COMPLEX PROCESSING OF IRON-MANGANESE ORE OF CENTRAL KAZAKHSTAN

Ye. Samuratov[1], A. Baisanov[1], M. Tolymbekov[1]

[1] Chemical-Metallurgical Institute, 100009, Kazakhstan, Karaganda, Ermekov str. 63,
hmi_science@mail.ru

ABSTRACT

Manganese deposits of Central Kazakhstan contain ore with high concentration of iron and manganese. Objective of our research is development of efficient processing scheme allowing to extract both components. The method of magnetizing roasting described in the paper allows to obtain high-quality manganese and iron concentrates. Semi-coke produced as by-product can be used as a reductant for ferroalloys production.

Agglomeration of concentrates and subsequent smelting of silicon manganese and high-carbon ferromanganese are also described in the paper.

The problem of off-grade iron-manganese ore utilization is becoming more urgent due to growing needs of metallurgy for manganese. Effective metallurgical processing of such ore requires complex pretreatment techniques with further agglomeration[1].

Kazakhstan has big reserves of manganese-containing minerals basically represented by iron-manganese varieties (70% of reserves) unsuitable for direct processing. 30% of reserves contain hard-concentrating oxidized ore. Depletion of high-quality manganese ore reserves and possibility of complete exhaustion within the nearest decade seriously restrain the development of manganese alloys production. In the future, producers of manganese alloys will have to use poor ores requiring deeper concentration and complicated processing techniques[2].

At present, iron-manganese ores (e.g., Deposits “Zapadny Kamys” and “Zhomart” in Central Kazakhstan) are not involved into production for lack of efficient processing methods. In order to provide raw materials for growing manganese industry it is necessary to develop such methods for manganese ore with high iron content.

One of possible decisions – magnetizing roasting with separate yield of iron and manganese concentrates was developed and tested in Chemistry and Metallurgy Institute. The method allows to obtain high-quality manganese concentrate suitable for manganese ferroalloys production.

Samples of iron-manganese ore of Zapadny Kamys and Zhomart Deposits were used in the research. The size of materials used was 0-5 mm. The chemical composition of the samples is represented in the table 1.

Table 1: Chemical composition of iron-manganese ore of “Zapadny Kamys” and “Zhomart” deposits

Material	Chemical composition, %									
	Mn	Fe	SiO_2	CaO	MgO	Al_2O_3	P	S	Roasting loss	Mn/Fe ratio
“Zapadny Kamys” ore	17,81	5,16	41,3	1,46	1,25	5,92	0,034	0,025	8,79	3,45
“Zhomart” concentrate	33,37	9,52	10,71	7,53	1,48	3,29	0,032	0,021	12,64	3,51

As shown in the table 1, ore of Zapadny Kamys Deposit has unfavorable Mn:Fe ratio (3,45). The ore of Zhomart Deposit is suitable only for silicomanganese production. However, after being properly treated such ores may become applicable for ferromanganese production. One of important features of the material - low phosphorus content (0,03% at an average) makes it a valuable metallurgical feedstock.

Main technological operations of the scheme are recovery annealing and dry magnetic separation. The objective of the first stage is recovery of metal oxides to metals or to lower oxides (traditionally achieved with gaseous, solid or liquid reductants[2]). In our method we have used gas coal of Shubarkol Deposit – Kazakhstan's biggest coal field.

Heat treatment of ore samples was carried out in pilot continuous process furnace with capacity of 100 kg. The furnace allows modeling industrial conditions and is similar to chamber furnaces with external heating. Chambers are heated up to 600°C by means of coal pyrolysis products combustion. As a result, mixture of semicoke (C-87,24%, volatile matter-8,76%, ash-2,11%, moisture-2,32%) and calcined ore was obtained. Semicoke was separated from ore by sieve separation. 120T Magnetic Separator was used for dry treatment of calcined ore.

Results of magnetizing roasting and magnetic separation at current intensity 12A are represented in the tables 2-5.

Table 2: Magnetic separation of "Zhomart" concentrate after magnetizing roasting, batch no. 1

Material	Yield, %	Chemical composition, %						Distribution, %				
		Mn	Fe	SiO_2	C	CaO	Mn/Fe ratio	Mn	Fe	SiO_2	C	CaO
Magnetic	16,40	9,13	56,35	10,01	2,82	1,64	0,16	4,78	87,01	15,07	4,66	2,26
Non-magnetic	83,60	35,69	1,65	11,07	11,32	13,91	21,63	95,22	12,99	84,93	95,34	97,74
Total	100	31,33	10,62	10,9	9,93	11,9	2,95	100	100	100	100	100

Table 3: Magnetic separation of "Zhomart" concentrate after magnetizing roasting, batch no. 2

Material	Yield, %	Chemical composition, %						Distribution, %				
		Mn	Fe	SiO_2	C	CaO	Mn/Fe ratio	Mn	Fe	SiO_2	C	CaO
Magnetic	17,39	8,3	45,72	9,65	2,37	1,23	0,18	4,72	89,49	15,50	3,98	2,57
Non-magnetic	82,61	35,28	1,13	11,07	12,05	9,82	31,22	95,28	10,51	84,50	96,02	97,43
Total	100	30,59	8,88	10,82	10,37	8,33	3,44	100	100	100	100	100

Table 4: Magnetic separation of "Zapadny Kamys" concentrate after magnetizing roasting, batch no.1

Material	Yield, %	Chemical composition, %						Distribution, %				
		Mn	Fe	SiO_2	C	CaO	Mn/Fe ratio	Mn	Fe	SiO_2	C	CaO
Magnetic	28,10	16,18	9,22	43,47	2,57	2,45	1,75	24,49	56,28	29,96	7,47	43,78
Non-magnetic	71,90	19,5	2,8	39,72	12,45	1,23	6,96	75,51	43,72	70,04	92,53	56,22
Total	100	18,57	4,60	40,77	9,67	1,57	4,03	100	100	100	100	100

