

PRODUCTION OF ALUMINA SUITABLE FOR ALUMINIUM INDUSTRY FROM LATERITES

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Samples of laterites have been investigated for their chemical composition and utilization as aluminium ore. Sodium carbonate extraction of the material at a suitable temperature can provide alumina of sufficient purity, suitable for electrolytic recovery of the metal from a fused cryolite bath.

Introduction

Deposits consisting largely of aluminium and ferric hydroxides with more or less of silica are known as laterites. They vary widely in composition and purity and may at times be valuable as a source of aluminium or iron ore. These deposits, occurring in large quantities in Ziarat in the Quetta Division, have not been exploited commercially so far. Realizing the importance of finding suitable ore deposits either for iron or aluminium industry, studies have been made in this paper on the aspect of utilizing the ore for the production of aluminium.

In the manufacture of aluminium there are two main stages: one being the production of pure alumina from some aluminous mineral, usually bauxite, and the other is the reduction of this oxide to metallic aluminium in a bath of fused cryolite.

For the production of alumina, the more important processes are those of (1) Bayer, (2) Hall and (3) Pederson and Hagland.

Processes for the Recovery of Alumina

About thirty samples were analysed (Table 1). The alumina content varied from 20 to 40%, the iron oxide content from 40 to 60%, and silica from 3 to 15%. The more important ones, with aluminium content from 35 to 43%, have been used in experiments for the recovery of alumina.

Treatment of the Ore with Sodium Hydroxide.—Attempts were made to develop a process like the Bayer's process by heating the samples with sodium hydroxide solution of sp. gr. 1.48 at a high temperature and pressure. For this about 50 g. of sample and 200 ml. of sodium hydroxide solution were taken in a flask which was introduced into an autoclave at 40 lbs. per sq. inch pressure, with no arrangements for stirring. Only 26.3% of alumina could be extracted.

Sodium Carbonate Extraction.—Reaction mixtures of different amounts of sample and sodium carbonate were heated for a definite time and at temperatures above 800°C. The resultant mass was leached out, filtered and washed with dilute sodium carbonate. The solution was then analyzed for alumina and silica (Table 2). It can be seen from the table that only 10 to 25% total silica is extracted while the extraction of alumina is almost complete in most of the cases, a minimum of its own weight of sodium carbonate being just sufficient.

Extraction of Alumina with Sodium Carbonate in the Presence of Calcium Carbonate.—The extraction of alumina was repeated by adding different amounts of calcium carbonate. This resulted in the reduced extraction of silica, but it could not be eliminated altogether (Table 3), showing only a slight tendency of decreased silica content with increasing weight of calcium carbonate.

Recovery of Alumina by Carbon Dioxide.—It was observed that precipitation of alumina was easier and quicker at lower temperatures, possibly due to the greater solubility of carbon dioxide at lower temperature (Table 4).

Conclusions

It can be seen from Table 1 that some of the better samples containing alumina up to about 40% and with low silica are potential sources of aluminium. As Pakistan is lacking in good quality iron ore, the laterites provide the raw materials for iron industry as well. Such samples have already been worked out elsewhere as by Pederson process.

For the production of alumina for aluminium industry alone, nearly the entire amount of alumina can be extracted, and the silica percentage of the recovered alumina can be brought to the allowable limit of maximum 0.5% by adjusting the conditions of extractions and precipitation by carbon dioxide (Table 4).

TABLE I.—ANALYSIS OF LATERITE SAMPLES.

