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BAUXITE DIGESTION STUDIES FOR OPTIMIZATION OF OPERATING PARAMETERS

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Abstract

Alumina extraction from bauxite by the Bayer's process requires an efficient digestion process. Bauxite digestion depends much on the temperature-pressure conditions, the recycled liquor concentration, bauxite mineralogy and charge quantity. The productivity of the entire Bayer process depends to a large extent on the digestion process. High-pressure digestion (235 to 245^{0}C) is used for boehmitic and diasporic bauxites.

A need has been felt to optimize the digestion conditions in order to achieve low caustic soda loss coupled with minimum bauxite consumption. In an effort to achieve the above-mentioned goals a series of experiments were conducted to find out the best parameter for conducting digestion at laboratory scale.

The effects of deslication and digestion temperature, bauxite charge, lime quantity and digestion liquor Molar Ratio (MR) are discussed in these paper.

Introduction

The important steps involved in the Bayer process are desilication, digestion, separation of red mud, and precipitation of the alumina trihydrate from the sodium aluminate solution and calcinations of the separated particles. The parameters for digestion and precipitation depend on the nature of the bauxite. When the bauxite is predominantly gibbsitic, the digestion can be carried out at relatively low temperatures – atmospheric digestion at 105^{0}C and low-pressure digestion at 140^{0}C to 145^{0}C. For Bohemitic bauxite (Bohemite concentration exceeding 8%), high temperature digestion at 240^{0}Cto 245^{0}C is preferred. Lime addition facilitates the extraction of boehmite. It may be noted that, among the alumina – bearing minerals in bauxite, gibbsite has maximum solubility in caustic, followed by boehmite and then diaspore. The mineralogical forms of the alumina – bearing minerals, influence the digestion conditions in the Bayer process. Caustic soda consumption is controlled by the digestion conditions and the amount of the kaolinite and quartz. In view of the heteromorphism and individualism of bauxites from various sources, it is necessary to carry out technological tests

involving digestion under specified conditions to determine the extractable alumina and caustic soda loss.

The performance of the digestion process is function of the various parameters such as digestion liquor concentrations and molar ratio, digestion temperature, bauxite charge, residence time and lime addition. In practice because of the fluctuating operations either all or a few of the above parameters do deviate from the laid down norms causing continuous variations in the digestion efficiency.

Experimental

Laboratory digestion tests were carried out in oil bath digester with small autoclave. Numbers of digestion tests were conducted by varying the parameters in the ranges mentioned in the table below:

Sl. No.	Parameters	Ranges
1	Desilication Temperature	88^0C, 95^0C
2	Lime Dosage	0.5% to 1.50% CaO of bauxite charge
3	Target MR	1.38 to1.50
4	Digestion liquor MR	2.90 to 3.40

Desilication studies were carried out at 88^0C and 95^0C at 1.45 Target MR and the results are given in Table-I. To optimize the lime quantity, deslication was carried out at 88°C and 95°C followed by digestion with variation in lime dosage and the results were shown in Table-II and Table-III. A set of digestion experiments was done at optimum desilication temperature and lime dosage with varying target MR and the findings of the tests are given in the Table-IV. Digestion experiments were also carried out by varying digestion liquor MR with two different desilication temperature (88°C, 95°C) and Target MR (1.38,1.45) with optimum lime dosages. The results of the tests are given in the Table-V to –VIII.

Results And Discussion

It can be seen from the Table –I that during conducting digestion test at desilication conditions, the desilication reaction is closer to completion when the Desilication was carried out at 95°C as compared to deslication at 88°C. But at the same time the soda loss is higher when the desilication is carried out at 95°C.

In view of the above it was necessary to conduct digestion test after deslication at 88°C & 95°C with varying lime additions, the results are given in Table-II & Table-III. The results show that under identical liquor concentration and MR, the best results are being achieved under the following conditions with respect to desilication temperature and lime dosage:

Desilication Temperature: 88°C
Lime Dosages : 0.75% CaO of bauxite charge
Under these conditions, the soda loss comes to a level with acceptable digestion efficiency while giving us low Fe_2O_3 and SiO_2 levels in the digested liquors.
Further, the digestion liquor MR and Target MR variation was also carried out to find out the best possible digestion parameters combination.

As a next set of experiments Target MR variation was done with the same bauxite and liquor. The results (Table-IV) show that there exist two Sweet Spots i.e. at 1.38 and 1.45 characterized by soda loss and bauxite consumption.

