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Pipeline Scaling Prevention and Removal Methods in Bayer Digestion Process

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Abstract:Indirect heating digestion process can greatly reduce the energy consumption and raise economic benefits in alumina production. In the digestion process of diaspore type bauxite, Since the silicon titanium compound precipitation, the device wall will form a hard, dense encrustation, causes the device to heat transfer coefficient decreased. In view of Chinese high silicon insoluble diaspore type bauxite mineral characteristics， the microstructure of the silicon titanium scaling and mineral composition have been analyzed. The scale prevention and removal methods have been studied. Using bauxite slurry fully predesilication and predetitanium can effectively reduce and prevent fouling formation, application of catalytic acid leaching can loose hard, dense silicon titanium scaling, and high pressure water washing, such scaling can be easily washed away.

Keywords: Indirect heating, digestion process, silicon titanium scale, predesilication,

1 Introduction

Indirect heating of enhancement digestion technology application, which can greatly reduce the energy consumption in alumina production, improves the heat utilization rate, strengthen production, raise economic benefits. However, because of silicon titanium mineral precipitation in the bauxite digestion process, the device wall to form a hard material, causing the device to heat transfer coefficient is greatly reduced, seriously affected the normal operation of equipment. Therefore, elimination and prevention research of scab, is to strengthen the alumina production process, improve productivity, reduce the energy consumption, but also the strengthening digestion key technology of application of indirect heating pipeline.

In recent years, many countries have done a lot of research on removal of scar, but, due to the different types of ores, process conditions are different, therefore, the scale prevention and removal methods are not the same. Baconian rise, have the following several kinds of scale prevention and removal methods. Removal methods are: (1) Acid leaching method, (2) high pressure water washing method, (3) mechanical cleaning method. Preventing methods are: (1) slurry fully pre-desilication, (2) organic compound coating, (3) ultrasonic and electromagnetic field treatment method. At present, the main application of scar removal method is acid leaching, high pressure water cleaning and mechanical cleaning method. China removal reactor scarring, mainly by artificial vibration and beating method, this method for indirect heating digestion scar removal is difficult to achieve.

In view of the digestion characteristics of high silicon diaspore, using indirect heat enhancement digestion technology, scarring problem will be more outstanding, accordingly, for the successful development and application of this advanced technology, this paper on the preventing and cleaning up to do a more comprehensive study, to explore suitable for China's national conditions technical measures, to reduce scarring, extend the production cycle, to strengthen production,

improves the heat utilization rate, reduce the heat consumption, raise the goal of economic benefits.

2 Experimental method

2.1 Experimental apparatus and process

With a grab the ore is grabbed into a hopper, mixed with lime, and alkali in wet grinding in ball mill. Classifier overflow into the pre-desiliconization slot, predesilicatted at 95℃for 6 hours, pre desilication slurry is pumped into the casing preheater for preheating in 8m^3/hr. 1~8 stage preheater is heated with evaporation steam, ninth stage preheater with molten salt heating, the slurry is preheated to a digestion temperature, from the ninth stage preheater into ten tandem stay tank, further digestion. The digestted slurry evaporate by 8 level, and then enter the dilution tank.

2.2 Experimental materials

Test using ore for Chinese diaspore type bauxite, silicon minerals in Table 1.

Lime chemical composition (lime mixed with many large green coke and limestone):

CaO 71.08%; MgO 6.85%

Chemical composition of bauxite digestion liquor are shown in Table 2.

Table 1 The composition of silicon mineral in bauxite

silicon mineral	Kaolinite	illite	chlorite	quartz	other
Content (%)	59.5	23.2	5.6	9.3	2.4

Table 2 Composition of Digestion Liquor(g/L)

Composition	Na_2O_T	Al_2O	Na_2O_K	$\alpha_k(=Na_2O_r/Al_2O_3)$
Content (%)	251.6	127.3	235.2	3.04

Legends: $Na_2OT=Na_2OK+Na_2OC$. molecular formula plus ( ) represents the mole numbers of the compound

3 Experimental results and discussion

3.1 Desiliconisation and titanium removing test

In the process of alumina production, titanium silicate mineral digestion behavior has a great effect on scarring of alumina production.Test is conducted in casing indirect heater, pre desilication slurry will be heatted from 95℃to about 260℃, then to retain tank for further digestion. Focused on the study of titanium silicate mineral behavior in the heating process, prompting some rules of scarring.

