Low-Cost Improvements to the Sandy DSP Process

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Abstract

At the same time that there are pressures to reduce the production cost of alumina and aluminium, quality bauxite is becoming more difficult to find, with reactive silica concentration always increasing. Reactive silica is the most costly impurity, because it often accounts for the majority of the need for caustic addition, which is lost via the bauxite residue in the form of a desilication product (DSP). A process aiming at recovering this DSP before it leaves the circuit and then to recover the caustic, hence this cost, has been proposed. The main principle of this process is to crystallise coarse DSP that can be separated from the bauxite residue easily and recycled. New advances of this concept are making use of concentrated caustic solutions, either pure caustic or evaporated liquor, to promote extensive agglomeration during the desilication phase.

Keywords: Bauxite, Digestion, Desilication, Silica, Caustic recovery.

1. Introduction

Bauxite is the main ore-type from which aluminum can be extracted in an economical way. Apart from various aluminium oxides, bauxite is mostly composed of iron, and silicon -based minerals. And these ores are also mainly treated for extraction using the Bayer process in which these aluminium-bearing compounds are dissolved in hot sodium hydroxide solution.

In this process the aluminium and most other compounds in the bauxite remain in the solid phase, as they are insoluble. However, the reactive silica and silicate compounds (referred to as silica in this paper), such as kaolinite, do react significantly as the bauxite goes through digestion the silicate minerals, typically dissolve and reprecipitates as sodium aluminum hydrosilicate, known as the desilication product (DSP).

Desilication is quite variable from one refinery to the other as it depends on the amount of silica in the bauxite and the digestion temperature (dictated by the type of aluminium-bearing mineral in the bauxite). The desilication in some cases is conveniently happening simultaneously with the digestion but in most cases with the current bauxite quality, needs to be done ahead of digestion. This step is important to minimize scale formation on heat transfer surfaces when the liquor will return to digestion in the next cycle, and also to remove other impurities like sodium carbonate from the Bayer liquor.

However, precipitation of DSP is costly, as sodium hydroxide (the key reagent in the Bayer process) and aluminum (element for the product alumina) are lost, being discarded as part of the bauxite residue. It is often said that bauxites with reactive silica concentrations greater than approximately 8 wt.% cannot be processed economically due to these losses. Another negative impact of the DSP in the bauxite residue is the added complexity of during the residue neutralization, tailings area remediation and recycling the residue for iron recovery, etc.

In a recent paper, a new concept where the DSP can be precipitated in a pre-desilication stage before digestion is described (Vaughan et al. 2019). The conventional pre-desilication can be modified to produced so coarse (large in size / sandy) that this DSP can be separated from the undigested bauxite (bauxite residue) after digestion. These solids that are then mostly DSP can be treated in a cost-effective manner (relative to whole bauxite residue treatments), in order to recover the compounds that are normally lost with the residue (Hodge et al. 2020a, and Hodge et al. 2020b). A process flowsheet for the so-called "Sandy Desilication Product Concentrate Sinter-Leach Process" is shown in Figure 1.

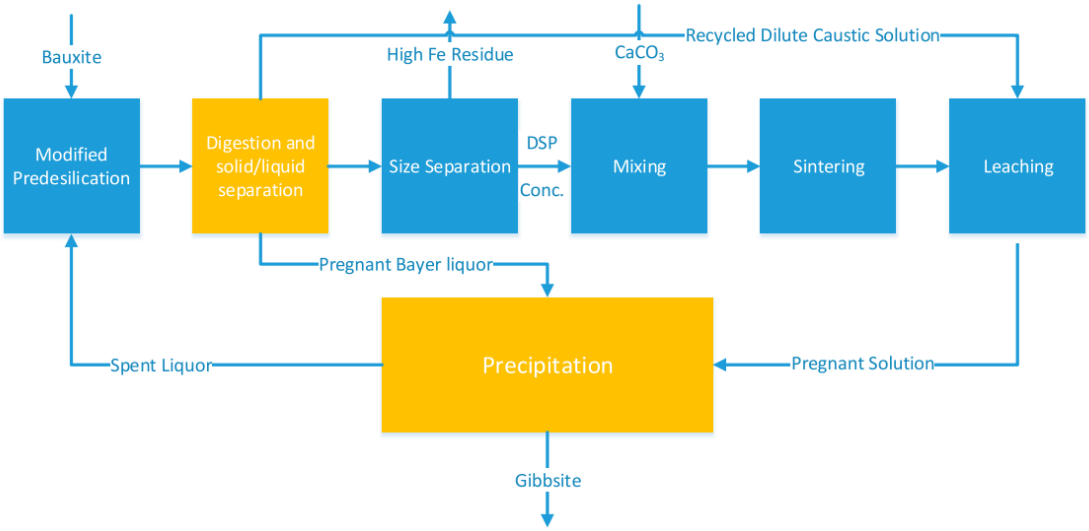

Figure 1: The Sandy Desilication Product Concentrate Sinter-Leach Process [from Hodge et al. 2019].