Sample No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Loss on ignition	13.20	9.26	11.40	10.76	10.00	8.49	13.18	10.80	11.17	10.33	10.74	10.29	10.95	14.52	17.18	12.69%
SiO ₂	10.80	7.61	4.76	11.10	11.80	7.74	9.00	8.77	4.74	14.78	7.27	11.27	12.00	3.60	20.62	12.14%
Fe ₂ O ₃	37.45	60.00	39.60	54.80	48.75	58.60	51.20	44.80	41.60	45.14	46.40	48.64	42.40	29.60	41.60	39.12%
Al ₂ O ₃	33.24	21.34	34.90	17.34	25.17	18.58	25.02	29.22	38.58	27.62	29.77	23.67	29.06	43.04	16.44	32.98%
TiO ₂	5.71	0.16	6.00	5.00	2.40	3.30	1.40	5.20	2.60	1.76	6.00	3.80	5.00	6.40	1.82	2.36%
CaO	Trace	1.47	2.60	1.01	1.26	2.80	1.20	0.78	1.34	—	—	0.47	0.78	—	—	— %
MgO	Trace	—	0.60	—	—	0.60	0.30	—	—	—	—	0.50	—	—	0.23	0.93%
Total	100.40	99.84	99.86	100.01	100.14	100.11	100.30	99.57	100.03	99.63	100.18	98.64	100.19	97.16	97.89	100.22

Sample No.	17	18	19	20	A	B	C	D1	D2	E	F	G	H	I
Loss on ignition	11.40	11.30	13.62	12.65	10.74	10.45	9.96	9.53	8.42	9.78	10.13	10.79	9.03	11.56%
SiO ₂	6.80	7.25	12.19	11.62	10.79	4.40	12.44	3.24	3.31	2.25	8.66	8.50	11.13	5.88%
Fe ₂ O ₃	47.20	48.00	28.80	49.74	38.40	40.00	52.80	40.80	60.00	53.60	50.40	40.00	41.60	48.00%
Al ₂ O ₃	30.78	30.88	39.13	19.42	32.36	36.70	16.15	38.30	21.83	26.18	24.96	32.00	30.76	28.94%
TiO ₂	4.20	2.85	5.60	5.30	6.00	6.00	4.00	5.80	4.80	5.80	3.33	5.00	5.60	4.00%
CaO	—	0.61	0.90	0.48	1.12	2.68	2.01	—	1.40	1.69	0.38	1.12	0.78	2.00%
MgO	—	—	0.42	0.82	—	1.66	1.34	1.52	0.47	—	1.25	0.85	0.62	— %
Total	99.38	100.89	100.66	100.03	99.41	101.89	98.70	99.19	100.23	99.29	99.11	98.26	99.52	100.38

TABLE 2.—EXTRACTION OF ALUMINA. WEIGHT OF ORE TAKEN IN EACH CASE = 4 G.

Original contents of ore		Sample No. 3			No. 9			No. 14			No. D1			No. B		
		SiO ₂ = 4.76 % Al ₂ O ₃ = 34.9 % Fe ₂ O ₃ = 39.6 %			SiO ₂ = 4.74 % Al ₂ O ₃ = 38.58 % Fe ₂ O ₃ = 41.60 %			SiO ₂ = 3.60 % Al ₂ O ₃ = 43.04 % Fe ₂ O ₃ = 29.60 %			SiO ₂ = 3.24 % Al ₂ O ₃ = 38.30 % Fe ₂ O ₃ = 48.80 %			SiO ₂ = 4.40 % Al ₂ O ₃ = 36.70 % Fe ₂ O ₃ = 40.00 %		
Expt. No.	Wt. of Na ₂ CO ₃ g.	Temp. of firing	% of Al ₂ O ₃ in soln.	% of SiO ₂ in soln.	Temp. of firing	% of Al ₂ O ₃ in soln.	% of SiO ₂ in soln.	Temp. of firing	% of Al ₂ O ₃ in soln.	% of SiO ₂ in soln.	Temp. of firing	% of Al ₂ O ₃ in soln.	% of SiO ₂ in soln.	Temp. of firing	% of Al ₂ O ₃ in soln.	% of SiO ₂ in soln.
1	1	840- 860°C.	15.20 15.77	0.40 0.375	850°C.	13.66 13.40	0.28 0.27	800- 1000°C.	8.40 8.50	0.21 0.21	820- 860°C.	11.77 11.97	0.187 0.275	800- 840°C.	15.68 15.27	0.63 0.62
2	2	„	29.82 27.80	0.587 0.575	800- 850°C.	30.75 31.11	0.85 0.86	800- 900°C.	33.22 34.76	0.83 0.77	820- 860°C.	29.61 29.15	0.45 0.45	800- 920°C.	29.48 29.41	0.60 0.60
3	3	800- 1000°C.	33.47 34.60	0.412 0.387	800°C.	35.10 35.10	0.11 0.97	800- 900°C.	39.05 38.88	0.67 0.55	820- 860°C.	37.00 36.50	0.625 0.575	840- 860°C.	34.21 34.01	0.75 0.76
4	4	„	35.03 34.73	0.40 0.46	Maker Burner Flame	36.87 36.08	0.65 0.65	800- 900°C.	40.33 39.67	0.55 0.55	820- 840°C.	30.47 36.74	1.012 0.987	800- 850°C.	35.53 35.50	0.73 0.82
5	6	800- 860°C.	34.56 34.86	0.50 0.487	„	30.85	0.72 0.72	800- 850°C.	41.39	0.37 0.46	820- 840°C.	38.00 37.85	0.77 0.80	820- 860°C.	35.36 35.47	0.34 0.32
6	8	„	35.95 34.47	0.475 0.50	All results calculated on basis of ore (wt.).											

