

THE ECONOMICAL FLEXIBILITY FOR PROCESSING DIASPORIC BAUXITE

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Key words: Diasporic bauxite, A/S ratio of bauxite (A/S), Bayer process, Dressing Bayer process, Sintering process, Mixed combination process, Serial combination process

Abstract

Until now, the domestic diasporic bauxite resources is the primary supplied bauxite for alumina production, and Bayer, dressing Bayer, sintering, mixed combination and serial combination processes are parallel used to produce alumina product in China. At the same time Chinese diasporic bauxite resources was seriously depleted recently with the greatly increasing of alumina capacity. In this paper, depending on current diasporic bauxite conditions, the raw material, energy consumption and raw materials & fuel cost are studied for processing different grade diasporic bauxite with different production processes, at same time the raw material, energy consumption and raw materials & fuel cost are discussed at same A/S for different processes, in order to provide references to economical usage of Chinese bauxite resources for Chinese alumina industry.

1. Introduction

Over 98% of bauxite in China is diasporic bauxite with higher alumina, high silicon dioxide and low ferric oxide. By the end of 2008, the surveyed bauxite resource is about 3 billion tons in China^[1], more than 60% of which is medium and low grade bauxite (A/S=4~6)^[2]. Basing on the conditions of Chinese bauxite resources; Bayer, dressing Bayer, sintering, Serial combination and Mixed combination processes are parallel used to produce alumina product in China. At the same time Chinese alumina industry develop rapidly in recent year. The capacity grows up 66% and the output grows up 49% from 2007 to 2010.

Table 1 the Capacity and Output of Alumina in China^[3]

Year	2007	2008	2009	2010
Capacity (Mt/a)	25.08	30.91	35.70	41.65
Output (Mt/a)	19.44	23.76	23.79	28.95

Table 3 Content of Al₂O₃ and SiO₂ in bauxite

A/S	3.5	4.0	4.5	5	6.5	8	10	12
Al ₂ O ₃ (%)	56.00	58.00	62.00	63.50	65.00	67.00	68.50	70.00
SiO ₂ (%)	16.00	14.50	13.78	12.70	10.00	8.38	6.85	5.83

2.2 The Main Parameters of Mass Balance

The mainly parameters of mass balance base on the production

It consumes rapidly for Chinese diasporic bauxite resource because of the increasing of the Chinese alumina capacity recently, Chinese diasporic bauxite resources were seriously depleted. The trend of the supplied bauxite A/S for one Chinese alumina refinery is shown figure 1.

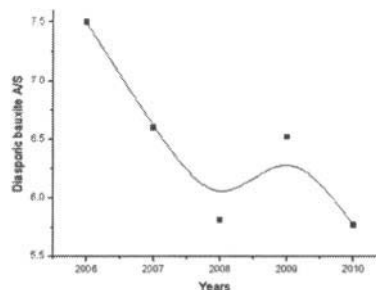


Figure.1 Bauxite A/S trend curve of one Chinese alumina Refinery

A/S is the most important indexes of bauxite quality in alumina production and greatly influences the raw materials & fuel cost of alumina in alkali process. The production cost increases day and day for alumina refinery because the diasporic bauxite grade (A/S) decreases rapidly, and influence the development of alumina industry. So it is realistically important to study the economical adaptability with different production processes for processing different grade (A/S) diasporic bauxite.

2. Mainly Study Conditions

2.1 Material Conditions

Depending on the diasporic bauxite resources and focusing on different processes, We suppose: Bayer bauxite A/S: 4.5~12; Dressing Bayer bauxite A/S: 3.5~5; Sintering bauxite A/S: 4.5~8; Serial Combination bauxite A/S: 3.5~10; Mixed Combination bauxite A/S: Bayer 4.5~10 (Sintering bauxite A/S=4.5, sinter A/S=2.40). The content of alumina and silicon oxide in different grade bauxite is shown in table 3.

technical parameters in this study are shown in table 4.

