Special Issue Published in International Journal of Trend in Research and Development (IJTRD),
ISSN: 2394-9333, www.ijtrd.com

Modeling of the Materials Burning Processes in the Rotating Tube Furnaces

Kulenova Natalya, Onalbayeva Zhanar,
Akhmetvaliyeva Zarina
D. Serikbayev East Kazakhstan state technical university
Ust-Kamenogorsk city, Kazakhstan

Shumskij Viktor
National on complex processing of mineral raw materials of the Republic of Kazakhstan
Regional state enterprise
Ust-Kamenogorsk city, Kazakhstan

Abstract: METSIM model has been built and model analysis of Waelz process of typical charge has been calculated. The charge is from zinc cakes and rich granulated slag of lead melting with the use of coke fines as fuel-reductive material. The size of model furnace, technological parameters and indexes of model process are adopted to known industrial data.

The model enables to estimate influence of charging, raw material composition, and operating conditions (blast consumption, consumption of oil-fuel, change in composition and consumption of fuel-reductive mix of carbon materials, amount of heat loss) on burden and heat balance of the process.

Movement of counter flows was calculated by sections with provision for chemical interactions, phases of mass- and heat-exchange inside the furnace. It enabled to get model profiles of components temperatures and concentrations of solid and gas phases along of furnace.

In this model heat balance is calculated and amount of gas is estimated (that is produced in boiler when the heat from furnace gases is utilized).

METSIM model also enables to study the influence of linear deformation of gas phase oxidizing potential and of flare flame spread on final technological parameters of materials roasting in rotary tube furnaces. It can be used for optimization of the process.

Keywords—METSIM; modeling; zinc cakes; tube furnaces;heat balance

I. Introduction

The results of modeling of materials roasting processes in rotary tube furnaces using METSIM are provided in this report. Means of metallurgic processes mathematical modeling that can be used for further prediction, optimization, and automation of technological processes are not widely used in metallurgical complex of Kazakhstan. However, the necessity to accelerate this process is required by objective requirements to increase efficiency of enterprises production activity.

There are not many universal mathematical packages for modelling chemical and metallurgical processes offered in the world market of specialized program products. One of such packages recognized worldwide among top industrial, engineering, and project companies of metallurgical profile is METSIM.

When technological processes are modelled in METSIM, standard equipment module is used where technical characteristics of real industrial equipment are entered. This enables to monitor interconnection of technology with its instrumentation.

Examples of METSIM usage for modelling a number of metallurgical processes are provided in works [1-5]. This article provides modelling results in package of METSIM processes of materials processing in rotary tube furnaces.

II. Model Simulation of the Waelz Metallurgical Process

Thus, METSIM model was built and model simulation of Waelz process was carried out. It was Waelz process of typical charge from zinc cakes and rich granulated slag of lead smelting with the use of coke fines as fuel-reductive material. Sizes of model furnace, its technological parameters and model process performance are adopted to known industrial data [6] Model process flow diagram of Waelz process is presented in Fig. 1.

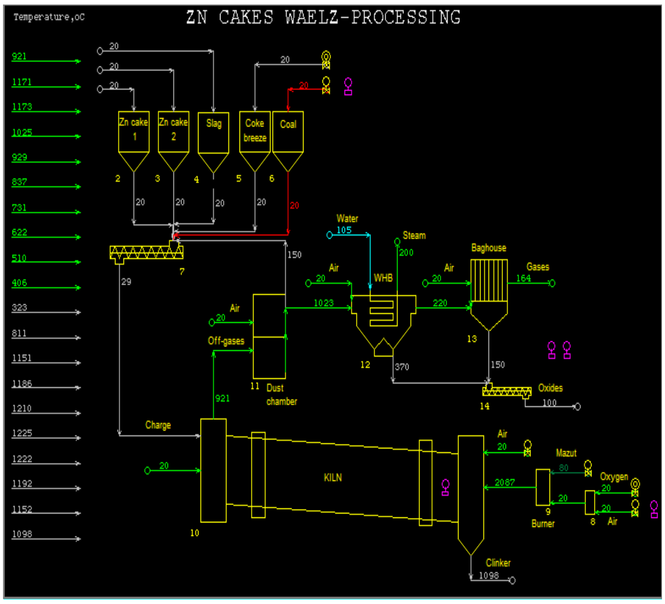

Fig. 1. Model flow diagram of Waelz process built in the METSIM database

The model enables to estimate influence of charging, composition of raw material, and operating conditions (blast consumption, oil-fuel consumption, change in composition and consumption of fuel-reductive mix of carbon materials, heat losses amount) on material and heat balance process. The diagram reflects temperatures of model material flows of Waelz process charge. Material flows (gases and solids) inside Waelz furnace are on the left in the diagram.