TABLE 3.—EXTRACTION OF ALUMINA WITH Na_2CO_3 AND CaCO_3 . WEIGHT OF ORE IN EACH CASE = 4 G. AND WEIGHT OF Na_2CO_3 IN EACH CASE = 4 G.

Expt. No.	Wt. of CaCO_3	Sample No. 3		No. 9	No. 14	No. D1	No. B
		% of Al_2O_3 in soln.	% of SiO_2 in soln.	% of SiO_2 in soln.	% of SiO_2 in soln.	% of SiO_2 in soln.	% of SiO_2 in soln.
1.	0.5 g.	34.53	0.475 0.48	0.58 0.41	0.50 0.44	0.50 0.55	0.51 0.40
2.	0.3 ,,	Not done	0.55 0.55	0.58 0.66	0.59 0.64	0.59 0.71	0.55 0.52
3.	0.2 ,,	„	0.60 0.59	0.57 0.59	0.61 0.59	0.589 0.61	0.84 0.71
4.	2.0 ,,	33.92 34.00	0.42 0.49	—	—	—	—

Temperature of firing varies from 800 to 940°C. in all experiments.

 TABLE 4.—RECOVERY OF Al_2O_3 BY PASSING CO_2 . ORIGINAL % OF SiO_2 ON WEIGHT OF Al_2O_3 (IN SOLUTION) PRESENT IN SOLUTION = 1.81.

Expt. No.	Dilution	At room temperature		At water bath temperature		% of SiO_2 in recovered Al_2O_3
		Al_2O_3 in 50 ml. of soln.	Wt. of Al_2O_3 recovered	Wt. of Al_2O_3 present in soln. of 50 ml.	Wt. of Al_2O_3 recovered	
1.	50 ml. of soln.	0.1667 g.	0.1556 g.	0.1667 g.	0.1412 g.	1.34
2.	50 ml. of soln. + 50 ml. H_2O	„	0.1594 „	„	0.1562 „	1.60
3.	50 ml. of soln. + 100 ml. H_2O	„	0.1610 „	„	0.1602 „	1.34
4.	50 ml. of soln. + 200 ml. H_2O	„	0.1591 „	„	0.1598 „	1.16
5.	50 ml. of soln. + 400 ml. H_2O	„	0.1697 „	„	0.1600 „	0.51
6.	„	„	0.159 „	„	0.1620 „	0.34
7.	„	„	0.152 „	„	0.1612 „	0.21

Further experiments are needed to implement these experiments at the pilot plant scale. Pakistan has no basic aluminium industry and the demand for the metal is so great that the process can be

of commercial success.

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