In this paper will be presented how typical Bayer plants can be modified to produce coarse DSP using streams that are available in their plant.

2. The Coarse DSP Process Advantages

2.1 Standard Predesilication

Whether there is a need for predesilication or not depends on the amount of silica in the bauxite. If the amount of silica is high with a sufficiently long/hot digestion, desilication can happen during digestion, hence doesn't require a specific section to take care of the silica. However, when the silica is lower than a certain level, during digestion the threshold required to autoprecipitate the DSP cannot be reached, and then specific section is required to carry out desilication fully.

The standard predesilication section of a Bayer plant can vary depending of the bauxite type and the amount of silica in the bauxite, but the principle is always more or less the same: allow bauxite to react with the caustic liquor in order to dissolve as much as possible of the silica and also allow it to re-precipitate to a suitably low solution concentration.

In general the pre-desilication circuit (Figure 2) is comprised of a series of CSTR tanks in cascade that are unseeded, especially the first one. The successive tanks may or may not receive some slurry from the last tanks to help increase the amount of seed in the circuit. To help increase the reaction kinetics, generally these tanks are held at the highest temperature that can be achieved at atmospheric pressure. This temperature also depends on whether or not the slurry is preheated. Following predesilication, the liquor volume and alkalinity can be increased by addition of evaporation liquor and fresh caustic, ahead of the aluminium (alumina) digestion stage.

3.2 Use of Concentrated Caustic Streams with the Integration of the Sandy DSP Process

As mentioned before, the Sandy DSP process requires a much higher caustic concentration than what is normally used for the predesilication (typically spent liquor) to achieve the agglomeration and crystal habit needed for the process to work. So, when integrating this process to a typical Bayer plant (Figure 7), some of the concentrated caustic streams can be blended in the right proportion to obtain the concentration required for this process to work. The remainder of the flows is then used to control the caustic concentration of the liquor to digestion, which target would then need to be adjusted as the bauxite slurry will be at a higher caustic concentration.

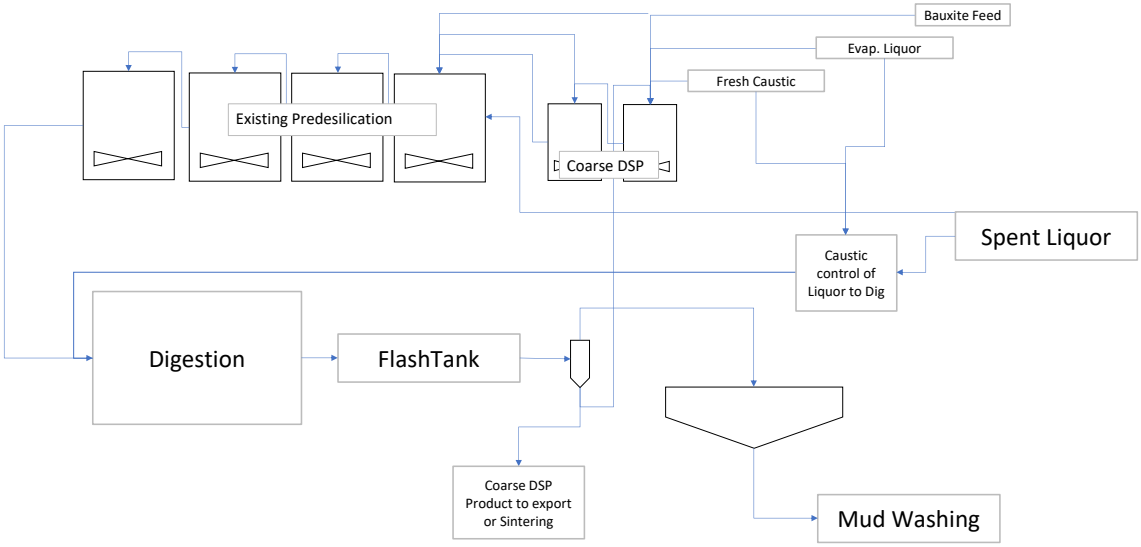

Figure 7. Schematic of the digestion and pre-desilication area after integration of the Sandy DSP process

4. Conclusion

As demonstrated in this paper, it is possible to integrate the Sandy DSP process to an existing plant by making use of evaporated liquor and concentrated caustic streams and by doing so increase the efficiency and profitability of the refinery.

Because this process is still quite novel and has yet to be piloted in continuous mode, it would require research and development efforts to identify the optimum process configuration and conditions. These are likely to be dependent on the liquor composition (particularly the organics, Seneviratne et al. 2017), the bauxite composition and equipment available (agitation is important factor for silica compounds kinetic). DSP seed quality, concentrations and control of the supersaturation during desilication also needs to be considered carefully.

5. References

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