Section-by-section calculation of counter flows movement taking into account chemical interaction, mass- and heat exchange of phases inside the furnace enables to get model profiles of temperatures and concentrations of solid and gaseous phases components along the length of the furnace.

Fig. 2 represents the example of model profiles of layer and gases temperatures, as well as zinc concentrate in material layer and zinc recovery degree into fumes during Waelz process of model charge, whereas material balance is provided in the table. This table also shows distribution of basic metals, sulphur and carbon into roasting products.

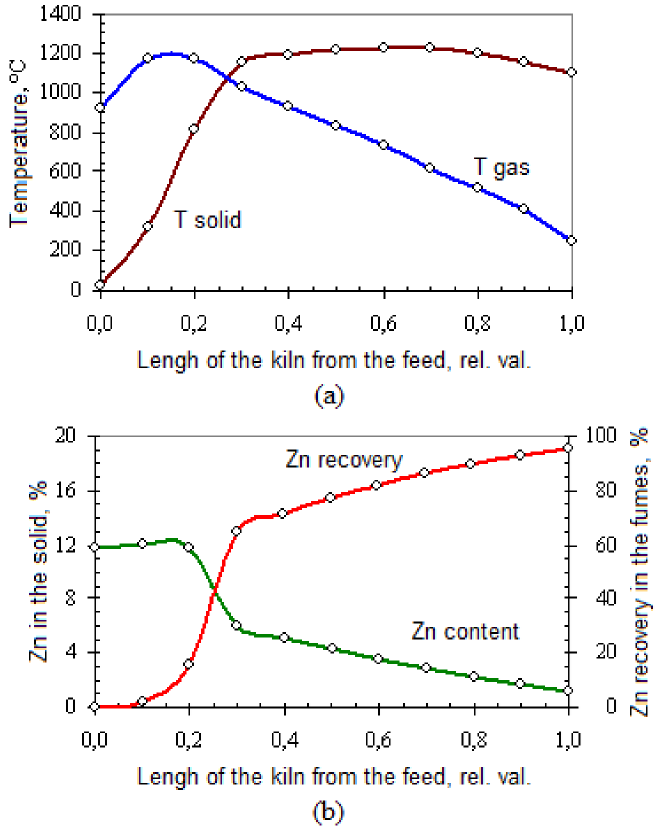

Fig. 2. Models of temperature (a) and concentration of Zn cakes (b) in the Waelz processing

III. RESULTS

The model provides calculation of process heat balance and estimation of steam amount that is produced in boiler when heat of furnace gases is utilized.

METSIM model enables to study influence of linear deformation of gaseous phase oxidizing potential and extension of burner flame on technological indicators of materials roasting in rotary tube furnaces, and this can be used for process optimization.

TABLE I. MODEL MATERIAL BALANCE OF CAKES IN THE WAELZ PROCESSING

Material	Dry mass t/day	Components (concentation/mass/recovery)								
		Zn			Pb			Cu		
		%	t/day	%	%	t/day	%	%	t/day	%
CHARGE:										
Zn cake 1	134.40	18.19	24.45	37.86	2.84	3.81	28.43	2.02	2.71	43.46
Zn cake 2	142.08	21.26	30.21	46.78	4.78	6.79	50.64	2.14	3.04	48.77
Slag	107.52	9.22	9.91	15.35	2.61	2.81	20.93	0.45	0.48	7.76
Total ore mixture	384.00	16.81	64.56	100.0	3.49	13.41	100.0	1.62	6.23	100.0
Coke fines	203.29									
Recycled dust	70.48	18.20	12.83	19.87	5.79	4.08	30.41	1.35	0.95	15.25
Total solid charge	657.77	3.03	77.39	119.87	0.68	17.49	130.41	0.28	7.18	115.25
Oil-fuel on burner	9.22									
Blast and air leak	1782.99									
Oxygen blast	10.13									
Total moisture	93.67									
Total charge	2553.77		77.39	119.87		17.49	130.41		7.18	115.25
Production:										
Clinker	320.48	1.13	3.63	5.62	0.32	1.03	7.69	1.89	6.05	97.09
Waelz oxides	105.14	57.91	60.89	94.30	11.77	12.38	92.28	0.17	0.18	2.90
Recycled dust	70.48	18.20	12.83	19.87	5.79	4.08	30.41	1.35	0.95	15.25
Gases	2057.60									
Dust with gases	0.08	65.84	0.05	0.08	4.78	0.00	0.03	0.24	0.00	0.00
Total production	2553.77		77.39	119.87		17.49	130.41		7.18	115.25