Finally, the digestion liquor MR was also varied with two desilication temperatures and two Target MR .The results are tabulated in Tables - V, VI, VII and VIII.

Conclusion

On careful observation of the results one can observe the best combination is as under:

Desilication Temperature	: 88°C
Target MR	: 1.45
Digestion liquor MR	: 3.24
Lime Dosage	: 0.75% CaO of bauxite charge

While carrying out the digestion studies under these conditions we can expect lower bound soda loss coupled with low bauxite consumption. We can also expect significantly lower Fe_2O_3 and SiO_2 levels in the digested liquor. While translating these results to plant level operation, some care must be taken on the following points:

(1) Bauxite used in laboratory test were of uniform mesh size, while that in the plant operation are of varying granulometry ranging from very coarse, to coarse and fine.
(2) The agitation level in the laboratory is not the same in plant conditions.
(3) In the plant flashing of digested slurry is being done which is not available in laboratory scale experimentation.

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TABLE- 1. DESLICATION STUDIES AT DIFFERENT TEMPERATURES

BAUXITE QUALITY	
$\%SiO_2$	2.16%
$\%Al_2O_3$	46.53%

DIGESTION LIQUOR	
Na_2Oc,gpl	181.3
MR	3.56
SiO_2 gpl	0.57

RESULTS	Deslication Temp.	
	88°C	95°C
Desilicated liquor Na_2OC	173.6	161.2
Molar Ratio	1.85	1.35
SiO_2 @ 140 gpl	1.70	0.96
Mud Load, %	51.92	49.21
Digestion Efficiency, %	67.07	74.07
Soda Loss, Kg NaOH / T Al_2O_3	28.54	34.95
Bauxite T / T Al_2O_3	3.20	2.9
% SiO_2 Reduction in liquor phase		28.9

TABLE - II : DESLICATION AT 88°C FOLLOWED BY DIGESTION WITH VARIATION IN LIME DOSAGE

BAUXITE QUALITY	
% SiO_2	2.81
% Al_2O_3	46.57

DIGESTION LIQUOR	
Na_2Oc,gpl	173.6
MR	3.40

Values at 140 gpl Na_2Oc	
Fe_2O_3,gpl	59.08
SiO_2,gpl	0.83
V_2O_5, gpl	1.39
P_2O_5, gpl	0.4

ANALYSIS OF DIGESTED LIQUOR

Parameters	No Lime	Lime Dosages ,% CaO of Bauxite charged				
		0.5	0.75	1.00	1.25	1.50
Na_2Oc, gpl	151.9	150.3	155	158.1	151.9	158.1
MR	1.48	1.48	1.47	1.48	1.48	1.47
	Values refered at 140gpl Na_2Oc					
Fe_2O_3,gpl	61.71	46.68	33.43	46.44	65.38	76.48
SiO_2,gpl	0.61	0.56	0.50	0.55	0.55	0.60
V_2O_5, gpl	1.44	1.54	1.53	1.58	1.64	1.50
P_2O_5,gpl	0.75	0.93	0.82	0.8	0.82	0.79
RESULTS						
Mud Load ,%	45.84	45.18	45.16	45.93	46.74	47.51
Digestion Efficiency,	84.72	86.48	86.89	87	87.22	87.06

%						
Soda loss ,Kg/ T Al_2O_3	72.94	66.7	67.51	66.68	65.05	65.61
Bauxite T/T Al_2O_3	2.53	2.48	2.47	2.47	2.46	2.47

TABLE - III : DESLICATION AT 95°C FOLLOWED BY DIGESTION WITH VARIATION IN LIME DOSAGE

BAUXITE QUALITY	
% SiO_2	2.81
% Al_2O_3	46.57

DIGESTION LIQUOR	
Na_2Oc,gpl	173.6
MR	3.40
Values at 140 gpl Na_2Oc	
Fe_2O_3,gpl	59.08
SiO_2,gpl	0.83
V_2O_5, gpl	1.39
P_2O_5, gpl	0.40

