RED MUD RECYCLING WITH THE EXTRACTION OF IRON-BEARING CONCENTRATE AND CEMENT CLINKER

ПЕРЕРАБОТКА КРАСНОГО ШЛАМА С ПОЛУЧЕНИЕМ ЖЕЛЕЗОСОДЕРЖАЩЕГО КОНЦЕНТРАТА И ЦЕМЕНТНОГО КЛИНКЕРА

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Abstract: *We present the experimental technology of full red mud recycling by the method of reduction roasting with calcium carbonate added into the raw mixture, which allows obtaining the iron-bearing concentrate with minimal impurities. The technology also includes the raw milling and magnetic phase separation. The silicate part resulting from the magnetic separation is roasted with some additives to the valuable cement clinker. At the end of recycling we get full red mud utilization and two valuable products – iron-bearing concentrate and cement clinker.*

Keywords: *RED MUD RECYCLING, REDUCTION ROASTING, MILLING, IRON-BEARING CONCENTRATE, CEMENT CLINKER*

1. Introduction

There are about 10 million tons of solid waste residues in present-day alumina industry. Those solid waste residues contain red mud and belit mud. The extraction of some useful elements from red mud makes it possible to obtain such valuable products as pig iron, iron-bearing concentrate, rare-earth elements, alumina concrete, constructional materials, etc. It can also contribute to reducing alumina and alkali losses.

As seen from a literature review, the final stage of experiments described in the works [1, 2, 3] yields foundry iron and slag which can further be used in the alumina or cement clinker production. However, abundant impurities in the red mud prevent the production of high-quality iron and alumina concrete. In particular, a pig iron may contain a considerable amount of sulfur and phosphorous, and the alumina concrete may contain alkaline, mayenit ($12CaO \cdot 7Al_2O_3$) and gelenit ($Ca_3Al_2Si_2O_{10}$).

2. Experimental

Based on some previous works [4, 5] we propose to make an initial raw mixture with the aim to obtain the reduced the ferric oxides, namely wustite (FeO) and magnetite (Fe_3O_4), and the Portland clinker in the process of roasting. During the reduction roasting the red mud impurities are expected to be absorbed by the Portland clinker silicate phases and not to get into the ferric oxides composition. We intend to separate magnetic ferrous phase by magnetic separation after the Portland clinker grinding with gypsum to a normative grade. As a result of such treatment, there can be three valuable products obtained: the Portland cement, the sulfide-silicate cement, and the iron-bearing concentrate. The general technological scheme is presented in Fig. 1.

We propose to carry out reduction roasting of the burden that consists of red mud, powdered quartz, carbon and calcium carbonate ($CaCO_3$). Before mixing the raw components they must be dried and homogenized by combined grinding. The chemical composition of the raw materials based on red mud is given in table 1. The compositions of two different burdens prepared on the red mud basis and the chemical composition of silicate component are presented in table 2. The roasting specificity is accounted for by the addition of calcium carbonate into the raw mixture in quantities needed for the formation of calcium-containing silicate materials during the roasting process. It helps to reduce silicate and ferrous phases. The reaction of calcium oxide with silicate oxide provides favorable thermodynamic conditions for the destruction of ferric oxides with silicate oxides and glass phases; it favors the formation of crystal phases of calcium-containing silicate materials, and the ferric oxides reduction.