The test results show that, kaolinite easily digestted in alkaline solution, in normal pressure. In 160 ℃ ~260 ℃, illite, chlorite, quartz is gradually digestted in alkaline solution with the increase of temperature, before 160 ℃ there is no reaction.

Change of concentration of SiO_2 and desilication rate changes have similar features, SiO_2 concentration increases slowly With digestion of kaolinite, which is due to the small number of residual kaolinite, rapid

movement of slurry and slow warming. SiO_2 concentration increased dramatically in the later stages, which is the result of illite minerals digestion, and temperature rise sharply. In the preheating process, the dissolution rate of silicon mineral is greater than SiO_2 precipitation rate in solution. As the result of changes in SiO_2 concentration and desilication ratio feature, silicon slag scarring is mild before ninth stage preheater.

In the ninth stage preheater, although desilication rate may cause scarring formation, but because the SiO_2 concentration in the solution is also increasing, so, even in the ninth stage preheater, scarring is milder than expected, as shown in Fig 1.

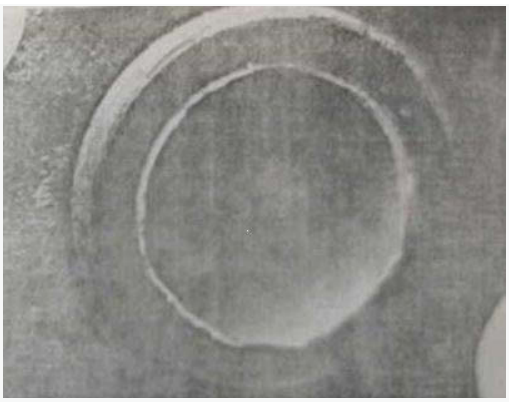

Fig 1 Below 180℃ preheater scab

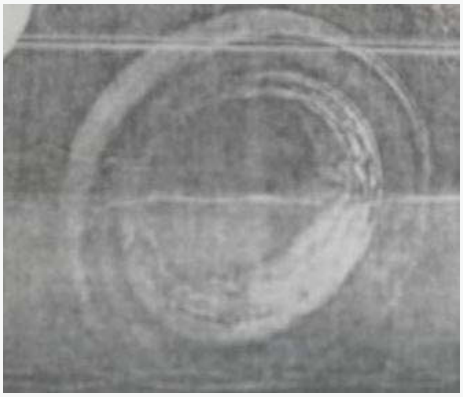

Fig 2 Higher than 180℃preheater scab

3.2 Titanium removing test

In China's bauxite ore, TiO_2 are mainly anatase and rutile, which accounted for 98.4% of the TiO2 total amount. Other TiO_2 is a very small amounts of white titanium mine and colloidal TiO_2. As a result of anatase particles small,and widely dispersed,which is easy to participate in the reaction, the bauxite titanium removing rate can reach 85%.

In the Low-temperature preheating stage (less than 200~220℃), removing of titanium are mainly anatase removal process. In the high temperature of 220~260℃, rutile particles also began to participate in the reaction.

According to above the test results of desiliconisation and titanium removing, it can show some regularity of the scarring:

1) Below 180℃ preheater scarred slightly;

2) Higher than 180℃, preheater scarring gradually serious, however, because the SiO_2 concentration in the solution is not reduced, scarring rate lower than expected;

3) The rate of desiliconisation and titanium removing increase steeply at 180℃, the removing rate of silicon and titanium are associated with the mineral composition of silicon and titanium, more with the increasing rate of temperature, so, the control of heating speed can control the scarring rate.

3.3 Components of the scarring and appearance

Use a screwdriver to remove from the preheater scarring, with anhydrous alcohol wash two times, drying, and crushing in agate mortar. The samples use for chemical and phase analysis. The components of the rolling skin, as shown in Fig 3.

