THE POSSIBILITIES OF UTILITIZING OF DUST AND SLUDGE FROM STEEL INDUSTRY

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MOŽNOSTI VYUŽITIA PRACHU A KALU Z OCELIARENSKEHO PRIEMYSLU

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Abstract

The objective of this work was to provide more insight into the processes affecting the reduction behavior of converter steel dust and sludge by the sintering.

To produce sinter, the converter steel dust and sludge were mixed with iron ore, limestone and coke. The mixture was ignited on a sinter strand and as air passes through the bed, the hot flame front causes sintering of the particles to agglomerate. The actual sintering process takes place in a very short time in which temperatures from 1400 to 1450^{o}C are attained. Due to the nature of this process, the result was an inhomogeneous product with low contents of Pb, Zn.

In the theoretical part of present work, basic data about problematic of lead and zinc removal from converter steel dust and sludge by reduction were studied.

Experimental work consists of two parts. In the first part of present work thermodynamic analyse of reactions is summarized. The second part is divided into laboratory, pilot plant and full plant experiments of lead and zinc removal from converter steel dust.

Key words: sintering, converter steel dust, converter steel sludge, lead and zinc removal

Abstrakt

Cieľom tejto práce bolo lepšie priblížiť procesy ovplyvňujúce priebeh redukcie oceliarenskych prachov a kalov pri aglomerácii.

Pre výrobu aglomerátu boli zmiešané oceliarenske kaly a prachy, železná ruda, vápenec a koks. Zmes bola zapálená na spekacom páse a pri prechode vzduchu cez spekanú vrstvu zóna horenia spôsobuje spekanie častíc do aglomerátu. Spekací proces prebieha v krátkom čase a je dosahovaná teplota 1400 až 1450°C. Vzhľadom na podstatu procesu, výsledkom bol nehomogénny product s nízkym obsahom Pb a Zn.

V teoretickej časti práce boli študované základné údaje o problematike odstraňovania zinku a olova z oceliarenskych kalov a prachov redukčným spôsobom.

Experimentálna časť je zložená z dvoch častí. V prvej časti práce je sumarizovaná termodynamická analýza reakcií. Druhá časť je rozdelená na laboratórne, poloprevádzkové a prevádzkové experimenty odtraňovania zinku a olova z oceliarenskeho prachu.

1. Introduction

The main problem so far is recycling or utilising dust and sludge of the steel industry. Dust and sludge from iron- and steelmaking processes usually have a high iron content.

A possibility to treat dusts scales and sludge in a separate process was studied in many countries. Many processes have been developed for this purpose but many of them have also been abandoned because of technical or economical problems. Methods can be divided into pyrometallurgical (high temperature) and hydrometallurgical (low temperature) processes.

Zinc is concentrated in the BF, BOF and EAF dusts because of its low vaporisation temperature. Zinc has harmful effect on the process performance and steel quality. The zinc
content of steel making dusts is, however, too small to be utilised economically in zinc production.

Coarse dust is separated from the BOF gas in the case of dry BOF gas treatment or as sludge in case of wet treatment (e.g. in a venturi scrubber). The composition of coarse dust can be seen from table 1 in comparison with the one for fine dust. The composition of coarse sludge and fine sludge has the similar relations.

Table 1 Composition of coarse and fine dust in [weight-%] – [1]

Parameter	Coarse dust [%]	Fine dust [%]
Total Fe	35 - 85	54 - 70
Metallic Fe	70 - 75	20 - 25
CaO	8 - 20	3 - 10
Zn	0,01 – 0,5	1,4 – 3,4
Pb	0,01 – 0,04	0,2 – 1,0

The coarse dust after preparation is usually returned to the oxygen steelmaking process or is recycled to the sinter strand. In the EU only a smaller part is put to landfill (Figure 1).

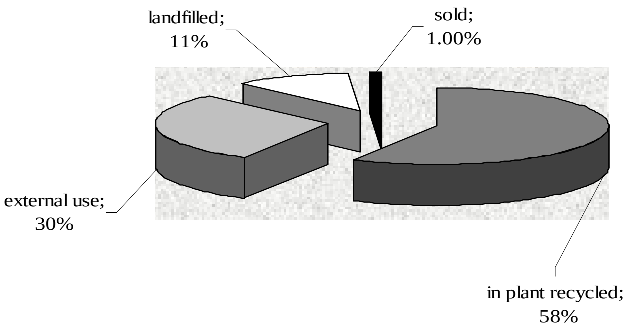

Fig.1 Fate of dust from dry BOF gas treatment – [1]

Table 1 indicates that fine dust, compared to coarse dust, contains significantly larger amounts of lead and zinc. The main source of these heavy metals usually is scrap charged to the BOF. In some cases it is possible to control the lead and particularly the zinc input with the scrap. This reduces zinc content to below 1% which is target of the measure. Because of the zinc content, very often the fine dust or sludge cannot be recycled but is put to landfill (Figure 2).