Table 4 the Main Parameters of the Mass Balance Calculation

Project	Unit	Bayer	Dressing Bayer	Sintering	Mixed combination	Serial combination
Flotation bauxite A/S		-	8*	-	-	-
Bayer digestion liquor α_k		1.42	1.42	-	1.42	1.42
Bayer red mud A/S		1.30	1.30	-	1.30	1.30
Bayer red mud N/S		0.43	0.43	-	0.43	0.43
Bayer spent liquor Na_2O_K	g/l	240	240	-	240	240
Bayer green liquor α_k		1.45	1.45	-	1.45	1.45
Sinter N/R		-	-	0.95	0.95	0.95
Sinter C/S		-	-	2.0	2.0	2.0
Na_2O net leaching yield of sinter	%	-	-	90-93	88.5	82-84
Al_2O_3 net leaching yield of sinter	%	-	-	95-97.5	95	92-93

Note:* Through the study as before, the concentrated bauxite A/S=8 is economical for dressing Bayer process^[5].

2.3 The Price of Raw Material & Fuel

The price of raw material & fuel is the average price of three alumina refineries in China^[6, 7, and 8].

calculation is used to calculate the study results, and the result is based on the tonne alumina. The main calculated results with different process for processing different A/S bauxite are shown in Table 5.

3. Results and Discussion

Company-owned software of mass & energy and cost

Table 5 Study Results

Item	Unit	Process	A/S							
			12	10	8	6.5	5	4.5	4	3.5
Bauxite charge (BAR)	t/t- Al_2O_3	Bayer	1.734	1.818	1.934	2.092	2.315	2.473	-	-
		Dressing Bayer	-	-	-	-	2.474	2.614	2.804	3.171
		Sintering	-	-	1.633	1.683	1.766	1.832	-	-
		Serial combination	-	1.556	1.602	1.665	1.725	1.779	1.917	2.004
		Mixed combination	-	1.607	1.65	1.702	1.749	1.781	-	-
Soda usage	kg	Bayer	91.49	109.23	137.06	172.28	235.78	271.11	-	-
		Dressing Bayer	-	-	-	-	137.3	137.3	137.3	137.3
		Sintering	-	-	57.76	59.44	82.57	97.92	-	-
		Serial combination	-	33.53	37.63	45.52	56.32	61.03	70.29	78.87
		Mixed combination	-	44.09	51.26	58.58	68.42	72.49	-	-
Process energy consumption	GJ	Bayer	12.31	12.38	12.52	12.66	13.43	13.47	-	-
		Dressing Bayer	-	-	-	-	12.78	12.8	12.81	12.85
		Sintering	-	-	32.07	32.86	34	34.78	-	-
		Serial combination	-	19.71	20.87	22.69	25.05	26.38	28.44	30.52
		Mixed combination	-	23.42	25.36	27.37	29.93	30.96	-	-
Raw materials & fuel Cost Ratio*	--	Bayer	0.871	0.881	0.907	0.949	1.042	1.091	-	-
		Dressing Bayer	-	-	-	-	1.083	1.109	1.145	1.218
		Sintering	-	-	1.142	1.154	1.195	1.228	-	-
		Serial combination	-	0.929	0.945	0.988	1.044	1.080	1.146	1.205
		Mixed combination	-	1.014	1.052	1.096	1.153	1.179	-	-

Note:* The study result of raw materials & fuel cost ratio which is basing on the raw materials & fuel cost of Bayer process when bauxite A/S is 4.9.

3.1 The Study of Same Process for Processing Different A/S Bauxite

1) Bauxite Charge (or BAR)

Bauxite charge varying with different A/S in different production processes is shown in figure 2.