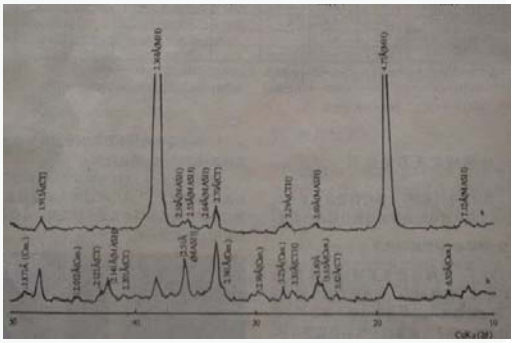

Fig 3 Figure 1 X-ray diffraction pattern of the rolling skin

The scarring in sleeve pipe preheater is composed of silicon slag scarring (mainly cancrinite), magnesium slag scarring [hydrated silicon magnesium aluminate and Mg $(OH)_2$] and titanium slag scarring (calcium titanate and hydroxy calcium titanate).

As the preheating temperature changes, in 180℃, due to the reaction rate of titanium minerals is very slow, TiO2 conversion rate is very low, even at this temperature， there is a small amount of scarring in sleeve pipe preheater, its composition is scarring of silicon and magnesium, but the presence of titanium scarring is mainly hydroxyl calcium titanate, the scar material is easy to clean;

Temperature higher than 260 ℃, the scale is composed of magnesium slag and perovskite, although perovskite scarring is difficult to clean, but the magnesium slag is easy to clean with acid, as the magnesium slag was cleaning the perovskite structure became loose, the scab cleaning is not difficult.

The MgO of ore and lime addition is the source of the MgO of calcium and magnesium scarring. Because the scarring of magnesium slag is easy to clean with acid, it make scar loose more and easily to clean. Reducing MgO content in raw materials, it can reduce the scaling rate, but the scar becomes hard, difficult to clean.

3.4 Scab cleaning method and results

As mentioned before, because there is a small amount of MgO in the raw materials, the scale structure becomes loose. This scarring can effectively remove with pickling and hydraulic flushing.

Hydraulic cleaning by CM-3 type hydraulic pump, power of 40 kW, displacement of 1.5M^3/hr, maximum discharge pressure is 700Kg/cm^2,Φ 26mm nozzle, flow beam diameter is less than 1.5mm.

Experiments were conducted at 180℃ and 260℃ preheater, its phase composition as shown in the table 3:

Table 3 the phase composition of preheater Inner Scar

Composition (%)	sodium silicate slag	hydrating garnet	perovskite	Mg（OH）$_2$	magnesium silicon slag	Boehmite
180℃ preheat scarring	42	9	0	4	29	6
260℃ preheat scarring	13	0	45	15	14	0

The results show that 180℃preheated scarring can be easily cleaned off with 10% sulfuric acid pickling for 90 minutes at 40℃, the temperature is the most important factor influencing pickling in the range of research (temperature 45～75℃, the sulfuric acid 5 ~ 15%, 90 ~ 270 minutes). With increasing temperature, scab off velocity increase, followed by the catalyst, with the extension of time, sulfuric acid concentration increase, scab off velocity also increases.

For high temperature preheating scarring, its digestion rate is up to 78% in 10%HCL pickling for 5 hours and adding the catalyst. Without the presence of a catalys, digestion rate of the preheating scarring reduce to only 42%. From the dissolved components, scarring of sodium, aluminum minerain is more easily digested, the digestion rate can reach more than 90%. Calcium titanate is difficult to be dissolved, without the presence of a catalyst, calcium titanate basically not digested, only adding catalyst, calcium titanate was dissolved in 40%.

4. **Conclusion**

4.1 The scarring in sleeve pipe preheater is composed of silicon slag scarring (mainly cancrinite), magnesium slag scarring [hydrated silicon magnesium aluminate and $Mg(OH)_2$] and titanium slag scarring (calcium titanate and hydroxy calcium titanate).

4.2 Below 180℃ preheater scarred slightly. The rate of desiliconisation and titanium removing increase steeply at 180℃, the removing rate of silicon and titanium are associated with the mineral composition of silicon and titanium

4.3 Temperature higher than 260 ℃,the scale is composed of magnesium slag and perovskite, as the magnesium slag was cleaning the perovskite structure became loose, the scab cleaning is not difficult.

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