The Improved Low Temperature Digestion (ILTD) Process and its Recent Developments

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Abstract

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The Improved Low Temperature Digestion (ILTD) Process is flexible and offers many benefits, compared with the Conventional Low Temperature Digestion Process, including the following:

- material and energy cost reduction of 15-40 %;
- savings in the chemical caustic losses by 30-80 %, depending on the process configuration and conditions;
- high precipitation liquor productivity of at least 90 g/L;
- higher production rate in the digestion by up to about 25 %;
- reduced quantity of bauxite residue generation by up to 30 % and with an extremely low soda and possibly high iron content;
- recovery of combined soda and alumina from desilication product (DSP);
- extending the options for the industrial utilization of the bauxite residue (processing of bauxite possibly with no waste to dispose of).

The ILTD Process was originally developed for processing gibbsitic type bauxites, which comprise nearly 90 % of the World's bauxite reserves. This paper reviews the current status of the development, the options for the utilization of the bauxite residue having low soda and possibly high iron content and that for the desilication by-product. A recent Case Study revealed that the ILTD Process is viable for processing high silica gibbsitic bauxites/laterites which contain e.g. 5.5 % or more of R.SiO_2 (Reactive silica). The breakthrough results (savings in the material and energy costs of about USD 60-75/t of alumina) greatly extend the viable processing of low-quality bauxites, even aluminous laterites that have been considered so far to be sub-economic. The worldwide amount of sub-economic bauxite resources of 10-25 Gt is deemed to be a conservative estimate. The updated ILTD Process calls for a shift of paradigm of the Bayer process since the alumina in kaolinite in bauxite can be extracted in a viable way.

Keywords: Production costs, Bauxite residue (red mud), Bayer process, ILTD Process, Waste free process.

1. Introduction

The two substantial unit operations of the Bayer process are the dissolution of the hydrated alumina minerals (digestion), and the crystallization of $Al(OH)_3$ (precipitation). The digestion process step highly depends on the mineralogical composition of the bauxite. The two major forms of digestion are: the low temperature digestion which was developed for the gibbsitic type bauxites and is operated at about 140-150 °C; and the high temperature digestion for the boehmitic and diasporic bauxites, applied at about 240-270 °C. Different flowsheets have been developed for the processing of bauxites with mixed mineralogy such as double digestion for mixed gibbsitic-boehmitic bauxites. It is worthwhile to mention the sweetening process as an occasional embodiment of the Bayer process and the serial combined and the parallel combined Bayer-sintering processes. The review of these non-conventional flowsheets is beyond the scope of the present paper.

2. Dissolution of Gibbsite, Transformation of Kaolinite into DSP

The reaction equation with the arrow to the right symbolizes the dissolution of gibbsite (digestion), with the arrow to the left depicts the precipitation of $Al(OH)_3$.

$$\underset{\text{(gibbsite)}}{Al(OH)_3 + OH^-} \underset{\text{cooling}}{\overset{\text{heating}}{\rightleftharpoons}} \underset{\text{(aluminate anion)}}{[Al(OH)_4]^-} \quad (1)$$

Dissolution reaction of kaolinite

$$\underset{\text{(kaolinite)}}{Al_2(OH)_4(Si_2O_5)} + \underset{\text{(hydroxide ion)}}{6OH^-} + H_2O \rightleftharpoons \underset{\text{(silicate anion)}}{2[SiO_2(OH)_2]^{2-}} + \underset{\text{(aluminate anion)}}{2[Al(OH)_4]^-} \quad (2)$$

The sodium aluminium hydrosilicate (desilication product, DSP, mostly sodalite) compound that forms in the liquid phase as per the desilication reaction equation (3) at temperatures of about 140-160 °C is described in a novel form [1]:

$$6[SiO_2(OH)_2]^{2-} + 6[Al(OH)_4]^- + 20Na^+ + X^{2-} \rightleftharpoons [Na_2O.Al_2O_3.2SiO_2.(1+k)H_2O]_3.Na_2X + \\ + 12OH^- + 12Na^+ + (9-3k)H_2O \quad (3)$$

where X: $2OH^-$, CO_3^{2-}, SO_4^{2-}, $2Cl^-$, $2[Al(OH)_4]^-$, etc., k = 0-1

3. The Reaction Mechanism and Rate Equations of the Dissolution of Gibbsite and Transformation of Kaolinite to DSP

3.1 The Reaction Mechanism

The kinetics of the dissolution of gibbsite and transformation of kaolinite to DSP was tested at about 100 °C and under a wide range of caustic concentrations [2]. The mathematical modeling of the set of kinetic tests enabled the comprehensive reaction mechanism to be determined [3], that is depicted with the following schematics [4].

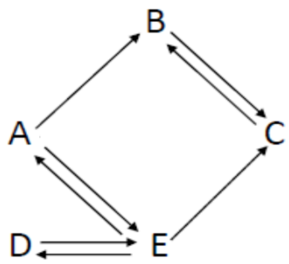

Figure 1. Reaction mechanism of dissolution of gibbsite and transformation of kaolinite to DSP. A: kaolinite, B: dissolved silica, C: sodium aluminium hydrosilicate (DSP), D: gibbsite, E: dissolved alumina

3.2 Reaction Rate Equations of Dissolution of Gibbsite and Kaolinite, Formation of Desilication Product

The reaction rate equations, which best describe the substantial reactions of the dissolution of gibbsite and the transformation of kaolinite into desilication product are shown below (4)-(6). The rate equation for the dissolution of kaolinite that was developed originally for the pre-desilication [3] has been adopted to the conditions of the low temperature digestion [1].

The ILTD Process concept calls for a shift of paradigm. The last sentence of the paper [4] is quoted here „Probably in the near future, silica in bauxites will not be considered as a constituent that is simply responsible for costs and many troubles but rather as one that can also be used to increase the economy of the Bayer process!".

The ILTD Process concept is deemed to be ready for its commercialization.

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