BENEFICIATION OF LOW GRADE LATERITES FOR THE PRODUCTION OF ALUMINA

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Beneficiation of low grade laterite ores has been investigated by (i) soda-sintering process, (ii) soda-lime, one-step sintering process and (iii) soda-lime, two-steps sintering process with 20% sodium carbonate leaching. The latter process gives alumina of sufficient purity suitable for the extraction of metal and preparation of aluminium compounds. The recovery of alumina is about 92%.

Introduction

Industrially workable deposits of laterite occur in Quetta, Rawalpindi, Sargodha and Peshawar Divisions of West Pakistan.[1] These reserves have not been utilized so far as a source of iron. Smelting by Pedderson process involves high cost of production due to the electricity used in the process. These deposits are of variable compositions and have usually a high silica content (3.6 to 29.7%). Chemical composition of a few representative samples of laterites of various areas supplied by the Geological Survey of Pakistan is given in Table 1.

Nabi Bux *et al.*[2] of these laboratories, have reported a sodium carbonate sintering method for extracting alumina from the low silica laterites of Ziarat area (silica content from 3.60 to 4.76%). However, this method cannot be used for the beneficiation of low grade laterites. In this investigation an attempt has been made for the extraction of alumina from the low grade indigenous laterites with a view to the utilisation of this important mineral as a source of aluminium and aluminium compounds.

Experimental

Soda Sintering Process.—Ore: Na_2CO_3 (1:1) mixture was heated for about 2 hr at different temperatures (800-900 °C). The resultant mass was leached out with water, and the solution filtered. Carbon dioxide was passed through hot filtrate (50-60°C). The precipitated alumina was analysed for silica, alumina and ferric oxide (Table 2).

The recovery of alumina is above 80% when the ore-silica mixture is heated to 800-850°C. The silica content in the recovered alumina varies between 1-48.%, depending upon the original silica content in the ore. Iron is also present in sufficient amount in the recovered alumina.

Soda-lime, One-step Sintering Process.—The ore: Na_2CO_3 ratio was kept at 1:1 and then different amounts of calcium carbonate were added. The results with ore-sodium carbonate: calcium carbonate (1:1:1) mixture at different temperatures are shown in Table 3. The extracted alumina has almost the same silica content as that obtained with sodium carbonate alone. Fe_2O_3 is however completely eliminated.

Soda-lime, Two-step Sintering Process.—The extraction of alumina was repeated at different temperatures by first sintering the ore with calcium carbonate (ore and calcium carbonate in the ratio of 1:1). Dicalcium silicate is formed at high temperature. The resultant mass was then re-sintered with sodium carbonate at 800–850°C. The sintered mass was then leached either with water or with 20% sodium carbonate solution. The results are shown in Table 4. In case of ore samples containing 7-11% silica, the silica content is reduced to 0.4-0.5%. Samples containing 16–20% silica when treated by this method yield alumina with a silica content of 1.0 to 2.26%.

Discussion

Generally it is not economical to employ the Bayer's process on aluminous ores which contain more than 5% silica[3] because it entails the loss of alumina and high consumption of caustic soda.

In this investigation laterite ores with 7–20% silica content were treated. The percentage of silica in the recovered alumina by sodium carbonate process is fairly high from 1–4.8% depending

upon the silica content in the original ore. The results obtained (Table 3) with soda-lime, one-step sintering process are also not encouraging. The slight decrease in silica content is not within the allowable limits of maximum 0.5% required for the aluminium metallurgy.

There is a marked decrease in the silica content of recovered alumina by soda-lime, two step sintering process. In case of ore containing 7.74–11.6% silica, the recovered alumina contains 0.4 to 0.5% silica only. The laterite samples containing 16–20% silica yield alumina with 1.2 to 2.26% silica. The recovery of alumina by this process is also increased from 88 to 92%. Leaching with 20% sodium carbonate solution is beneficial in reducing the silica content.

Table 1.—Analysis of Laterites from the North-Western Region of West Pakistan.

Laterites Sample No.	Fe_2O_3	Al_2O_3	TiO_2	CaO	MgC	SiO_2	Loss on ignition	Total
1	58.60	18.58	3.30	2.80	0.60	7.74	8.49	100.11
2	54.80	17.34	5.00	1.01	—	11.10	10.76	99.91
3	45.14	27.62	1.76	—	—	16.06	10.33	100.91
4	41.60	16.44	1.82	—	0.23	20.62	17.18	97.90
62 KWS-83	26.60	40.90	2.80	1.80	—	17.50	9.70	99.36
PR-1780	30.40	34.75	3.00	1.80	1.60	11.60	16.65	99.80
PR-1786B	17.60	38.30	0.20	0.48	0.70	29.45	12.42	100.95
PR-1788	20.80	40.00	1.20	2.52	1.50	18.95	13.80	98.77
BPR-1790	29.60	28.00	1.00	0.75	1.50	23.80	12.52	97.17
PR1791	17.80	32.95	1.20	2.82	1.25	29.70	13.17	98.89
PR-1792B	16.80	49.70	1.00	0.80	0.35	14.00	16.96	99.61
PR-1792C	21.60	34.70	1.50	1.60	1.30	23.90	14.30	98.90
FLK-134	27.20	46.90	2.40	Trace	0.30	10.97	10.38	98.09
62-FLK-135	24.72	48.59	2.56	0.10	0.68	11.75	10.40	99.86
62-FLK-136	21.92	51.22	2.56	0.36	Trace	12.14	11.04	99.24

Sample No. 1-4 from Ziarat area.