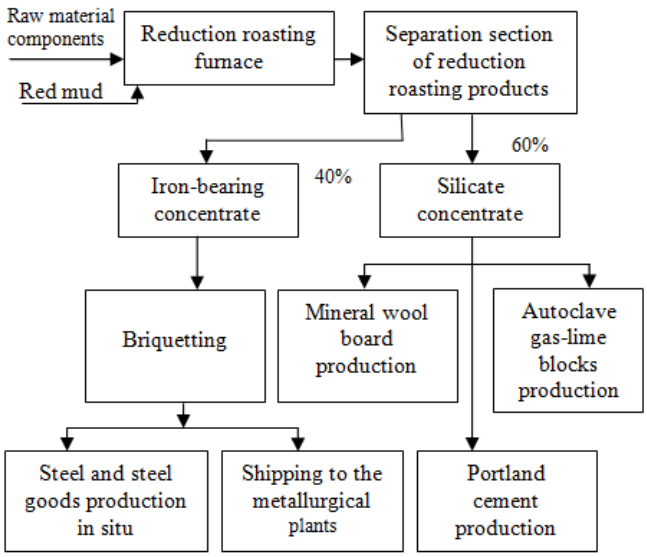

Fig. *The general technological scheme of pyrometallurgical conversion*

Table 1*. Chemical composition of raw materials.*

Component	Content, mass %								
	CaO	SiO_2	Al_2O_3	Fe_2O_3	SO_3	MgO	Other	$\Delta m_{calcination}$	Sum
Microcalcite ($CaCO_3$)	56,35	0,04	0,06	0,04	0,02	0,01	0,01	43,46	100
Red mud	12,1	8,99	12,55	44,89	2,5	0,7	11,53	6,74	100
Coke fine	0,00	0,00	0,00	0,00	0,00	0,00	98,90*	1,10	100

* - carbon

Table 2. *Compositions burdens prepared on the red mud basis and the chemical composition of silicate component*

Clinker name	Initial raw material composition, mass. %		Chemical composition of silicate component, mass %				
	MC*	RM**	C	CaO	SiO_2	Al_2O_3	Fe_2O_3
Burden 1	65,0	32,0	3,00	58,5	8,7	8,4	11,2
Burden 2	10,0	76,0	14,00	36,2	19,2	11,1	14,2

* - microcalcite
** - red mud

The further separation of silicate and iron-bearing concentrate from the final composition produced by roasting is performed by the pneumatic method in cyclones. The silicate concentrate obtained after the separation is further used in clinker roasting. In order to reach a required module characteristics some correctional additives are put into the silicate concentrate prior to the Portland cement roasting at 1400℃.

3. Results and discussion

The chemical results of reduction roasting which allow the determination of a harmful impurity content in the iron-bearing concentrate are presented in table 3. The final composition of a synthesized clinker obtained by the X-ray diffraction analysis is presented in table 4.

Table 3. Chemical analysis results of iron-bearing concentrate

Material name	Composition content in iron-bearing concentrate, mass %		
	Fe_{met}	S	P
Iron-bearing concentrate from burden 1	56,02	0,015	0,033
Iron-bearing concentrate from burden 2	58,16	0,011	0,026

Table 4. Synthesized clinker phase composition on the X-ray diffraction analysis basis

Basic cement phases	Clinker 1, mass %	Clinker 2, mass %
$3CaO{\cdot}SiO_2$ (C_3S)	67,0	68,0
$2CaO{\cdot}SiO_2$ (C_2S)	10,0	7,0
$4CaO{\cdot}Al_2O_3{\cdot}Fe_2O_3$ (C_4AF)	17,0	20,0
$3CaO{\cdot}Al_2O_3$(C_3A)	6,0	5,0
Sum	100,0	100,0

The experimental results show that after the reduction roasting and separation the metalized iron prevails in iron-bearing concentrate, which is beneficial for utilizing the iron-bearing concentrate produced. Furthermore, the produced iron-bearing concentrate is cleaner in phosphorus and sulfur content and can be used as a cooler in converter industry.

The physico-mechanical properties of clinkers produced from silicate concentrate at 1400 ℃ with reference to Gosudarstvennyj standart (GOST) 31108-2003 “Cementi obschestroitel’nye. Technicheskye usloviya” [6] requirement are in good agreement with GOST requirement to CEM I 32.5N GOST 33108-2003 [7] mark.

4. Conclusion

The paper presents technology that can be used for obtaining the iron-bearing concentrate with minimal impurities and valuable cement clinker. The problem related to abundant impurities in the red mud which prevent the production of high-quality iron and alumina concrete is solved by the method of reduction roasting of burden on the red mud basis with calcium carbonate added into the raw mixture. The experimental results show that the final iron-bearing concentrate and cement clinker have beneficial properties and can be used in further production. The paper also presents the general technological scheme of pyrometallurgical conversion used in red mud utilization.

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