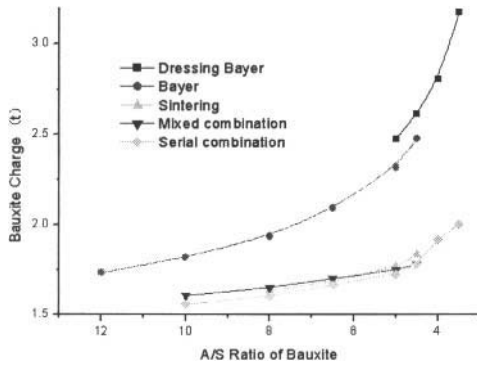


Figure.2 Bauxite charge varies with different A/S in different production processes

Bauxite charge increases with the decreasing of A/S when A/S is from 12 to 3.5 in all processes. The crossing point is 5.75 for mixed combination and sintering process, bauxite charge of sintering process is more than bauxite charge of mixed combination process when A/S is less than 5.75, and bauxite charge of mixed combination process is more than sintering process when A/S is more than 5.75.

2) Soda Usage

Soda usage (as Na₂CO₃) varying with different A/S in different production processes is shown in figure 3.

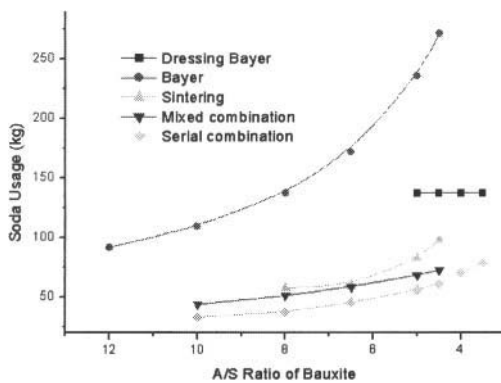


Figure.3 Soda usage varies with different A/S in different production process

Soda usage increases with the decreasing of A/S when A/S is from 12 to 3.5 in all processes.

3) Process Energy Consumption

Process energy consumption varying with different A/S in alumina production is shown in figure 4.

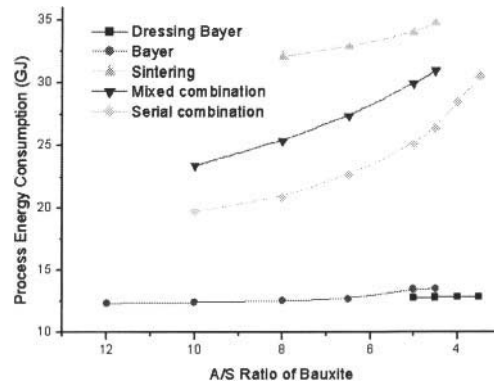


Figure.4 Process energy consumption varies with different A/S in different production processes

Process energy consumption increases with the decreasing of A/S in all processes. It decreases slowly in Bayer and sintering process, and quickly in mixed combination and serial combination process. Process energy consumption hardly varies in dressing Bayer, which means that the influence of A/S is weak on process energy consumption in dressing Bayer process.

4) Raw Materials & Fuel Cost

Raw materials & fuel cost is composed of raw materials and energy cost. Raw materials & fuel cost ratio (basing on the Bayer raw materials & fuel cost when A/S is 4.9) varying with different A/S in different production processes is shown in figure 5.

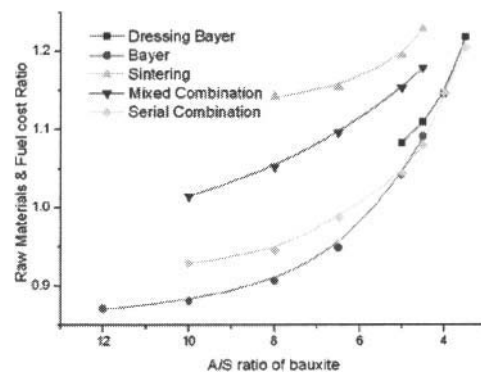


Figure.5 Raw materials & fuel cost varies with A/S ratio in different production processes

Raw materials & fuel cost increases with the decreasing of A/S in all processes. The Raw materials & fuel cost of sintering and mixed combination process is more expensive than the raw materials & fuel cost of Bayer and dressing Bayer and

Serial combination processes. The turning point of Raw materials & fuel cost is 8 for Bayer process; it increases quickly when A/S is less than 8, and slowly when A/S is more than 8.

