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SIMULATION AND EXPERIMENTAL VERIFICATION THE TREATMENT OF DISPERSED ZINC AND IRON BEARING MATERIALS USING SOFTWARE PACKAGE FOR THE WAELZ PROCESS (SPW)

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ABSTRACT

Simulation of the Waelz process, using Software Package for the Waelz process (SPW) was studied. SPW is a mathematical model used for calculation the technological parameters of processing zinc bearing materials in the Waelz process. The used material was zinc oxide jarosite – PbAg residue (Concentrate A) and zinc neutral leach residue (Concentrate B). Experiments have been performed in order to verify the results obtained by simulation. Results of experiments were in correlation with the results from simulation. Distribution of zinc from input charge to clinker in simulation and experiment was 5.94 % and 9.46 %, respectively.

***Keywords:** Waelz process, SPW, zinc, simulation, verification*

INTRODUCTION

The Waelz process can be used for treatment of ores, tailings, slags, slimes and various wastes, as well as for recovery of zinc, lead, cadmium, indium, tin, arsenic, antimony, mercury and molybdenum. Some of these metals volatilize in the form of metal vapors (Zn, Cd, Hg), sulfides (Pb, Sn, As, Hg) or chlorides (In). Silver partially volatilized in the Waelz kilns [1]. Other, the non-volatile metals from the raw materials (Fe, Cu, Ag, Ca, Al, Mg, Si), remain in clinker.

Using pyrometallurgical methods for treatment the mentioned wastes, among various products, zinc sulfide concentrate is obtained. This product is treated in hydrometallurgical leaching processes mostly with dilute H_2SO_4. During the leaching of zinc sulfide concentrate, jarosite group of minerals [2, 3] and zinc neutral leach residue is obtained [4]. General formula of the jarosite group of minerals is $AB_3(TO_4)(OH,H_2O)_6$, where A is K^+, Na^+, H_3O^+ NH_4^+, Ag^+, $1/2Pb^{2+}$, B is Fe^{3+} and T is S^{6+}, P^{5+} or As^{5+} [5]. Jarosite contains 20-32 % Fe, 2-6 % Zn and less than 1 % Pb [6]. Due to presence of toxic leachable elements such as As, Cd and Pb, jarosite is categorized as a hazardous waste and its disposal represents the major environmental and ecological problem [7]. The zinc neutral leach residue contains mainly Fe and Zn in the form of $ZnSO_4$ and $ZnO{\cdot}Fe_2O_3$ [4].

Simulation of the Waelz process, where the raw materials are zinc oxide jarosite – PbAg residue (Concentrate A) and zinc neutral leach residue (Concentrate B), is presented in this work. Experiment has been done after simulation using the Software Package for the Waelz process (SPW) in order to verify the simulation results.

EXPERIMENT

Concentrate A and Concentrate B, coke (<1 mm and >1 mm) and flux were also used in this study. The chemical characterization of Concentrates A and B was done using the AASand ICPMS after multi-acid digestions, AAS42S and IMS40B methods, respectively. The XRD patterns of Concentrates A and B were also done. Devices used for the XRD spectrum of Concentrates A and B were ItalStructure APD2000 and Philips PW-1710, respectively. Thermal analysis (DTG, TG) of mixture of Concentrates A and B (ratio 75:25) was performed using the instrument SDT Q600. 10 mg of sample was heated in a pot of Al_2O_3 with volume of 0.1 cm^3 in a stream of nitrogen, at flow rate of 100 cm^3/min in temperature interval 30-1000°C.

According to the obtained chemical composition of raw materials, the mineralogical composition of the same was calculated and used in SPW. The necessary quantity of fuel (coke) and flux (lime) was calculated by SPW, based on the composition of 100 kg mixture Concentrate A and Concentrate B.

SPW is used for calculation the technological parameters of processing the zinc bearing materials in the Waelz process. This is mathematical model which is used for determination the real parameter values and relations, which is adopted in a system of automatic process control. Distribution of elements from the raw materials to products (dust and clinker) is made, based on the historical data from real production. Besides, SPW is used for assessment the influence of introducing the new raw materials on techno-economic indicators.

Experiments were carried out after obtaining the model results. Defined quantity of Concentrate A (750 g) and Concentrate B (250 g) were measured and pelletized together with fine coke (<1 mm) and flux. Quantity of fine coke and flux was 20% and 10% in relation to the mixture of Concentrate A/Concentrate B, respectively. The rest quantity of coke (>1 mm), 260 g was directly added to the furnace. Total quantity of coke was 46% (460 g) in relation to the mixture of Concentrate A/Concentrate B.