Sample No. 62KWS-83 from Northern Chitral.

Sample No. PR 1780-1792B from Sargodha District.

Sample No. PR -1792C from Sargodha District.

Sample No. 62-FLK-134-62FLK-136 from Abbottabad.

TABLE 2.—EXTRACTION OF ALUMINA WITH SODIUM CARBONATE.
(Soda-sintering) Ore : Na_2CO_3 (1 : 1)

	Sample No. 1	Sample No. 2	Sample No. 3	Sample No. 4	Sample No. PR-1780
SiO_2	7.74%	11.10%	16.06%	20.62%	11.60%
Al_2O_3	18.58%	17.34%	27.62%	16.44%	34.75%
Fe_2O_3	58.60%	54.80%	45.14%	41.60%	30.40%

Temp.	% SiO_2	% Al_2O_3*	% Fe_2O_3	% SiO_2	% Al_2O_3*	% Fe_2O_3	% SiO_2	% Al_2O_3*	% Fe_2O_3	% SiO_2	% Al_2O_3*	% Fe_2O_3	% SiO_2	% Al_2O_3*	% Fe_2O_3
800°C	1.04	87.3	0.34	1.51	85.3	0.23	2.45	82.8	0.23	4.82	75.6	0.23	1.60	84.0	0.20
850°C	1.1	88.6	0.34	1.50	84.9	0.23	2.50	83.1	0.23	4.79	76.8	0.23	1.58	85.1	0.21
900°C	1.00	88.7	0.34	1.50	85.5	0.23	2.50	83.9	0.23	4.80	76.9	0.23	1.59	85.2	0.20

*Recovery % on the basis of alumina present in the ore.

TABLE 3.—EXTRACTION OF ALUMINA WITH SODIUM CARBONATE—CALCIUM CARBONATE.
(One-step sintering) Ore : Na_2CO_3 : $CaCO_3$ (1 : 1 : 1)

	Sample No. 1		Sample No. 2		Sample No. 3		Sample No. 4		Sample No. PR-1780	
Temp.	% SiO_2	% Al_2O_3*	% SiO_2	% Al_2O_3*	% SiO_2	% Al_2O_3*	% SiO_2	% Al_2O_3*	% SiO_2	% Al_2O_3*
800°C	1.07	86.80	1.51	83.9	2.50	82.0	4.6	76.5	1.41	84.1
850°C	1.05	87.40	1.50	84.3	2.50	82.6	4.6	77.1	1.40	85.3
900°C	1.03	88.70	1.52	85.5	2.50	83.7	4.5	77.4	1.40	86.4
950°C	1.00	88.75	1.52	85.4	2.51	83.9	4.5	77.5	1.40	86.4

*Recovery % on the basis of alumina present in the ore. Traces of Fe_2O_3 were found in all samples.

Table 4.—Extraction of Alumina with Calcium Carbonate and Sodium Carbonate. (Two-step sintering) Ore: $CaCO_3$: Na_2CO_3 (1:1:1)

Temp.	Sample No. 1		Sample No. 2		Sample No. 3		Sample No. 4		Sample No. PR-1780		
	%SiO_2	%Al_2O_3*	%SiO_2	%Al_2O_3*	%SiO_2	%Al_2O_3*	%SiO_2	%Al_2O_3*	%SiO_2	%Al_2O_3*	
850°C	0.50	89.4	0.70	88.1	1.40	83.8	2.25	78.9	0.70	90.0	Leaching with water
900°C	0.50	88.7	0.70	88.9	1.40	84.1	2.26	90.0	0.70	90.2	
950°C	0.50	90.0	0.70	89.0	1.40	85.0	2.25	90.1	0.70	91.0	
850°C	0.46	91.9	0.52	89.3	1.20	86.1	2.16	91.0	0.53	91.4	Leaching with 20% sodium carbonate
900°C	0.45	92.4	0.50	90.2	1.20	87.0	2.10	92.0	0.50	91.7	
950°C	0.40	92.6	0.50	90.3	1.10	87.3	2.10	92.1	0.50	91.8	

*Recovery % on the basis of alumina present in the ore. Traces of Fe_2O_3 were found in all the samples.

The laterite ores with as high a silica content, as 11.6% on treatment with soda-lime, two-step sintering process and leaching of the resultant mass with 20% sodium carbonate solution, yield alumina which is of sufficient purity for aluminium metallurgy and manufacture of aluminium chemicals. This process may be extended to the extraction of alumina from high silica bauxite ores.

The optimum temperature for the extraction of alumina in the soda-lime, two-step sintering process is lime sintering 900–950°C, and soda sintering 800–85°C.

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