# Control of Product Size and Strength with Challenging Impurity Balance

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**Abstract**

Producing a good quality product depends on many refinery aspects. In several parts of the world, refineries have been designed and built for many decades. Bauxite chemical composition determines plant equipment and technology used in a refinery such as digestion design, precipitation design and impurity removal systems. Aughinish Alumina Ltd (AAL) was constructed for an oxalate free precipitation circuit and this is still a critical criteria to successfully control product size and product strength. Increase in production over the years from 800,000 tons in 1983 to approximately 2 million tons per annum in 2018 have led to an increase in the level of alumina, silica and oxalate scaling rate of the precipitation equipment and pipework. Opportunities to improve liquor productivity such as increased seed charge, increased surface area, liquor temperature and supersaturation control are covered in detail. The risks associated with generating solid phase oxalate and how it is controlled at AAL is also dealt with. This paper provides a summary of the general approach to control product size and strength at AAL to produce a good quality product.

**Keywords:** Product quality, precipitation, oxalate, product size, product strength.

## 1. Introduction

This paper reviews the evolution of the precipitation circuit in a refinery from its initial design and manufacturing capabilities of 800,000 tons in 1983 to approximately 2 million tons per annum in 2018. It looks at the requirements for strong nucleation, agglomeration and growth as well as the classification equipment as it pertains to product quality. The impact of Sodium Oxalate as a liquor impurity in a largely oxalate free circuit is examined.

## 2. Overview of Aughinish Alumina Precipitation Circuit

Aughinish runs an essentially oxalate free continuous circuit producing sandy alumina using Alcan design technology. It consists of three agglomerators and twelve precipitators in each of two chains with four in-tank precipitator coolers installed in each chain. The original design of three sets of primary and secondary gravity classifiers were supplemented by secondary hydrocyclones in 1994. Coarse seed filtration (CSF) on two filters was installed in 1997, with a third installed in 2006 to give 100% flexibility. Fine seed filtration (FSF) was installed in 2005. Four hydrate thickeners remain unchanged from the original design. The initial coarse seed charge has increased from 250 g/l to 420 g/l. The combination of coarse seed and fine seed filters increased liquor productivity by 5 g/l. Product quality design was for < 12% -45µ and < 20 % Attrition Index, the actual being achieved is < 10% for both parameters on average.

Figure 13 shows a block diagram of the Precipitation Circuit at Aughinish. Heat Inter-stage Department (HID) is the vacuum flash area where the pregnant liquor from the security filtration area is cooled under vacuum from 105 °C to 85 °C and where the spent liquor exchanges heat with the resultant vapour to heat up the spent liquor going back to the digestion area.

CSF is the area where the solids from the underflow of the secondary classifier is filtered and recycled in pregnant liquor to give increased residence time and a higher seed charge in the growth tanks. FSF represents the area where the underflow of the thickeners is filtered and recycled in a more supersaturated liquor to improve liquor productivity and quality of the agglomerates.