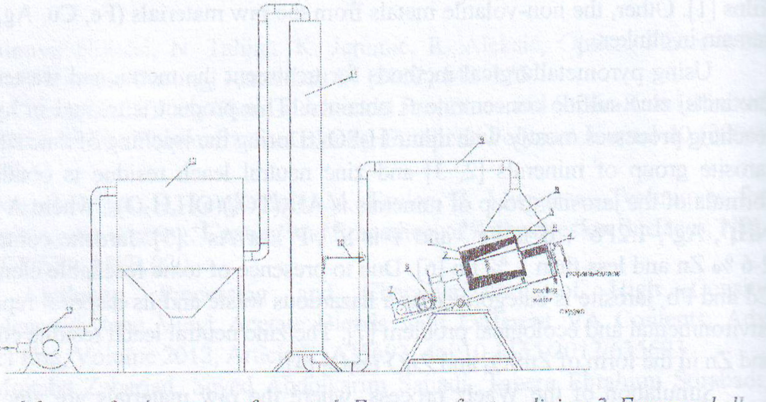

Figure 1 *Technical design of a short rotary furnace: 1. Furnace refractory lining, 2. Furnace shell, 3. Cover, 4. Burner, 5. Thermocouple, 6. Reducer, 7. Electromotor, 8. Hood, 9. Pipeline for waste gas outlet, 10. Probe for measuring the quality of waste gas, 11. Cooler, 12. Bag filter, 13. Fan*

Experiments were carried out in a short rotary furnace in order to optimize the temperature regime, furnace refractory lining and the amount of material. The furnace is equipped with a system for collection the process gases and dust removal. The hood, which conducts emission gases to bag filter through a system of pipelines and coolers, was mounted above the furnace. Figure 1 shows a technical design of short rotary furnace.

RESULTS AND DISCUSSION

Table 1 shows the results of chemical analysis of Concentrates A and B.

Table 1 *Chemical analysis of Concentrate A and Concentrate B*

Element	Zn	Pb	Fe	Ag	Cu	S	K	Na	Mg	Al	Ca
Concentrate A, %	7.40	6.43	25.5	0.02	0.48	9.00	0.37	0.07	0.08	1.47	0.74
Concentrate B, %	22.9	4.83	33.0	0.01	0.95	1.92	0.14	0.03	0.16	1.33	0.56

According to the XRD analysis, it was found out that the most intensive diffraction peaks in Concentrate A correspond to the jarosite group of minerals. The following mineral phases are tridymite (SiO_2) and anglesite ($PbSO_4$). The identified minerals in Concentrate B were magnetite (Fe_3O_4), wurtzite (minerals group (Zn, Fe)S), lead(II)-oxide (Pb_2O_3) and kaolinite ($Al_2Si_2O_5(OH)_4$).

Figure 2 shows a thermogram of the concentrate mixture (ratio 75:25). The first weight loss (about 7 wt.%) occurs in temperature interval 300-430°C with DTG maximum at 420°C. The observed detected weight loss is attributed to releasing of hydroxyl and ammonium groups from jarosite. The second weight loss (about 17 wt.%) occurs in temperature interval 500-850°C. This loss of weight is attributed to releasing of SO_3 from sulfate groups in jarosite and degradation of $PbSO_4$. The second loss of weight is characterized with two DTG maximums at 590 and 770°C.

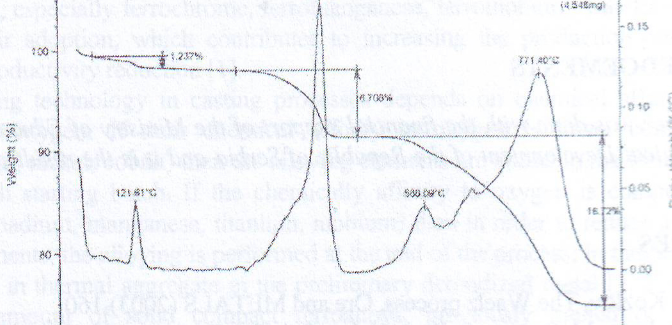

Figure 2 *Thermogram of mixture with 75 % Concentrate A and 25% Concentrate B – TG curve (black) and DTG curve (blue)*

Simulation of the Waelz process using the SPW was performed based on chemical and structural analysis. According to the results from SPW, coke and flux consumption was 44.86 kg and 10.0 kg per 100 kg (44.86 % and 10.0 %) Concentrate A/Concentrate B mixture. Consumption of flux was adjusted by control the basicity which was 0.965. The obtained results from simulation in SPW were used for process optimization. Total quantity of coke and flux in the experiment was 460.0 g and 100.0 g per 1000 g Concentrate A/Concentrate B mixture (46.0 % and 10 %), respectively. Quantity of obtained clinker and dust were 641.4 g and 243.0 g from the SPW simulation and 640.0 g and 140.0 g from the experiment. Transfer of elements to clinker from the input charge is presented in Table 2.

Table 2 *Transfer of elements to clinker from input charge*

Element	Zn	Pb	Fe	Ag	Cu	S	K	Na	Mg	Al	Ca
SPW, %	5.94	7.42	92.3	49.1	92.3	31.3	92.3	91.7	93.0	92.4	93.1
Experiment, %	9.46	3.32	64.9	92.3	89.5	12.7	99.0	98.9	38.8	93.3	30.1

As it can be seen from Table 2, the obtained results from simulation are quite different related to those from the experiment. All differences between results from simulation and experiment originate from different furnace construction. The laboratory furnace used in presented experiment does not have an appropriate length for effective performing the process. Due to that, the material could not be mixed well and diffusion of CO through the input material is hindered which results in lower reduction of metals. One part of input material remains in the original state and yield of metals in products is lower than expected.

CONCLUSION

Comparison of the results from simulation and experiment, verification of SPW software simulation has not been successfully performed. All differences between the results from simulation and experiment originate from different furnace construction. It is necessary to perform more experiments.

In further work more experiment will be done where treatment of three components system will be performed. The third component will be EAFD. Besides that, one part of coke will be substituted with various types of waste plastic, as an alternative fuel and reducing agent.

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