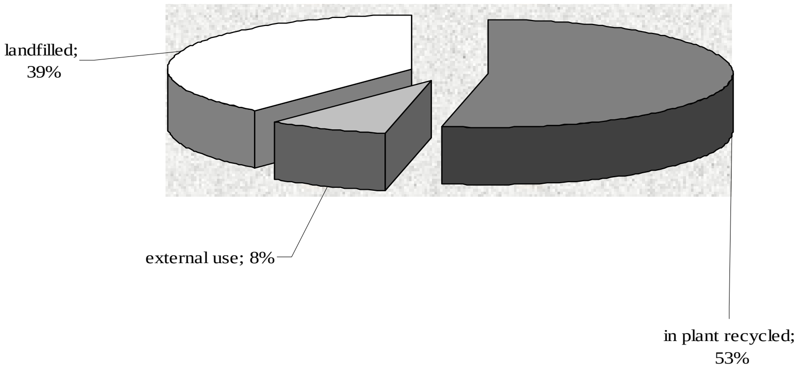

Fig.2 Fate of sludge from (wet) BOF gas treatment in the EU – [1]

Technically it is possible to extract the non-ferrous metals from this sludge and dust, after which the valuable iron-containing "cleaned" solids can be recycled into the iron-making process.

The following methods can been applied (in different stages of development):

- Rotating hearth furnace process (Inmetco) [2];
- Fluidised bed process (Thyssen) [3];
- Circulating fluidised bed reactor;
- High turbulence mixer process;
- Plasma process (Siromelt, Plasmelt) [4];
- Multi-role oxygen cupola furnace.

This work deals with problems of oxygen converter flue dust treatment. Among feasible technological processes providing utilization of converter flue dust sintering process can be included. In production of sinter from converter dust and sludge combustion gases are generated, that are contaminated by solid matters, mostly by Zn and Pb oxides. These can be used after their elimination as Zn-Pb concentrate utilised in non-ferrous metals metallurgy for production of Zn and Pb.

2. Experimental part

Thermodynamic analysis of metallized sinter production.

The aim of the analysis was to evaluate from thermodynamic point of view the possibilities of Zn and Pb separation from recycled secondary raw material (converter dust and sludge).

Starting composition of model system equals to experimental sinter charge.

Starting composition of the system: (counted to 100 g of charge).
FeO .... 43,68 %
Fe_2O_3................. 21,06 %
$ZnO*Fe_2O_3$........ 8,56 %
PbO.................... 0,56 %
C......................... 12,57 %
O_2....................... 0,16 dm^3
N_2....................... 0,6 dm^3

Results of thermodynamic calculations of the analysed system.

From thermodynamic point of view decomposition of zinc ferrite at specified conditions occurs already in low temperature range, kinetics of the process is limiting. From thermodynamic point of view decomposition of zinc ferrite is finished at temperature of 800 °C (Figure 3).

In temperature interval 800 to 1500 °C certain part of Zn is deposited in melt. At temperatures over 1400 °C zinc exists nearly exclusively in form of Zn (g).

Distribution of Zn and Pb in form of gaseous components at minimum amounts of air occurs at lower temperatures – up to 1000 °C.

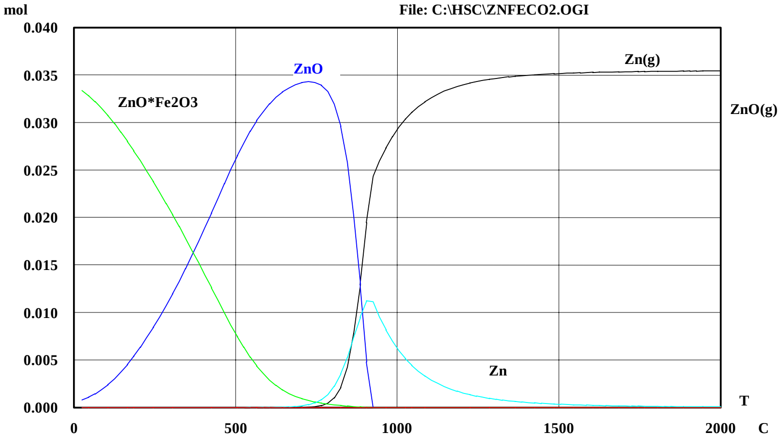

Fig.3 Distribution of Zn in relation to temperature at minimum amount of air

By increasing of oxygen content oxides become major components of the system (Figure 4). Distribution of Zn and Pb in form of gaseous components at maximum amounts of air occurs over temperature of 1400 °C.

