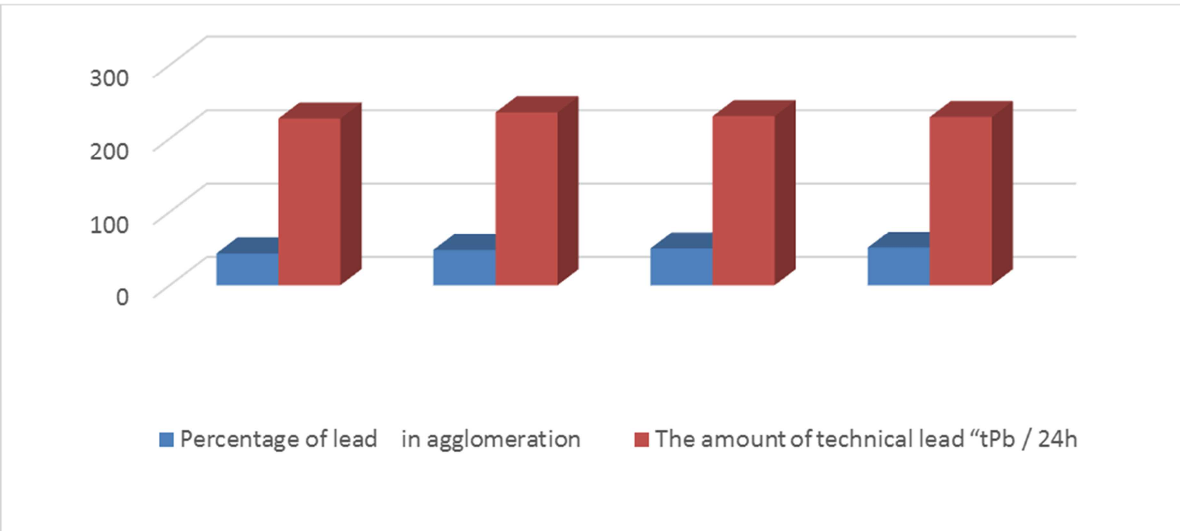

Fig. 2. *Percentage of Lead agglomeration and the impact on the profitability of technical Lead.*

4. Management Quantity of Slag

Managing the amount of slag in the process of obtaining technical Lead is made to work the material balance of the composition of demand for melt reductive and constructive solutions in ducts furnaces working space in in order to economic and environmental sustainability of the process.

Calculating the amount of slag is made according to equation:

$$G_{slag} = G_{load} – G_{Pb\ technical} – G_{dust}$$

G_{load} - The dosed amount of load on the furnace for melting measured in unit.

$G_{Pb\ technical}$ - Quantity technical Lead produced depending on the percentage of Lead in agglomerate.

G_{dust} - The amount of dust in the atmosphere flow depending on the amount of load to melt.

Alternative I. Calculation of the amount of slag when agglomeration contains 43.6% Pb.

G_{load} = 639.44 $\frac{t}{24h}$ measured in a furnace and which consisting of:

$$G_{agglomerate} + G_{Coke} + G_{dust} = 534+58.08+47.3$$

G_{dust} - the amount of 7-9% load values during calculations appropriated amount of 8%:

$$G= 639.4 \cdot 8\%\frac{t}{24h}\ dust$$

$$G_{dust} = 51.15\frac{t}{24h}$$

$$G_{slag} = 639.44 – 227.01 – 51.15\frac{t}{24}$$

$$G_{slag} = 361.28\ \frac{t}{24h}\ 639$$

Alternative II. Calculation of the amount of slag when agglomeration contains 48% Pb.

$$G_{slag} = G_{load} – G_{Pb\ technical} – G_{dust}$$

$$G_{slag} = 639.44 – 235.3– 51.15\ \frac{t}{24h}$$

$$G_{slag} = 352.99\ \frac{t}{24h}\ 639$$

Alternative III. Calculation of the amount of slag when agglomeration contains 50% Pb.

$$G_{slag} = G_{load} – G_{Pb\ technical} – G_{dust}$$

$$G_{slag} = 639.44 – 230.2– 51.15\ \frac{t}{24h}$$

$$G_{slag} = 358.09\frac{t}{24h}$$

Alternative IV. Calculation of the amount of slag when agglomeration contains 51% Pb.

$$G_{slag} = G_{load} – G_{Pb\ technical} – G_{dust}$$

$$G_{slag} = 639.44 – 229.06– 51.15\ \frac{t}{24h}$$

$$G_{slag} = 359.23\frac{t}{24h}$$

Estimated size for the amount of slag depending on the lead content in the agglomerate. The alternative I-IV are shown in Table 2 and Fig. 2.

