AKW Equipment + Process Design Expertise in Alumina Refineries

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Abstract

As the Bauxite and Alumina industry currently face important market challenges, a key objective is to improve and optimize the overall process chain, from bauxite mining and processing through to the refinery and smelter process. Since 1978, AKW Equipment + Process Design delivered more than 50 projects in alumina refineries. There, AKW A+V hydrocyclones AKA-VORTEX and distributors AKA-SPIDER have been operating successfully for several decades. For the special conditions of hot caustic soda, AKW Equipment + Process Design proprietary polyurethane hydrocyclones are also used with great success, contributing to significant cost savings without compromising process performance. Beside this traditional approach, AKW Equipment + Process Design recently introduced its unique twin hydrocyclone concept for alumina classification. Also made of our proprietary polyurethane, this newly introduced system is capable of delivering further cost savings, especially through smaller footprint and easier maintenance. An explanation of the installation and operation of such alumina clusters in a refinery will be shown as an example.

Keywords: Alumina refinery; alumina classification; twin hydrocyclones; annular distributor.

1. Introduction

Alumina is usually produced from bauxite in the well-established Bayer process. This process utilizes the thermodynamic properties of the caustic soda-aluminum hydroxide system. In the Bayer process, a caustic soda liquor flows in a circuit which is fed with ground bauxite and then heated to digestion temperature. The bauxite's alumina minerals dissolve at the elevated temperatures and pressures in the digesters. Afterwards, the undissolved material from the bauxite, i.e. the bauxite residue or red mud, is removed from the process by means of thickeners and/or filters. The supersaturated liquor is then cooled to induce crystallization. To accelerate the precipitation process to commercially feasible rates, previously precipitated alumina tri-hydrate (fine seed, coarse seed) is added to the pregnant liquor to improve the crystallization rate and product quality. At the end of the precipitation process, alumina tri-hydrate can be separated by hydrocyclones into product, fine and coarse seed and de-liquored by filters. In a last process step, the aluminum hydroxide is converted to alumina by calcination. [1, 2]
The "all time modern process philosophy" can be summarized in the following manner:

- decreasing of energy consumption by improvement of liquor productivity;
- decreasing of Al-hydrate losses;
- increasing the particle strength of alumina;
- improving alumina handling,
- minimizing the environmental impact;

It has to be taken into account that the Bayer process is constantly evolving and the specific techniques employed in this highly sophisticated industry for the various steps of the process do vary from refinery to refinery. Always however, alumina tri-hydrate crystal formation (the nucleation and growth of alumina tri-hydrate crystals), and the precipitation and collection thereof, are critical steps in the economic recovery of aluminum values in all plants. Bayer process operators strive to optimize their crystal formation and precipitation methods to produce the greatest possible product yield from the Bayer process, while producing crystals of a given particle size distribution. A relatively high coarse, and low fines content in alumina product is beneficial to the subsequent processing steps required to convert alumina to aluminum metal. The state of the art technique to separate the coarse particles as product and the fine particles as seed (coarse and fine seed) is presently hydrocyclones. [3]

2. Application of hydrocyclones in the Bayer process

The use of hydrocyclones in the alumina industry using the Bayer process goes back to a development in the late sixties between VAW, a German alumina producer (Schwandorf, Lünen, Stade) and AKW A+V. Shortly after this successful introduction of cyclones in the Bayer process, NABALCO, Gove was the first Australian refinery to install AKW A+V hydrocyclones in 1978. In Australia Kwinana, Pinjarra and Wagerup followed in the 1990s.

2.1. About the operational principal of hydrocyclones

The hydrocyclone can be classified as a mechanical separation device in which sedimentation takes place in a centrifugal field. It is rather like a tube centrifuge with a nonrotating body. If the rotation of the basket in a centrifuge is regarded purely as a feature of design, and not as an essential functional factor, then the hydrocyclone can be regarded as a solid-wall overflow centrifuge with automatic slurry discharge.

The simple construction of the hydrocyclone, and in particular the lack of rotating parts, means it can be made of a variety of materials and in different shapes, which is an advantage in combating wear and corrosion.

Rotational motion in a hydrocyclone is produced by the suspension entering tangentially under pressure. Flow is at first down the inner wall of the cylindrical section and the cone, as far as the stagnation point near the cone apex. There, because the opening is small, the downward primary vortex is forced to turn upwards again, forming the secondary vortex. This revolves tightly around the air core near the axis and finally leaves the cyclone body through the upper axial nozzle, or vortex finder. In a cross section of the body, both spirals rotate in the same direction; in longitudinal section, however, they move in opposite directions.

In state of the art refineries, hydrocyclone installations as product cyclones and seed cyclones are an integral part of the process chain. To underline the benefit of such an installation a paper of the TMS Light Metals Congress 2005 is cited.

"Alpart's old classification units consists of gravity settlers for Primary, Secondary and Tertiary material. The Primary material was then washed counter-currently across settled hydrate tanks. Sump material that consisted of fines was also recycled to the primary vessels via a Sump Relay Tank (SRT). This consisted of material varying from 10-20% on –44 µm, and ≈ 6% on –20 µm, the highest in terms of percentage for -20µm in any stream in the circuit, except for the tertiary seed. This stream recycled ≈ 3000tpd at 3000 gpm, and averaged >200gpl solids. It consisted mainly of Hy-tank (Hydrate Tank) overflow and sump material. The resultant overload of classification caused excess fine seed, the use of higher temperatures, and 3-4 agglomeration trains along with fine seed re-digestion to maintain seed balance. This meant at times ~80% of product material came from agglomeration trains, giving a weak product.
To improve the product cut and capture, a series of cyclones were installed above the settled hydrate tanks. Upon completion, hydrate capture increased from 50% to 80%, and cut improved to 55% on -44µm through the cyclones.
However, there was still considerable hydrate re-cycle, as the settled hydrate tanks were still allowed to overflow. Since September 2003, a 'Classification Control Philosophy' was implemented to change the operating mode.
The focal points of the philosophy were:

- *Cycloning of all product material.*
- *Pumping Primaries at specified rates to maintain a 'soft hydrate bed' and reduce pressure variations to cyclones.*
- *Removing SRT traffic from the product primaries.*
- *Operating the Hy-tanks as agitated vessels and do not overflow.*

The result was a 50% reduction in the recycle load on the classification and sump system. Furthermore, this mode of operation has helped to reduce secondary overflow solids and maintain good seed balance. This has ensured that there is only need for 2-3 ≈ 2.5 agglomeration trains, under normal operating conditions, with no need for re-digestion of fine seed." [5]

5. References

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