Material	Dry mass t/day	Components (concentation/mass/recovery)								
		Fe			S			C		
		%	t/day	%	%	t/day	%	%	t/day	%
CHARGE:										
Zn cake 1	134.40	25.00	33.60	35.43	5.91	7.94	31.01			
Zn cake 2	142.08	20.72	29.44	31.04	8.81	12.52	48.87			
Slag	107.52	27.00	29.03	30.61	3.07	3.30	12.87			
Total ore mixture	384.00	23.98	92.07	97.08	6.19	23.76	92.75			
Coke fines	203.29	1.36	2.76	2.92	0.78	1.59	6.20	80.00	162.63	95.43
Recycled dust	70.48	20.53	14.47	15.26	5.23	3.69	14.39	11.31	7.97	4.68
Total solid charge	657.77	4.28	109.30	115.26	1.14	29.03	113.34	6.68	170.60	100.10
Oil-fuel on burner	9.22				2.93	0.27	1.05	84.56	7.79	4.57
Blast and air leak	1782.99									
Oxygen blast	10.13									
Total moisture	93.67									
Total charge	2553.77		109.30	115.26		29.03	114.39		178.39	104.68
Production:										
Clinker	320.48	28.73	92.08	97.10	5.97	19.14	74.72	19.73	63.24	37.11
Waelz oxides	105.14	2.62	2.75	2.90	2.56	2.69	10.49	1.44	1.52	0.89
Recycled dust	70.48	20.53	14.47	15.26	5.23	3.69	14.39	11.31	7.97	4.68
Gases	2057.60				0.18	3.79	14.78	5.14	105.67	62.00
Dust with gases	0.08	3.29	0.00	0.00	2.56	0.00	0.01	1.44	0.00	0.00
Total production	2553.77		109.30	115.26		29.30	114.39		178.39	104.68

As an example Fig. 3 shows estimated changes of temperature profiles of arseno-pyrite ore oxidizing roasting in tube furnace of 40 m during blast supply into furnace inside zones. Calculation is done when air is consequently added to the burner into furnace inside zones, that are located at various distances (number at curves) from its discharge end. Amount of supplied air is 5 % of primary and secondary air blast.

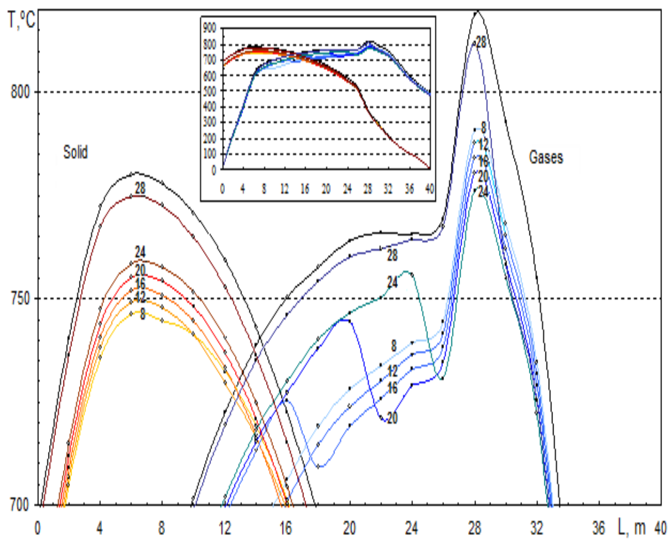

Fig. 3. Model temperature profiles of ore roasting with inside zones blast

Thus, METSIM enables to model such complex metallurgical processes as materials roasting in rotary furnaces with counter flows of solids and gases. The results of model calculations can be used for designing of process flow diagrams with calculation of equipment and optimization of materials roasting process in rotary furnaces.

References

[1] J.M. Gray, D.J. Palmer, "Development of a METSIM Model of a Zinc Plant Circuit", CHEMECA 91 Conference. Ne-wcastle, Australia, pp. 359-366, 18-20 September 1991.

[2] A.G. Hunt, E.J. Grimsey, N.B. Gray, "Simulation of the Kalgoorlie Nickel Smelter Flowsheet using METSIM", 5th Extractive Metallurgy Conference. AusIMM. Perth, Western Australia, pp.251-255, 2-4 October, 1991.

[3] T.R.A. Davey, K.J. Charlesworth, J.T. Bartlett, "The use of METSIM to Model Multi-Stage Desilverising of Lead by Zinc", International Symposium Extractive Metallurgy of Copper, Nickel and Cobalt. TMS. Warrendale, PA, USA, pp.153-167, 1993.

[4] E. Iasillo, C. Rempel, A. Holtzapple, "Development of accurate metal production forecasts for a heap leach project using METSIM® dynamic simulation and defensible column leach testing data", Proceedings of the Heap Leach Solutions Conference**.** Vancouver, pp. 86-100, 2013.

[5] M.J. Walker, "KIVCET smelter on-stream at Trail", Mining Journal. pp. 256- 263, April. 1998.

[6] M.A. Abdeyev, A.V. Kolesnikov, N.N. Ushakov, "Waelz processing of zinc and lead-containing materials", J. Metallurgy, Moscow, p.120, 1985.