Table 5: Magnetic separation of “Zapadny Kamys” concentrate after magnetizing roasting, batch no. 2

Material	Yield, %	Chemical composition, %						Distribution, %				
		Mn	Fe	SiO_2	C	CaO	Mn/Fe ratio	Mn	Fe	SiO_2	C	CaO
Magnetic	39,24	15,36	9,04	44,55	2,45	2,04	1,70	33,25	68,38	41,10	11,56	31,54
Non-magnetic	60,76	19,92	2,7	41,23	12,1	2,86	7,38	66,75	31,62	58,90	88,44	68,46
Total	100	18,13	5,18	42,53	8,31	2,53	3,49	100	100	100	100	100

As seen from the tables, extraction of manganese and iron into nonmagnetic form amounted 95,28% and 10,51% correspondingly (Zhomart concentrate). The product contains 35,28% Mn and 1,13% Fe (table 3). Processing of Zapadny Kamys ore allowed to obtain nonmagnetic product containing 19,92% Mn and 2,7% Fe. Extraction of manganese and iron was 66,75% and 31,62% correspondingly (table 5).

The size of concentrates is 0-5 mm, which indicates the necessity of agglomeration for further application. Residual solid carbon containing in the concentrates (6,45-12,45%) is favorable for sintering and further smelting as it may decrease the reductant consumption.

Two agglomeration methods were used in our work – sintering (Zhomart concentrate) and briquetting (ore of Zapadny Kamys mixed with Zhomart concentrate).

Sintered ore, later used for high-carbon ferrochrome smelting was obtained in sintering pan with residual carbon used as fuel. Table 6 represents sintering performance.

Table 6: Agglomeration of “Zhomart” concentrate

Sample no.	Weight, kg	Yield, %		Composition, %							Sintering duration, min	Layers temperature, °C	
		size 0-5mm	size +5mm	Mn	Fe	MgO	CaO	SiO_2	C	Mn/Fe		Upper	Lower
3	19,86	16,6	83,4	43,06	3,05	0,49	11,54	14,26	0,32	14,12	12:27	1360	1390
8	21,32	21,6	78,4	43,47	2,49	1,48	12,17	12,18	0,22	17,46	12:32	1290	1315
9	20,37	21,2	78,8	43,88	2,37	0,74	11,23	13,68	0,13	18,51	11:09	1250	1400
12	21,77	42,4	57,6	48,23	1,52	0,25	9,36	12,61	0,19	31,73	12:14	1100	1270
16	18,99	19,2	80,8	43,78	2,76	1,11	11,08	14	0,53	15,86	12:13	1330	1435

Silicomanganese was produced from briquetted mixture of Zhomart and Zapadny Kamys concentrates (ratio 1:1) in laboratory press with maximal pressure of 40 ton-force. The briquettes are cylindrical, 70-90 mm high and 65 mm in a diameter. Chemical composition of the briquettes is given in the table 7.

Table 7: Chemical composition of briquettes

Batch no.	Composition, %				
	Mn	Fe	SiO_2	C	CaO
1	27,59	2,23	25,4	11,89	7,57
2	27,6	1,92	26,15	12,08	6,34
Average	27,6	2,07	25,77	11,98	6,96

Semi-industrial tests of ferromanganese and silicomanganese production were carried out in ore-smelting furnace with transformer power 0,2 megavolt-ampere. Results of pilot smelting are represented in the table 8.

Table 8: Chemical composition of pilot smelting products

No.	Metal yield, kg	Composition, %								
		Metal		Slag						
		Mn	Si	MnO	SiO_2	P	FeO	CaO	MgO	Al_2O_3
1	2	3	4	5	6	7	8	9	10	11
Silicomanganese										
1	8,87	66,05	16,4	8,23	44,61	0,01	0,42	23,04	2,09	19,57
2	10,79	69,76	16,95	8,44	41,38	0,011	0,51	18,61	2,09	19,94
3	10,18	68,89	16	8,44	41,38	0,011	0,51	18,61	2,09	19,94
4	6,16	66,93	18,47	8,02	35	0,068	0,47	21,01	3,82	23,08
Ferromanganese										
5	7,28	80,88	4,62	15,4	33,99	0,07	0,49	21,46	2,86	13,22
6	17,24	80,66	4,46	13,93	32,15	0,065	0,35	36,21	0,48	8,97
7	16,9	81,31	4,22	7,6	33,49	0,028	0,32	45,15	6,21	6,95
8	15,95	81,1	3,42	16,67	33,32	0,053	0,32	35,31	1,91	7,49
9	14,06	85,67	2,63	8,23	33,32	0,076	0,28	46,04	6,24	6,95
10	8,09	81,97	2,55	17,72	27,29	0,044	0,38	36,21	1,43	6,95

Manganese alloys produced in the furnace meet the requirements of National Standards. Extraction degree of manganese and silicon has amounted, correspondingly: 83-85% and 56-60% for silicomanganese; 68-70% and 10-15% for high-carbon ferromanganese.

CONCLUSION

The possibility of sub-grade iron-manganese ore processing into high-quality manganese concentrates was demonstrated. Magnetizing roasting was found appropriate for sub-grade ore processing.

Efficient agglomeration techniques for concentrates were developed. Semi-industrial smelting tests have demonstrated the suitability of obtained concentrates for production of high-quality manganese ferroalloys.

Thus, the methods of sub-grade iron-manganese ore processing described in the present paper would contribute to development of mining and ferroalloy industries of Kazakhstan.

REFERENCES

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