For Bayer and serial combination process, the crossing point is 4.9. Bayer process's Raw materials & fuel cost is cheaper than the raw materials & fuel cost of serial combination process when A/S is more than 4.9; the raw materials & fuel cost of serial combination process is cheaper than Bayer process when A/S is less than 4.9.

3.2 The Study of Compositions for Different process on Raw Materials & Fuel Cost at the Same A/S Ratio

Due to the crossing point of raw materials & fuel cost is 4.9 for Bayer and serial combination process. So we study the composition of raw materials & fuel cost at A/S is 4.9. And the raw materials & fuel cost is from low to high: Bayer and serial combination, dressing Bayer, mixed combination, sintering process. The difference of raw materials & fuel cost is discussed one by one as follow.

1) The Composition of Raw Materials & Fuel Cost for Bayer Process

The raw materials & fuel cost of Bayer process is same as serial combination process and which is lowest compared with five processes at the same A/S ratio of bauxite. The composition of raw materials & fuel cost is shown in figure 6.

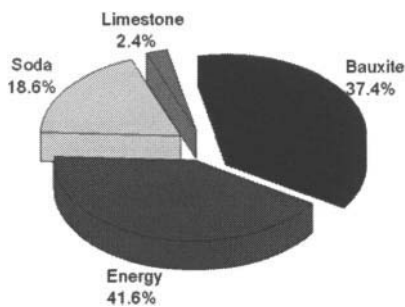


Figure.6 Compositions of raw materials & fuel cost at the A/S ratio of 4.9 in Bayer process

Comparing with the raw materials & fuel cost of other process, the raw materials & fuel cost of Bayer process is sensitive to the price of bauxite and soda. Bayer process is suitable to be used in such area where the price of bauxite and soda is lower and price of other materials and fuel are in the middle. And it is more rivalrous for the area where having high grade diasporic bauxite.

2) The Composition of Raw Materials & Fuel Cost for Serial Combination Process

The raw materials & fuel cost of serial combination process is same as Bayer process and which is lowest compared with five processes at the same A/S ratio of bauxite. The composition of raw materials & fuel cost is shown in figure 7.

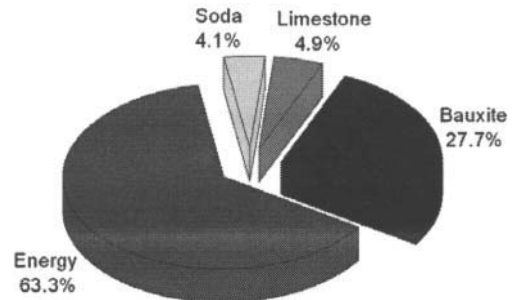


Figure.7 Compositions of raw materials & fuel cost at the A/S ratio of 4.9 in Serial combination process

Comparing with the raw materials & fuel cost of other process, the raw materials & fuel cost of serial combination process is sensitive to the price of energy. Serial combination process is suitable to be used in such area where the price of energy is lower and there is abundant of low grade diasporic bauxite with low content of iron^[9, 10, 11, and 12]. Serial combination process is realistic for technical reconstructing and production organization of alumina refineries with both sintering system and Bayer system on the condition of decreasing of bauxite grade.

3) The Composition of Raw materials & fuel Cost for Dressing Bayer process

The raw materials & fuel cost of dressing Bayer process is a little higher than Bayer and serial combination process compared with five processes at the same A/S ratio of bauxite. The composition of raw materials & fuel cost is shown in figure 8.

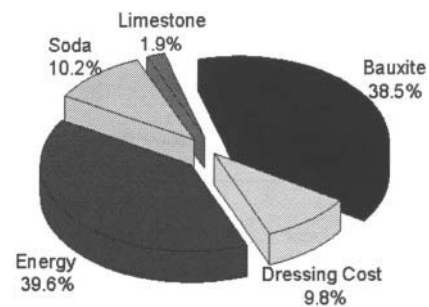


Figure.8 Compositions of raw materials & fuel cost at the A/S ratio of 4.9 in dressing Bayer process

Comparing with the raw materials & fuel cost of other process,

the raw materials & fuel cost of dressing Bayer process is sensitive to the price of bauxite and not sensitive to cost of energy. Dressing Bayer process is suitable to be used in such area where the price of bauxite is lower and there is abundant of low grade diasporic bauxite.

