Improvement in Control Strategy to Maximize Productivity and Enhance Hydrate Particle Strength in Bayer Precipitation Circuit

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Abstract

Maximizing of alumina precipitation per liter of circulated liquor (liquor productivity or yield) is a key objective of an alumina refinery which reduces operating costs as the yield increases. An equally important KPI (key performance indicator) in alumina production is the hydrate strength which is critical to avoid high attrition (tendency of alumina to breakdown during calcination process and handling). Higher attrition has potential to higher dusting, leading to the product loses and environmental concerns. It also affects efficiency and stability of pot operation in smelters. Organic build up in aluminate liquor due to high organics in feed bauxite or ageing of liquor affects the yield and the quality of product hydrate. Hence, optimization of the process parameters, including the removal of oxalate impurities from the Bayer circuit to control below the critical saturation limit (defined as critical oxalate concentration or COC) is essential for managing the detrimental effects of these impurities on the yield and the alumina quality. This paper outlines the various control methodologies adopted at Lanjigarh Alumina Refinery for enhancing the hydrate strength and maintaining optimum liquor productivity while charging high organic content bauxite. Initial data analysis of 2 years showed that a variety of factors, including higher temperature and seed charge in agglomerator led to lower supersaturation resulting in weak particle bonding and low strength. Efficient control measures like, Tschamper Ratio (TR) based control with the algorithms in DCS, oxalate inventory management for maintaining margin between circuit oxalate concentration and COC which included precipitation end tank temperature control, part diversion of oxalate enriched liquor stream for destruction through lime and seed washing were introduced. Lanjigarh Refinery has also taken up a way forward to look into possibilities of further improving hydrate strength with potential improvement in liquor productivity by the simulation of hydrate classification circuit to optimize seed charge and granulometry control.

Keywords: Yield, Hydrate strength, Tschamper Ratio, Critical oxalate concentration.

1. Introduction

M/s Vedanta Aluminium Limited is located at Lanjigarh, Orissa State, India, having a capacity of 2 MMTPA smelter grade alumina production by employing Bayer Process of low temperature and pressure digestion. Alumina hydrate in solid form is precipitated from a super-saturated aluminate liquor, produced from the digestion of bauxite ores. In the Bayer Process, an important design objective is to maximize liquor yield (defined as kg of alumina produced per liter of circulated liquor). The main advantages are as follows:

- Plant production capacity increases with more or less the same equipment (at least within a certain production range); i.e., the capital cost per annual ton production capacity drops for several process areas (e.g., digestion, decantation, precipitation, and power station)
- Lower steam and energy consumption per tonne alumina (e.g., digestion steam and overall pumping power)
- Although not straight forward, in some aspects, product quality control improves when the conditions for yield increase is provided (e.g., increasing the alumina super-saturation

of the mixture of aluminate liquor and spent liquor recycled with the seed charge in precipitation feed improves hydrate strength which is critical to avoid high attrition (tendency of alumina particle breakdown during calcination process and handling) resulting higher fines (-325 mesh) fraction in alumina).

The productivity and economy of all alumina refineries depend on optimizing the precipitation process. The dual aim of the precipitation process is to maximize productivity and to improve product quality. The yield and strength of hydrate precipitated are dependent on process parameters and to some extent on certain impurities. The important parameters are temperature profile of precipitation circuit, initial alumina to caustic ratio (RP or A/C), concentration of pregnant sodium aluminate liquor, seed ratio, precipitation time, impurity level of input seed hydrate and aluminate liquor. The attrition of alumina can occur during precipitation and/or calcination where the latter is more prominent and dependent on the precipitation conditions. The strength of alumina is determined by the term of attrition or attrition index (breakdown of particles) of alumina during calcination. Not only the mode of calcination influences the breakdown of alumina to some extent, but also the strength of the crystal of hydrate plays a greater role. All parameters which influence the precipitation yield and the strength of crystals are very much dependent on the precipitation process and the liquor quality which is again dependent on the chemistry and minerology of bauxite and its processing technology. This paper describes the different methodologies adopted to maximize the productivity as well as improve the product quality.

2. Liquor Productivity (Yield) Increase Options Adopted by Refinery

The liquor productivity for the refinery was running very low at 68–72 gpl during the past years. This was very low as compared to the design. The increasing recirculation load of the refinery was leading to high energy costs as well as reducing throughput from the refinery. The Figure 1 shows the liquor productivity for a period of 10 months wherein the average productivity was 68 gpl.