With increasing proportion of carbon in the system proportion of elementary zinc and lead vapours increases (Figure 5). The conditions for removal of these accompanying elements are improved.

Conclusions from thermodynamic analysis of metallized sinter production.

Decomposition of zinc ferrite at specified conditions occurs already in low temperature range (at minimum amount of air) and in big temperature range (at maximum amount of air), kinetics of the process is limiting.

In contrary to Zn, Pb concentrates in metallic phase in bigger quantity, mainly in zone of low temperatures up to 1000 °C. This fact can be explained by better reducibility of PbO by solid carbon, when compared with ZnO.

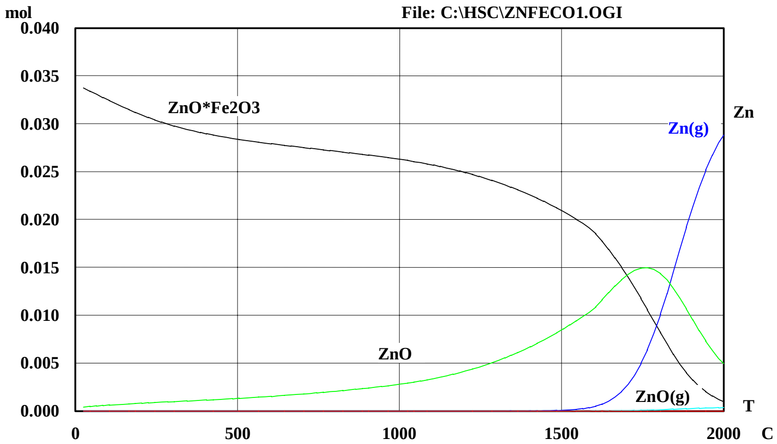

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Fig.4 Distribution of Zn in relation to temperature at maximum amount of air

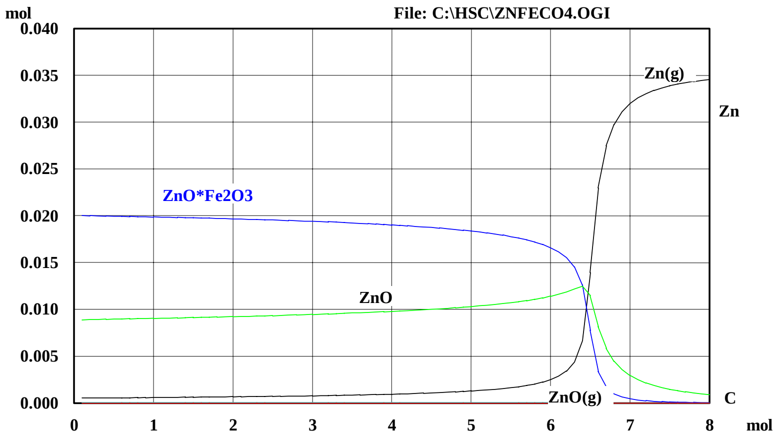

Fig.5 Distribution of Zn in relation to C quantity at temperature of 1600 °C at maximum amount of air

Laboratory experiments

The aim of laboratory experiments was to determine optimum amount of fuel to provide necessary metalization rate and the highest removal rate of Zn and Pb, to determine optimum gas-dynamic conditions and to study the strenght of the sintering product [5].

For sintering in laboratory conditions the charge, that consisted of converter dust, converter sludge, (table 2), lime and coke breeze, was used.

Table 2 Chemical composition of incoming raw materials

Component	Chemical composition [%]								
	Fe	FeO	Fe_2O_3	SiO_2	CaO	MgO	Al_2O_3	Zn	Pb
Converter dust	57,3	3,38	77,9	2,25	6,35	2,04	0,92	0,90	0,20
Fine converter sludge	56,4	55,0	11,4	1,25	4,79	1,19	0,93	0,74	0,13
Coarse converter sludge	67,7	24,2	3,20	3,00	13,6	4,90	0,72	0,12	0,02

Sintering experiments were realized in sintering pan, (Figure 6).

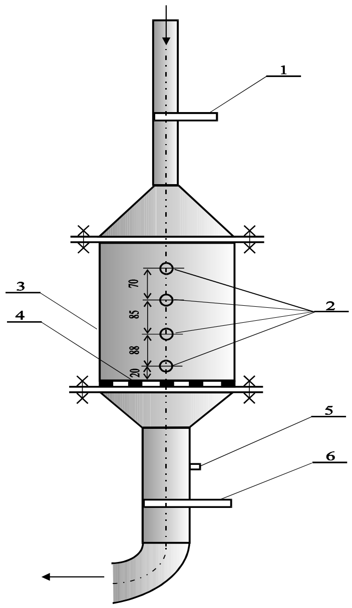

Fig.6 Scheme of sintering pan
1 – measurement of sucked air amount, 2 – measurement of temperature in sintered layer, 3 – pan body, 4 – grate, 5 – measurement of chemical composition and temperature of combustion gases, 6 – measurement of sucked combustion gases amount

Figures 7,8 indicate influence of fuel amount and rate of sucked air on removal rate of Zn.

