Digestion-Evaporation Combined Process in Alumina Refinery

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Abstract

In the Bayer process, the digestion and evaporation are both processes with high energy consumption. Heat energy is recovered by multi-stage flash in digestion process. In alumina refineries with diaspore as raw material, the temperature of the final flash discharged slurry is usually over 120 ℃. Because of the limitation of heat transfer temperature difference, it is difficult to continue to reduce. Multistage falling film evaporation process is often used in evaporation process. All evaporators after four effects are usually vacuum evaporators, the temperature of slurry is usually low. This paper discusses how to achieve better energy cascade utilization through combined process of digestion and evaporation, and then reduce the production cost of alumina.

Keywords: Combined Process, Digestion, Evaporation.

Definitions of terms:
"A/S": mass ratio of Al_2O_3 to SiO_2 in the solid
"N/S": mass ratio of Na2O to SiO2 in the solid
"Rp": mass ratio of caustic Al_2O_3 to Na_2O in liquor
"N_K": caustic concentration of the liquor (as Na_2O)

1. Introduction

Reducing energy consumption in alumina production is an important research topic in the field of alumina refinery. In China, diaspore is the main kind of bauxite in alumina refineries, which requires digestion temperature is generally above 265 °C [1]. Compared with the refineries using gibbsite, the digestion process of the refineries using diaspore consumes much more energy. According to Z.X. Wang' research [2], the total energy consumption per ton alumina of a certain alumina refinery in China is 11.72 GJ/t-Al_2O_3, in which, steam accounts for 60.23 % and energy consumption reaches 7.06 GJ/t-Al_2O_3. G. Jin's research shows that 55.27 % of the total energy consumption in the process of diaspore digestion is ultimately taken away by the pulp [3]. Because of high alkali concentration is needed in the diaspore digestion, boiling point elevation is higher. N_k of test liquor usually reaches 220 - 240 g/L. After multi-stage flashes, N_k in the solution can reach as high as 260 - 290 g/L. At this concentration, the boiling point elevation of the solution can reach to 18 - 20 °C. Under the condition of such a high boiling point elevation, it is difficult for positive pressure flash to continue to reduce pulp temperature and recover heat energy. Moreover, if vacuum flash is used, the temperature of slurry is too high, and the vapor produced by vacuum flash is difficult to be used effectively. Therefore, we design a new process, which combines the digestion process and evaporation process of Bayer alumina refinery into a new process. The heat of the digested pulp can be further recovered and utilized by using the temperature difference between the digestion process and the evaporation process.

2. Process Design

2.1. Design Tool

We take the process simulation software SYSCAD from Kenwalt Australia Pty Ltd. as design tool. We use the software to build digestion and evaporation computation model to simulate an alumina refinery. Then we build a digestion-evaporation combined process simulation to calculate the energy consumption saved by this process.

2.2. Design Basic Parameters

Our design basic parameters are from an alumina refinery in Guizhou, China. This refinery design capacity is 1600 kt/a, divided into two production lines, capacity of single production line is 800 kt/a. Bauxite used in this refinery is diaspore with A/S of about 5 - 5.5, Al_2O_3 is about 50 %, concentration of test liquor is N_k = 249 g/L, digestion temperature is 265 °C. Evaporative water requirement is about 3.38 t per ton alumina,. The temperature of digestion feed slurry is about 93 °C. For one production line, feed slurry mass flow is 1299 t/h, while volume flow is 817 Nm^3/h.

2.3. Digestion Simulation

The digestion process of the alumina refinery is the tube-digestion process. A total of nine-stage preheating tube heat exchanger is set up. The heating medium of the preheating tube heat exchanger is flash vapor. The one-stage live steam condensate tube heat exchanger is heated by live steam condensate. The one-stage live steam tube heat exchanger is heated by live steam. Pressure of the live steam is 6.4 MPa, the temperature is 300 °C. The slurry is heated to the digestion temperature in the tube heat exchanger using live steam. After the reactor, temperature of the slurry is reduced to 126 °C by ten-stage flash cooling. The nine-stages flash vapor is used to preheat the slurry in the tube heat exchanger, and the last flash vapor is used to heat the pre-desilicon pulp.

The simulation model established by SysCAD software is shown in figure 1.

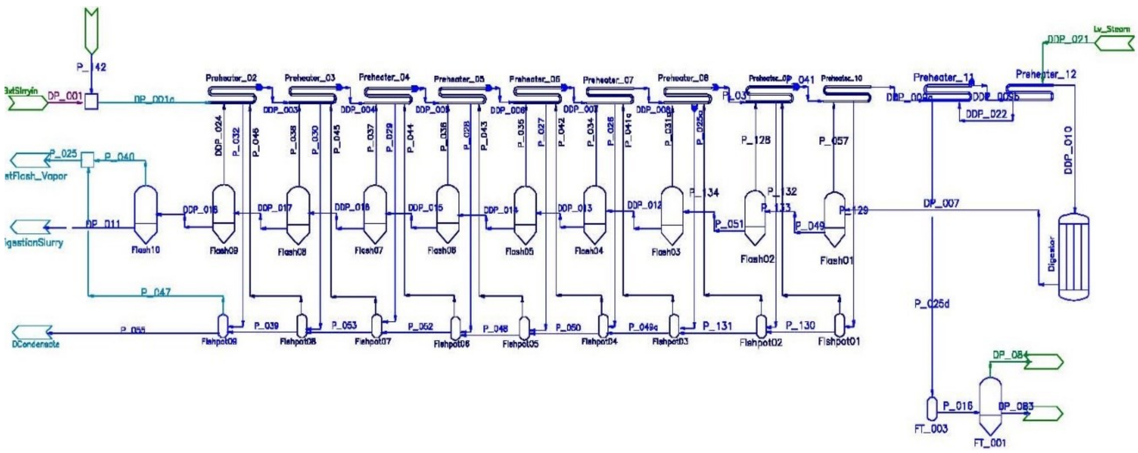

Figure 1. Digestion Process Flow Chart.

The heat balance of the digestion process calculated by the model is shown in table 1.

In summary, through the joint design of digestion process and evaporation process, the temperature difference between different processes in alumina refinery is effectively utilized. Low-grade heat is fully utilized, while reducing the production cost of alumina, the equipment investment and occupation of alumina refinery are also reduced, the distance of material transportation is shortened, and enormous economic benefits can be achieved for alumina refinery.

4. References

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