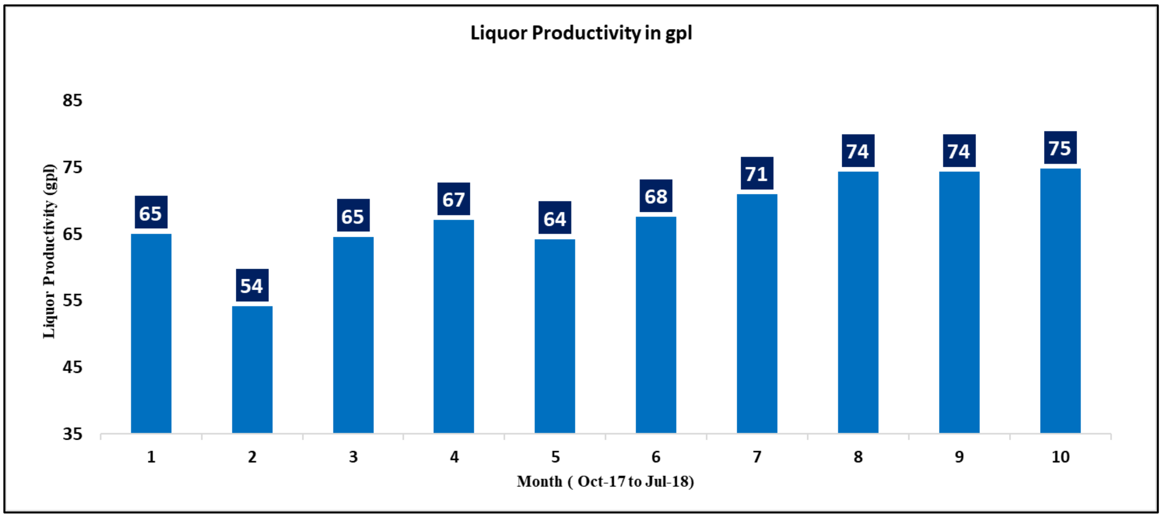

Figure 1. Liquor productivity graph.

The following options were analyzed for the possibility of an increase in the yield:

1. Targeting optimum temperature profile across precipitation by increasing availability and performance of Inter stage coolers. To increase availability of Interstage coolers (ISCs) , the refinery took the following steps:

4. Summary of Findings and Conclusion

Increase in apparent breakage in calcination was caused by:

- Increased production rate in calciner.
- Weaker hydrate strength due to reduced supersaturation in agglomeration and initial growth tanks and over-agglomeration.
- Reduced supersaturation caused by increased agglomeration temperature as well as 1st growth temperature (mainly caused due to poor HID performance).
- Weaker particle strength due to increased over-agglomeration (as indicated by +120µm increase in agglomeration).
- Slightly weaker hydrate growth ring strength due to reduced supersaturation in growth.
- Though the agglomeration index has been steady on long term basis, it was increased for a while during the phase 1 and 2 (sharp increase of +120 µm in agglomeration output), but it was returned to normal in the later end of phase 2. Such increase partially contributed to the weaker hydrate.
- Increased organics in the system due to bauxite source change resulted an increase of oxalate levels in the circuit causing oxalate outbreak and impacting precipitation seed size disturbances.

Actions taken for improving the hydrate particle strength:

- Debottlenecking of HID for temperature reduction and control in agglomerator and 1st growth tank through installation of additional HID system.
- Targeting bound soda content in agglomerated product to control the soda content of product in the range of ~0.35 % with a minimum cap of 0.32 %.
- Inclusion of the sizing analysis of +120 microns particle size in agglomeration to monitor and control over agglomeration.
- Introduction of Tschamper Ratio control in DCS to monitor and control TR on real time basis (target 10-13 g/m^2).
- Measurement of the hydrate and alumina attrition index in house to monitor trends.
- Reduction of the precipitation tank solids to avoid / reduce oxalate precipitation.
- Increase of the end tank temperatures of precipitation circuit to reduce oxalate precipitation.
- Start-up of the seed washing unit and ensuring the optimum caustic concentration and temperature for effective oxalate wash.
- Oxalate destruction unit operation for oxalate conversion from liquor phase to solid phase by lime dosage and disposed of through mud.

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6. References

1. Wind S., Jensen-Holm C. and Raahauge B., Development of particle breakdown and alumina strength during calcination. *Proceeding of the 9th International Alumina Quality Workshop*, 18-22 March 2012, Perth, Australia, 308-315.
2. L., Armstrong et al., Alumina attrition - investigation of hydrate structure, *Proceeding of the 4th International AQW (Alumina Quality Workshop)*, 2-7 June 1996, Darwin, Australia, 239-249.

3. Wijayaratne H. and H. M., Balancing sodium impurities in alumina for improved properties. *Metallurgical and Materials Transactions B*, Oct 2018, Vol. 49, Issue 5, 2809-2820.
4. J. V. Sang, Factors affecting residual Na2O in precipitation products, *Proceeding of 117th TMS annual Meeting*, 25-28 January 1988, Phoenix, Arizona, USA, *Light Metals 1988*, 147-156.
5. Chris Vernon et al., Soda incorporation during hydrate precipitation, *Proceeding of 134th TMS Annual Meeting*, 13-17 February 2005, San Francisco, California, USA, *Light Metals 2005*, 191-196.