4) The Composition of Raw Materials & Fuel Cost for Mixed Combination Process

The raw materials & fuel cost of mixed combination process is in the middle compared with five processes at the same A/S ratio of bauxite. The composition of raw materials & fuel cost is shown in figure 9.

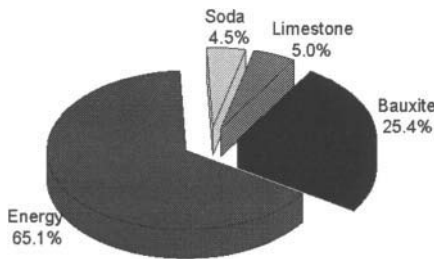


Figure.9 Compositions of raw materials & fuel cost at the A/S ratio of 4.9 in mixed combination process

Comparing with the raw materials & fuel cost of other process, the raw materials & fuel cost of mixed combination process is sensitive to the price of energy and not sensitive to price of bauxite.

5) The Composition of Raw Materials & Fuel Cost for Sintering Process

The raw materials & fuel cost of sintering process is highest compared with five processes at the same A/S ratio of bauxite. The composition of raw materials & fuel cost is shown in figure 10.

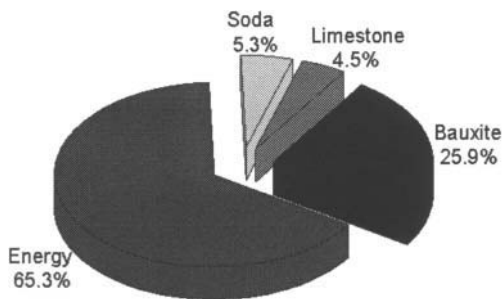


Figure.10 Compositions of raw materials & fuel cost at the A/S ratio of 4.9 in sintering process

Comparing with the raw materials & fuel cost of other process, the raw materials & fuel cost of sintering process is sensitive to

the price of energy because of sintering system.

3.3 Discussing

Sum up, for the same process, the various consumption increases with the decreasing of A/S of bauxite. For the quantity of consumptions at the same A/S(4.9): bauxite charge(BAR) is highest and process energy consumption is lowest in dressing Bayer process; soda usage is highest in Bayer process, process energy consumption is highest in sintering process; bauxite charge and soda usage are lowest in serial combination process. For raw materials & fuel cost at the same A/S (4.9), the raw materials & fuel cost of Bayer, serial combination and dressing Bayer process are obviously cheaper than sintering and mixed combination process. For composition of raw materials & fuel cost: Comparing with other process, the percentage of soda cost is highest in Bayer process; the percentage of bauxite cost is highest and the percentage of energy cost is lowest in dressing Bayer process; the percentage of energy cost is highest in sintering process; the percentage of soda cost is lowest in serial combination process.

4. Conclusions

As Chinese diasporic bauxite resources was seriously depleted. The decreasing of diasporic bauxite A/S is a problem for all of Chinese alumina refineries. At same time, the increasing of energy and bauxite price gives the pressure to the raw materials & fuel cost of alumina production.

We can know through the study: Firstly, sintering and mixed combination processes lose the competitive forces in Chinese alumina industry on the currently conditions of the high price of energy and materials. Bayer and dressing Bayer process with low energy consumption and serial combination process with low materials consumption are better than other processes.

Secondly, the price of material and energy is different in different area, it is appropriate to using combination process for area where the price of raw material (bauxite and soda) is higher and the price of energy is lower; it is appropriate to using Bayer and dressing Bayer process for area where the price of raw material (bauxite and soda) is lower and the price of energy is higher. Finally, for middle and low grade bauxite, combination process is realistic for technical reconstructing and production organization of alumina refineries with both sintering system and Bayer system.

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