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BALANCE MODELLING OF A NON - STANDARD AGGLOMERATION PROCESS

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ABSTRACT

An ore deposit "Obrochiste" in the Republic of Bulgaria contains a lot of reserves of comparatively poor carbonate manganese ore (about 23 % Mn). The effective utilization of this ore attracts research interest for a long time.

In the same time a considerable amounts of Bulgarian plants produce sulphuric acid, from where significant quantities of spent vanadium catalyst drop out.

The aim of this paper is to model the possibility for joint agglomeration of carbonate manganese ore and worked off vanadium catalyst for further metallurgical processing.

Keywords: Agglomeration, carbonate manganese ore, vanadium catalyst.

INTRODUCTION

In the Republic of Bulgaria there is a deposit of considerable quantities of poor carbonate manganese ore [1–5] and at the same time as waste product from the manufacturing of sulphuric acid a significant quantity of vanadium catalyst drop out and are an ecological problem [6].

It is interesting to study the possibility for recovery of these materials to produce complex alloys with an application in the industry and especially in the metallurgy [7-9].

The process in anelectrothermal furnace requires amalgamation of starting materials to suitable sizes and decarbonatization of the ore. It is supposed that the most suitable method for common amalgamation is the agglomerated process [10-13].

The main aim of this study is to model the preparation of an agglomerate from the manganese concentrate of Obrochishte and deactivated vanadium catalyst using of the software program "AGLOPRICE" and to establish the technological parameters of the process and select suitable compositions for experimental laboratory agglomeration.

EXPERIMENTAL

The program "AGLOPRICE" is created in 1985 by a scientific team from the section MFM, UCTM – Sofia [14]. It gives a possibility for calculation of the parameters of the starting materials for preparation of agglomerates. It allows for working with different percentage ratios between the concentrate and the catalyst. The modeling ends with producing the results for the material and heat balance. The calculations are for 100 kg finished agglomerate.

The agglomeration calculations hold for a non - calcium oxide agglomerate prepared from manganese concentrate and vanadium catalyst.

The chemical composition of the used starting materials is presented in Table 1.

The manganese concentrate and the vanadium catalyst are introduced in the program as mixtures with different percentage ratios between them. The sum of

Table 1. Chemical composition of the starting materials.

Chemical composition of the worked of catalyst									
V_2O_5	Fe_2O_3	SiO_2	K_2O	Na_2O	Al_2O_3	SO_3			
4.12 %	3.40 %	57.12 %	6.71 %	3.93 %	0.82 %	23.88 %			
Chemical composition of coke breeze for agglomeration									
FeO	SiO_2	Al_2O_3	CaO	MgO	S	FeS_2	C	v. c.	MnO
3.71 %	6.08 %	2.31 %	1.18 %	0.46 %	1.79 %	1.16 %	78.62 %	4.20 %	0.49 %
Chemical composition of manganese concentrate									
MnO	CO_2	FeS_2	Fe_2O_3	P_2O_5	SiO_2				
44.56 %	19.33 %	2.25 %	1.79 %	0.31 %	12.40 %				
MgO	CaO	Al_2O_3	$K_2O + Na_2O$	$H_2O_{h.}$ и oth.	W from B				
2.00 %	3.90 %	2.10 %	1.15 %	1.20 %	8.97 %				

Table 2. Changing the quantity of the oxides in the agglomerate.

№	Fe_2O_5	FeO	FeS_2	MnO	SiO_2	Al_2O_5	CaO	MgO	P_2O_5	SO_3	V_2O_5	R_2O	S	oth.
1	3.82	1.00	0.15	59.35	21.00	3.04	5.29	2.70	0.41	0.67	0.29	2.28	0.01	0.00
2	3.77	1.00	0.14	55.62	23.86	2.91	4.96	2.53	0.39	1.32	0.57	2.91	0.01	0.00
3	3.72	1.00	0.14	51.97	26.66	2.79	4.64	2.37	0.36	1.96	0.85	3.53	0.01	0.00
4	3.67	1.00	0.13	48.40	29.41	2.67	4.32	2.20	0.34	2.59	1.12	4.14	0.01	0.01
5	3.63	1.00	0.12	44.91	32.09	2.55	4.01	2.05	0.31	3.21	1.38	4.73	0.01	0.01
6	3.58	1.00	0.11	41.48	34.72	2.44	3.71	1.89	0.29	3.81	1.64	5.31	0.01	0.01
7	3.49	1.00	0.09	34.84	39.82	2.21	3.12	1.59	0.24	4.97	2.15	6.44	0.01	0.01
8	3.41	1.00	0.08	28.47	44.72	2.00	2.56	1.30	0.20	6.10	2.63	7.52	0.01	0.01
9	3.33	1.00	0.06	22.33	49.43	1.79	2.02	1.03	0.16	7.17	3.09	8.57	0.00	0.02
10	3.25	1.00	0.04	16.44	53.96	1.59	1.50	0.76	0.11	8.21	3.54	9.57	0.00	0.02
11	3.17	1.00	0.03	10.67	58.33	1.40	0.99	0.50	0.07	9.21	3.97	10.53	0.00	0.02
12	3.10	1.00	0.02	5.29	62.53	1.22	0.51	0.26	0.04	10.17	4.39	11.46	0.00	0.02

Note: The percentages proportion between the concentrate and the catalyst from the different variants (1 – 12) are: – 1 - 95:5, 2 - 90:10, 3 - 85:15, 4 - 80:20, 5 - 75:25, 6 - 70:30, 7 - 60:40, 8 - 50:50, 9 - 40:60, 10 - 30:70, 11 - 20:80, 12 - 10:90; $R_2O = K_2O + Na_2O$

both starting materials is 100 %. The ratios are from 95 % to 10 % for the manganese concentrate (respectively for the catalyst – from 95 % to 5 %). Between 95 % and 70 % of the concentrate, the step is 5 % and between 70 % and 10 % of the concentrate – 10 %.