ANALYSIS OF DIGESTED LIQUOR

Parameters	No Lime	Lime Dosages ,% CaO of Bauxite charged				
		0.50	0.75	1.00	1.25	1.50
Na_2Oc, gpl	144.1	144.1	139.5	145.7	144.1	146.4
MR	1.43	1.44	1.44	1.46	1.46	1.47
	Values refered at 140gpl Na_2Oc					
Fe_2O_3,gpl	41.95	39.65	41.14	42.97	63.68	58.26
SiO_2,gpl	0.74	0.69	0.66	0.64	0.68	0.71
V_2O_5, gpl	1.23	1.16	1.29	1.33	1.35	1.33
P_2O_5,gpl	0.38	0.56	0.70	0.74	0.56	0.55
RESULTS						
Mud Load ,%	44.1	45.4	46.61	46.84	47.78	48.42
Digestion Efficiency, %	86.22	86.13	85.9	86.14	86.43	86.4
Soda loss ,Kg/ T Al_2O_3	79.2	80.01	80.72	77.73	78.71	79.32
Bauxite T/T Al_2O_3	2.49	2.49	2.50	2.49	2.48	2.48

TABLE - IV DESLICATION AT 88°C FOLLOWED BY DIGESTION WITH 0.75% LIME ADDITION WITH VARYING TARGET MR

BAUXITE QUALITY	
% SiO_2	2.71
% Al_2O_3	45.92

DIGESTION LIQUOR	
Na_2Oc gpl	181.3
MR	3.16

RESULTS	
Parameters	Target MR

	1.38	1.40	1.42	1.45	1.47	1.5
Mud Load ,%	46.45	46.62	46.99	46.67	46.81	46.55
Digestion Efficiency, %	85.22	85.61	85.6	85.82	85.95	86.4
Soda loss ,Kg/ T Al_2O_3	71.05	75.58	75.56	75.92	74.96	76.3
Bauxite T/T Al_2O_3	2.55	2.54	2.54	2.53	2.53	2.52

TABLE - V: DESLICATION AT 88°C FOLLOWED BY DIGESTION WITH 0.75% LIME ADDITION AT 1.45 TARGET MR WITH VARYING DIGESTION LIQUOR MR

BAUXITE QUALITY	
% SiO_2	2.76
% Al_2O_3	45.89

Parameters	Digestion Liquor Concentration and in gpl and MR					
	182.9	182.90	181.4	182.9	179.8	179.8
	2.91	3.02	3.13	3.24	3.37	3.41
Mud Load ,%	46.72	46.84	46.47	46.12	46.48	46.51
Digestion Efficiency, %	86.1	85.94	86.09	86.31	86.04	86.26
Soda loss ,Kg/ T Al_2O_3	74.44	75.38	75.1	71.49	73.81	75.79
Bauxite T/T Al_2O_3	2.53	2.53	2.53	2.52	2.53	2.53

TABLE - VI: DESLICATION AT 95°C FOLLOWED BY DIGESTION WITH 0.75% LIME ADDITION AT 1.45 TARGET MR WITH VARYING DIGESTION LIQUOR MR

BAUXITE QUALITY	
% SiO_2	2.76
% Al_2O_3	45.89

Parameters	Digestion Liquor Concentration in gpl and MR					
	182.9	182.90	181.4	182.9	179.8	179.8
	2.91	3.02	3.13	3.24	3.37	3.41
Mud Load ,%	46.68	46.44	46.24	46.65	46.6	46.67
Digestion Efficiency, %	86.13	86.11	86.29	85.94	86.16	86.44
Soda loss ,Kg/ T Al_2O_3	73.12	73.23	72.00	72.01	73.89	73.39
Bauxite T/T Al_2O_3	2.53	2.53	2.52	2.54	2.53	2.52

TABLE - VII: DESLICATION AT 88°C FOLLOWED BY DIGESTION WITH 0.75% LIME ADDITION AT 1.38 TARGET MR WITH VARYING DIGESTION LIQUOR MR

BAUXITE QUALITY	
% SiO_2	2.76
% Al_2O_3	45.89

Parameters	Digestion Liquor Concentration in gpl and MR				
	179.8	**181.40**	**184.5**	**184.5**	**184.5**
	2.90	**3.00**	**3.16**	**3.24**	**3.38**
Mud Load ,%	16.89	47.16	47.13	47.05	46.94
Digestion Efficiency, %	85.23	85.25	84.78	84.95	85.14
Soda loss ,Kg/ T Al_2O_3	68.36	73.09	75.96	77.83	72.69
Bauxite T/T Al_2O_3	2.56	2.56	2.57	2.56	2.56