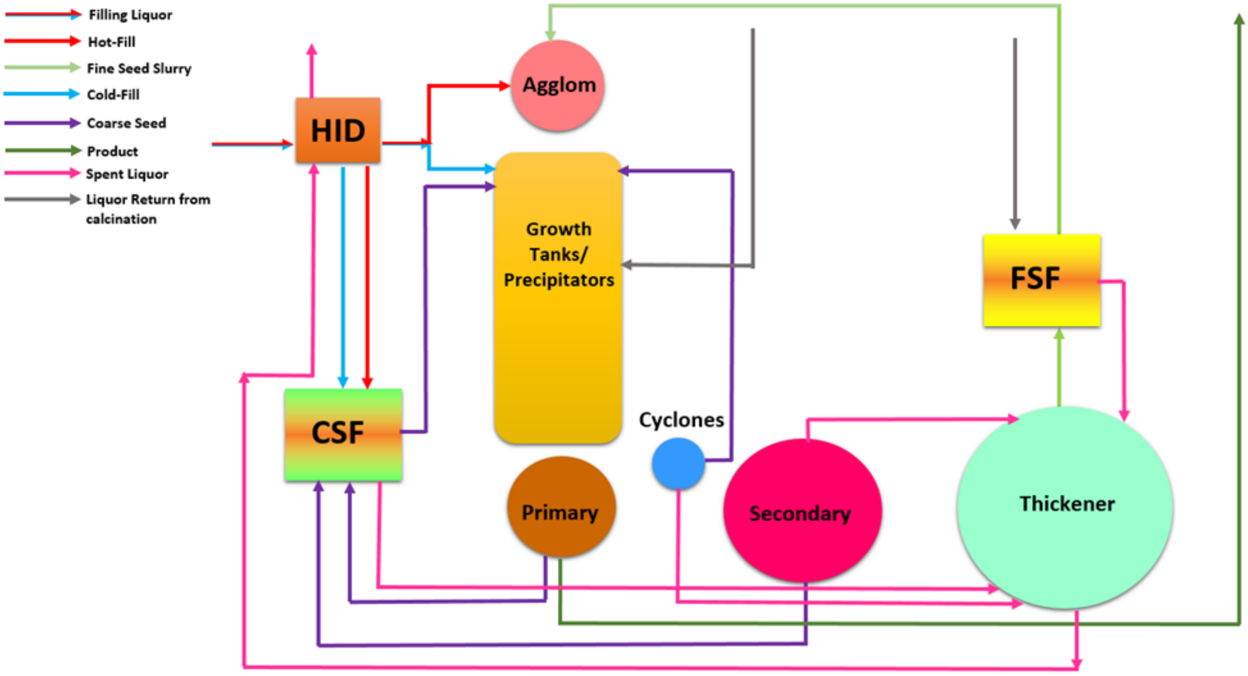


**Figure 13. Block diagram of the precipitation circuit at Aughinish.**

## 3. Control of Precipitation at Aughinish

The precipitation circuit at Aughinish is divided into the following areas:

- Precipitation
- Classification
- Equipment essential for controlling productivity and quality

### 3.1. Process Flow through Precipitation

As shown in Figure  the pregnant liquor flow from the security filtration area is cooled in HID, causing it to become supersaturated. This increases the driving force for the aluminate ion to precipitate out of solution as alumina trihydrate. Fine seed is added to the pregnant liquor to provide a large surface area for the hydrate to precipitate onto. A number of large vessels, three agglomerators of 1200 $m^3$ volume, followed by twelve precipitators of 4500 $m^3$ volume (See Table 1 and

Table 2), provide the residence time required for precipitation. Continuous agitation is provided to keep the solids in suspension and at the same time increase the number of sites on the seed for precipitation to take place. Temperature control (hotfill/coldfill) and the amount of seed added (coarse seed return/fine seed return) to the pregnant liquor determines the size and strength of the precipitated hydrate. Hotfill is filling liquor flow direct from HID. Coldfill is filling liquor flow from HID that has passed through the interstage heat exchangers. The different temperature flows are needed to effect temperature changes at various stages in precipitation to control alumina

It is critical to maintain a manageable and well defined fines balance through good control of nucleation and seed classification to produce a strong agglomerate which will not breakdown in calcination.

Opportunities to improve liquor productivity include increasing seed charge, increasing seed surface area, reducing circuit temperatures, increasing alumina supersaturation or upgrading plan equipment but all of these need to be carefully assessed for their impact on product quality and cost effectiveness.

The impact of sodium oxalate needs to be carefully assessed when deciding the most appropriate mode of operation for any particular plant based on bauxite quality and equipment availability.

## 7. References

1. Misra, C. and White, E.T., 1971. Crystallisation of bayer aluminium trihydroxide. *Journal of Crystal Growth*, 8 (2), pp.172-178.
2. King, W.R., 1973. In *Light Metals.* 1973, p.551.
3. Halfon, A. and Kaliaguine, S., 1976. Alumina-Trihydrate Crystallisation.1. Secondary Nucleation and Growth-Rate Kinetics. *Canadian Journal of Chemical Engineering*, 54, pp.160-167.
4. Veesler, S. and Boistelle, R., 1993. About supersaturation and growth rates of hydrargillite $Al(OH)_3$ in alumina caustic solutions. *Journal of Crystal Growth*, 130, pp. 411-415.
5. White, T. and Bateman, S.H., 1988. In *Light Metals.* 1988, p.157.
6. Dirksen, J.A.. and Ring, T.A., 1991. Fundamentals of secondary nucleation. *Journal of Crystal Growth*, 13/14, pp.493-499.