The main technological indexes are: agglomeration return – 30 %; humidity of the starting materials – 8 %; dust and mechanical wastes – 2 %.

From these initial conditions the program "AGLOPRICE" models the material balance and the heat balance for each composition.

RESULTS AND DISCUSSION

The calculated chemical composition of the agglomerate from different starting materials is given on Table 2.

Table 3. Material and heat balances of the calculated agglomerates.

Material balance (90 manganese concentrate:10 vanadium catalyst) – income, kg	Material balance (90 manganese concentrate:10 vanadium catalyst) – extraction, kg	Heat balance (90 manganese concentrate:10 vanadium catalyst), kJ.kg^{-1} agglomerate
coke – 7.85	agglomerate – 100.00	$Q_i = Q_c = 2232.86$
mixture – 138.60	agglom. return – 30.00	
agglom. return – 30.00	smoke gases – 150.53	
air – 92.53	sum – 280.70	
water – 11.72		
sum – 280.70		
Material balance (80:20) – income, kg	Material balance (80:20) – extraction, kg	Heat balance (80:20), kJ.kg^{-1} agglomerate
coke – 7.32	agglomerate – 100.00	$Q_i = Q_c = 2128.41$
mixture – 135.68	agglom. return – 30.00	
agglom. return – 30.00	smoke gases – 140.67	
air – 86.36	sum – 270.67	
water – 11.44		
sum – 270.67		
Material balance (70:30) – income, kg	Material balance (70:30) – extraction, kg	Heat balance (70:30), kJ.kg^{-1} agglomerate
coke – 6.82	agglomerate – 100.00	$Q_i = Q_c = 2028.27$
mixture – 132.89	agglom. return – 30.00	
agglom. return – 30.00	smoke gases – 131.34	
air – 80.45	sum – 261.34	
water – 11.18		
sum – 261.34		
Material balance (60:40) – income, kg	Material balance (60:40) – extraction, kg	Heat balance (60:40), kJ.kg^{-1} agglomerate
coke – 6.34	agglomerate – 100.00	$Q_i = Q_c = 1932.16$
mixture – 130.21	agglom. return – 30.00	
agglom. return – 30.00	smoke gases – 122.14	
air – 74.77	sum – 252.25	
water – 10.92		
sum – 252.25		
Material balance (50:50) – income, kg	Material balance (50:50) – extraction, kg	Heat balance (50:50), kJ.kg^{-1} agglomerate
coke – 5.88	agglomerate – 100.00	$Q_i = Q_c = 1839.86$
mixture – 127.63	agglom. return – 30.00	
agglom. return – 30.00	smoke gases – 113.43	
air – 69.31	sum – 243.52	
water – 10.68		
sum – 243.52		

From the Table it follows that the concentration of Fe_2O_3 changes in unimportant range, while that of FeO remains constant. The concentration of the following oxides: Al_2O_3, CaO, MgO, P_2O_5, K_2O_3, Na_2O and SO_3 are also changed significant by, respectively: from 3.04 % to 1.22 %; from 5.29 % to 0.51 %; from 2.70 % to 0.24 %; from 0.41 % to 0.04 %; from 2.28 % to 11.44 % and from 0.49 % to 10.17 %. The leading oxides in the agglomerates are changed in wide limits. In the calculated 12 composition MnO decreases from 59.35 % to 5.29; V_2O_5 and SiO_2 increase, respectively from 0.29 % to 4.39 % and from 21.00 % to 62.53 %. With increasing the quantity to the catalyst, FeS_2 decreases from 0.15 % to 0.02 %, S decreases below 0.01 % and the rest of the compounds increase up to 0.02 %.

When the catalyst is 5 %, 10 % or 15 %, the quantity of V_2O_5 in the agglomerate is not significant. So the content of V will be very low in the alloy from this agglomerate. On the other side, the higher content of the catalyst in a starting material in the cases, when it is above 50 % V_2O_5 and the lower content of the concentrate in the cases when below 30 % MnO, will created a possibility for insufficient scorch the material in the agglomeration process. In this respect it is important to give attention to compositions with 10, 20, 30, 40 and 50 % vanadium catalyst. Further down are shown the material and the heat balances for the chosen cases. The calculations are for 100 kg agglomerate and the results for the mixture are for the respective ratios between the concentrate and the catalyst. Everywhere in the heat balances the sum of the input sources of heat – Q_i equals the sum of the items of expended heat – Q_c.

The material and heat balances of the particular models to the agglomeration process are show in Table 3.

CONCLUSIONS

For the experimental laboratory manufacturing of the complex alloy which contains Mn and V, it is necessary to make a choice from the compositions with enough quantity of MnO; with maximum content of V_2O_5; with optimum content of SiO_2, Al_2O_3, CaO and MgO. At the same time the agglomerate have to have a good scorching. The obtained results allow to conclude that for experimental preparation of agglomerates suitable are the starting materials with 20 %, 30 % and 40 % vanadium catalyst which satisfy all conditions. The obtained contents in the agglomerate for most oxides is expected to be in the following limits: MnO – from 48.40 % to 34.84 %, V_2O_5 – from 1.12 % to 2.15 %, SiO_2 - from 29.41 % to 39.82 %, Al_2O_3 – from 2.67 % to 2.21 %, CaO – from 4.32 % to 3.12 %, MgO – from 2.20 % to 1.59 %, Fe_2O_3 – from 3.67 % to 3.49 % and they are expected to satisfy the requirements for thermal preparation of a complex alloy.

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