Table 2. *Presentation of the amount of slag in the quantity of load and the percentage of Lead in the agglomerate.*

The percentage of Lead in the agglomerate	The amount of load t / 24h	The amount of technical Lead t / 24h	The amount of slag t / 24h
43.6	639.44	227.01	361.28
48.0	639.44	235.30	352.99
50.0	639.44	230.02	358.09
51.0	639.44	229.06	359.03

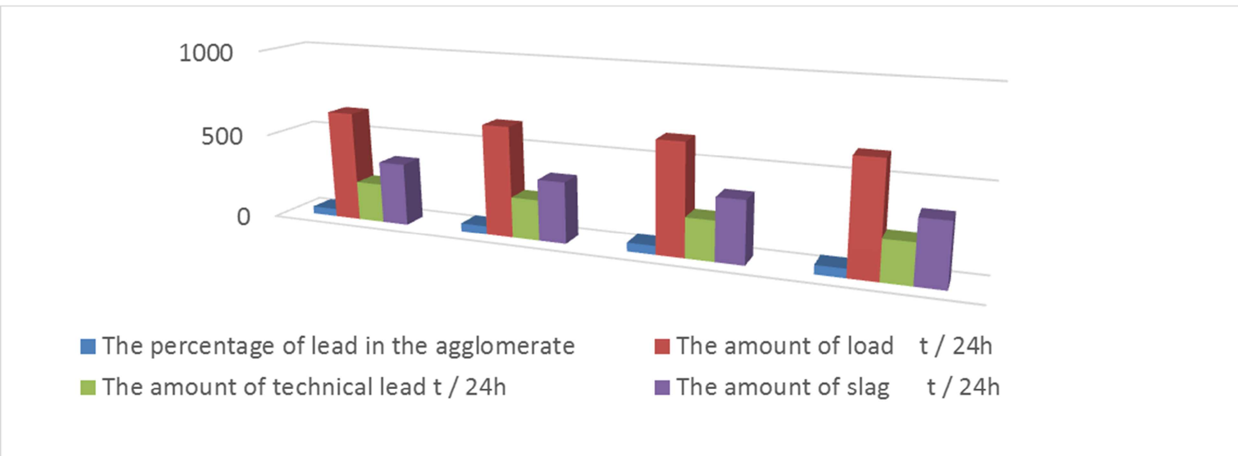

Fig. 3. *The percentage of Lead agglomeration and its impact on the amount of slag.*

5. Management of Lead in Slag

The amount of losses Lead to slag depends on many factors such as the percentage of Lead in agglomeration, the amount of gas during the melting process technology and reductive load of furnace working space which gives the product as impurities technical and slag.

The amount of Lead oxide in the slag can be calculated by a mathematical model.

$$G_{PbO} = G_{Slag} \text{ x } 0.236\ \% \frac{t}{24h}$$

G_{Slag} - is the amount of slag, 0.236% - the composition of Lead oxide slag.

Alternatives I. Amount of oxide Lead when agglomeration slag contains 43.6% (Pb).

$$G_{PbO} = 361.28 \text{ x } 0.236\ \% \frac{t}{24h}$$

$$G_{PbO} = 0.852 \frac{t}{24h}$$

Alternative II. Amount of oxide Lead when agglomeration slag contains 48% Pb.

$$G_{PbO} = 352.99 \text{ x } 0.236\ \% \frac{t}{24h}$$

$$G_{PbO} = 0.833 \frac{t}{24h}$$

Alternative III. Amount of oxide Lead when agglomeration slag contains 50% Pb.

$$G_{PbO} = 358.09 \text{ x } 0.236\ \% \frac{t}{24h}$$

$$G_{PbO} = 0.845 \frac{t}{24h}$$

Alternative IV. Amount of oxide Lead when agglomeration slag contains 51% Pb.

$$G_{PbO} = 359.03 \text{ x } 0.236\ \% \frac{t}{24h}$$

$$G_{PbO} = 0.847 \frac{t}{24h}$$

The amount of Lead sulfate slag can be calculated according to the equation and it's important position in the management structure of Lead slag losses.