Removal rates of Zn and Pb in metallized sinters increased with increasing content of coke breeze (Figure 7). It can be stated also in context with thermodynamic analysis of model system, where increase of starting amount of carbon over 6 moles heavy increased equilibrium amounts of Pb (g) and Zn (g).

Increase of sucked air rate resulted in increased removal rates of Zn and Pb in metallized sinters, that was caused by more intensive removal of Zn and Pb vapours from sintered layer (Figure 8). Larger dispersion of Zn removal rate values is related to different pre – pelletisation rates of sinter charge.

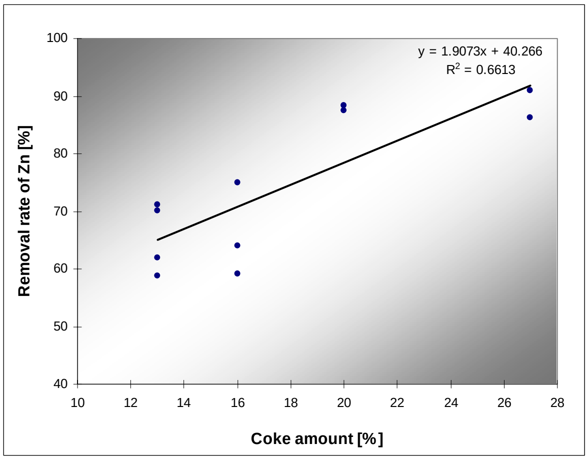

Fig.7 Influence of fuel amount on removal rate of Zn

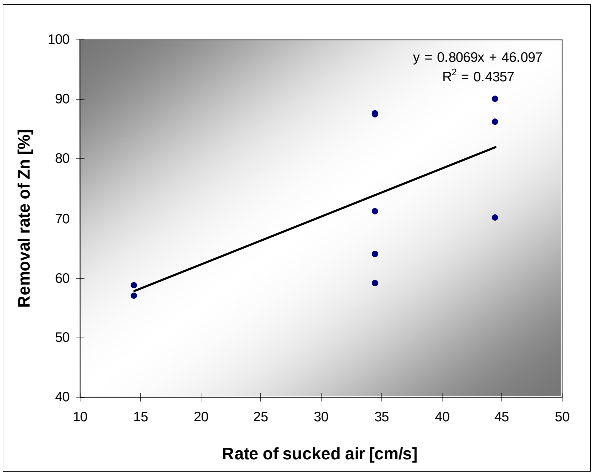

Fig.8 Influence of rate of sucked air on removal rate of Zn

In the next phase of research pilot plant and plant experiments of converter dusts and sludges treatment on sintering band were realized. Maximum removal rates of Zn and Pb in realized esperiments are in (Figure 9).

Conclusions

Results of the experimental work are:

1) Removal rates of Zn and Pb in metallized sinters increased with increasing content of coke breeze. It can be stated also in context with thermodynamic analysis of model system, where increase of starting amount of carbon over 6 moles heavy increased equilibrium amounts of Pb (g) and Zn (g).

2) Increase of sucked air rate resulted in increased removal rates of Zn and Pb in metallized sinters.

3) In production of metallized sinters, in process of gas cleaning formed Zn –Pb phase should be concentrated in non – oxidation atmosphere. When product has at minimum 30% of Zn – Pb phase, it can be utilized in non – ferrous metallurgy.
4) In practice utilization of produced sinter in production of steel in electric arc furnace was examined. The results of this sinter use in electric arc furnace do not show negative influence on chemical composition of steel and slag.

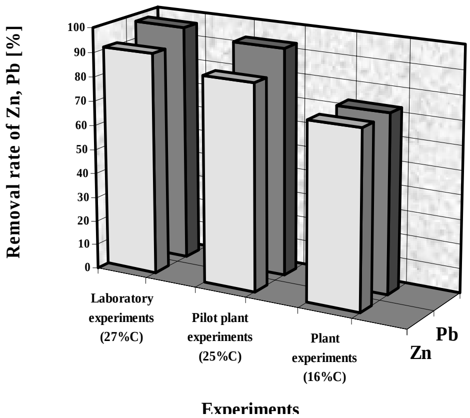

Fig.9 Maximum removal rates of Zn and Pb in realized experiments

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