Estimated size for the amount of Lead oxide slag depending on the Lead content in the agglomerate, the alternative I-IV (management of Lead slag), appear in the tab. 3 and fig. 3

***Table 3.** The amount of Lead oxide slag depending on the percentage of Lead agglomerate and quantity of slag.*

The percentage of Lead in the agglomerate	The amount of load t / 24h	The amount of slag t / 24h	The amount of Lead oxide slag t / 24h
43.6	639.44	361.28	0.852
48.0	639.44	352.99	0.833
50.0	639.44	358.09	0.845
51.0	639.44	359.03	0.847

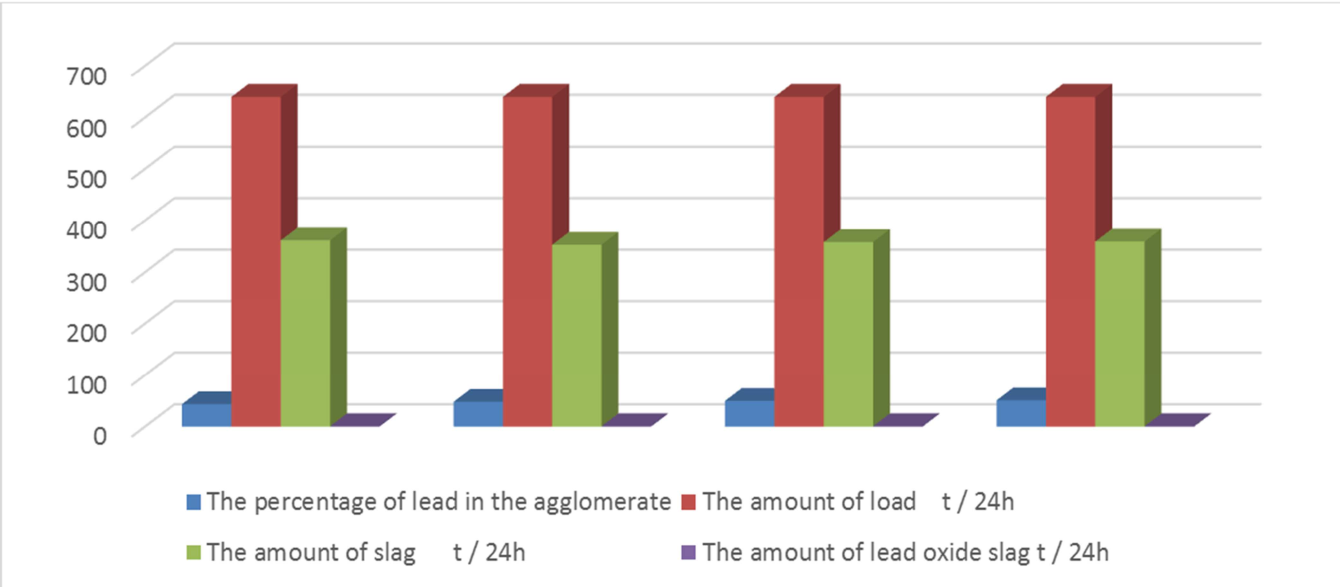

***Fig. 4.** Percentage of Lead agglomeration and its impact on the amount of oxide Lead slag. 6. Conclusions.*

Based on calculations made it can be concluded that all positions balance the technical lead, slag and lead slag losses are of great value in the process of reductive melting in ducts furnaces.

To have minimum loss of Pb in slag should be some parameters while maintaining the previously defined values (such as the temperature of the slag, the Cu content in the load, emptying the furnace to be continued) parameter for retention of Pb in the agglomerate should be 43.6- 48% margins. This finding is analyzed analytically and graphically.

The results obtained lead to the loss of the slag values of 0833-0852 t / 24h, before excrete size which expressed the importance of the amount of lead in the agglomerate which to achieve economic effects should be 43.6-48% boundaries.

The rest of the lead slag (out of a total 1.6% Pb) is connected as PbSO4 and metallic lead (Pb).

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